# Annual Progress Report
## 2023-24

# Central Cotton Research Institute Multan

## Pakistan Central Cotton Committee

### Ministry of National Food Security & Research
### Government of Pakistan


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# ANNUAL REPORT

# 2023-24

CENTRAL COTTON RESEARCH INSTITUE, MULTAN

Pakistan Central Cotton Committee

Ministry of National Food Security & Research

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# PREFACE

The year 2023 remained blissful for the revival of cotton crop in Pakistan. The country harvested substantially higher cotton production to the level of 8.023 million bales against 4.280 million bales during last year depicting an increase of 87.45% (Source: PCGA Arrivals 18.12.2023). This robust recovery in cotton production is attributed mainly to the favorable weather (lesser rains and moderate temperatures) and low pest pressure upto July. In addition, the Economic Coordination Committee (ECC) has also approved intervention price of Rs. 8,500 per 40 kg for the crop season 2023-24 crop on 14.03.2023, which was much higher than the price (Rs. 5,700 per 40 kg) announced during the year 2022-23. This single and timely act of Government encouraged farmers to cultivate cotton more than 10% of the preceding area. Moreover, the induction of Trading Corporation of Pakistan (TCP) has also helped to maintain the cotton prices to the range of Rs.7,800-8,500 (seed-cotton) and Rs.17,500 to 18,500 per 40 kg lint prices. All these factors helped in reviving and enhancing the cotton production in the country. Efforts are now underway to enhance cotton production to meet domestic industrial demand and export requirements. The Government is also exploring trade opportunities and new markets for enhancing exports.

The Punjab Seed Council (PSC) in its 57th meeting held on 12.08.2023 in Lahore approved two new *Bt*. varieties *Bt*.CIM-775 and *Bt*.Cyto-511 of Central Cotton Research Institute (CCRI), Multan. These cotton varieties have high fiber properties, good productivity and high resistance to virus (CLCuV). The production potential of these varieties is more than 45 kg per acre. Cotton variety *Bt*.Cyto-511 is highly heat tolerant and has excellent productivity in hot weather, while *Bt*.CIM-775 is an outstanding variety with relatively higher tolerance against sucking insects.

Central Cotton Research Institute, Multan in collaboration with Statistical, Economic and Social Research and Training Centre for Islamic Countries (SESRIC), Turkey organized a training course on "Productivity Enhancement of Cotton by Using Modern Agronomic Practices" under the Organization of the Islamic Conferences (OIC) Cotton Capacity Building Programme (COTTON-CAB) for the benefit of National Cotton Institutions in OIC African Member Countries during February 14-16, 2023. The training course was also coordinated by Islamic Development (IsDB), Food & Agriculture Organization (FAO) of the United Nations and African Association. A total of 37 participants from African countries i.e. Nigeria, Togo, Uganda, Cote-D'Ivoir, Mozambique, Namibia, and from Turkey & Azerbaijan attended the training program. There were 09 cotton experts from Pakistan Central Cotton Committee (PCCC) and 04 from Muhammad Nawaz Sharif University of Agriculture, Multan (MNSUAM) who delivered lectures on various cotton agronomic practices. Participants appreciated the resourcefulness of experts. In addition, the Institute actively remained engaged with international cotton organizations in cotton promotion and development programs throughout the year. The celebrations of World Cotton Day on 7th October, launching of Cotton Innovation Newsletter from the platform of the International Cotton Researchers Association (ICRA) Secretariat based at the Institute.

The Institute has recently entered into agreement with Centre for Agriculture and Bioscience International (CABI), Pakistan for the promotion of organic cotton cultivation and insect pests & disease management. The Institute will provide logistics support, research & development programs and mutual research projects. In addition, the Institute has also engaged with Institute of Cotton Research (ICR), Chinese Academy of Agricultural Sciences (CAAS) China and M/s Jinghua Seed Industry, China for mutual collaboration in cotton research & development programs for testing & evaluation of advanced cotton strains, capacity building, varietal development and marketing programs. Moreover, CCRI, Multan also collaborated with Sangtani Women Rural Development Organization (SWRDO), Rajan Pur for training of farmers in cotton production technology during the season.

Pink bollworm (PBW) has been a serious pest management issue for the last several years. To address this issue, CCRI, Multan organized the first national seminar on PBW management in 2015 and the activity continued every year until 2021. In the year 2021, an international seminar was arranged in which foreign researchers were also invited to share their findings to understand the PBW and its management more holistically. The local scientists, pesticide and seed industry personnel, cotton farmers, extension agents and policy makers participated in the seminar. The seminar earned heavy attendance and the recommendations were placed before provincial and federal Governments for implementation and policy formulation. Moreover, the Institute has also fabricated a Mechanical Boll Picker (MBP) called “Pink bollworm Manager” for eradication of leftover bolls containing PBW larvae during winter. This machine proved to be very effective in eradicating PBW at CCRI, Multan. Consequently, the demonstrations of the Pink bollworm Manager were carried out successfully during the season. Farmers and agriculture extension workers participated in these demonstrations.

The changing climatic conditions (rising temperatures, rains and drought) and rise in the cost of production are adversely affecting the cotton cultivated area and its production. The cotton production and yield improvement is becoming a big challenge under the current scenario. The cost of production is continuously increasing with reduced profitability over time. The Institute has thus introduced a new eco-friendly technology called “Low Expenditure & Environment Friendly (LEEF)” for sustainable cotton production. The LEEF technology uses mulches from crop-based residues placed at the beds after thinning. The plant residues applied included straws, husks, grasses, compost, and manures. This technology maintains moderate soil temperatures, conserves moisture, prohibits weed emergence and improves microbial activities. Moreover, the mulches after decaying add up to the soil health in the form of organic matter and nutrients.

The provision of funds for the cotton project “Better Cotton Initiative for Sustainable Cotton Production in Pakistan” by the Ministry of National Food Security & Research is highly appreciated. This has helped in expanding the cotton development programs in Punjab (Multan and DG Khan) and Sindh (Nausharo Feroze and Shaheed Benazir Abad), in addition to providing necessary operational expenses for the Institute in carrying out research plans smoothly. Under the project, a total of 48,313 farmers were trained on principles & criteria for better cotton production, covering an area of 157,030 acres.

I am also thankful to the cotton stakeholders mainly All Pakistan Textile Mills Association (APTMA), Pakistan Cotton Ginners Association (PCGA), Seed Association of Pakistan (SAP), Pakistan Crop Protection Association (PCPA), CropLife Pakistan and Pakistan Kissan Ittehad (PKI) for their continued support in cotton development programs.

I am grateful to the entire scientific, administrative and field staff of the Institute who have worked hard to their utmost despite acute shortage of financial resources.

I also pray to Allah for the betterment of cotton in the country, wellbeing of farming community and all the trading bodies engaged in cotton business in the years to come. May the upcoming years bring happiness and prosperity for us all (Aameen).

**Dr. Muhammad Naveed Afzal**
**Director**

March, 2024

# ANNUAL REPORT
# CENTRAL COTTON RESEARCH INSTITUTE, MULTAN
# 2023-24

## I. EXECUTIVE SUMMARY

### i). Introduction

Central Cotton Research Institute (CCRI), Multan, the prime research facility of Pakistan Central Cotton Committee (PCCC) was established in 1970. By the grace of Allah, the Institute has completed 53rd year after its establishment. The Institute is equipped with different research disciplines including Agronomy, Plant Breeding & Genetics, Cytogenetics, Entomology, Plant Pathology, Physiology/Chemistry, Fibre Technology, Transfer of Technology and Statistics. The research work has been focused on the following main aspects:

1. Study cotton plant from botanical, genetical, production, physiological, chemical, entomological, pathological and other relevant aspects in a coordinated manner.
2. Undertake research work of national importance and handle problems of inter-regional nature.
3. To develop cost-effective cotton production technology.
4. Advanced knowledge of the cotton plant responses to environment with a view to better cope with 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. Promote mechanization in cotton production system.
8. Transfer production technology to the cotton growers.
9. Educate and motivate cotton growers and monitor research outcomes.
10. Provide technical support to the Pakistan Central Cotton Committee in coordinating and developing a national program for cotton research.
11. Training manpower across the country and other cotton growing countries on “cotton research and development”.
12. Facilitation and research guidance to students at graduate and higher level degree courses.

The Institute has so far developed 38 elite cotton varieties since its inception. Developments have been made in earliness, heat tolerance, drought tolerance, disease resistance and fiber quality traits. CCRI, Multan pioneered in developing cotton leaf curl virus (CLCuV) resistant varieties when the country suffered a huge loss in cotton production during 1993-94. In addition to the varietal development, the scientists of the Institute developed water-saving planting techniques, pest scouting models and Economic Threshold Levels (ETLs) for various pests, evaluate nutritional requirement of cotton varieties, and addressing soil health issues. Since its establishment, CCRI, Multan has made tremendous progress in cotton R&D in various aspects of cotton crop.

### ii) Staff Position

A total of 118 staff members including 35 officers and 83 other staff members remained at the Institute during the period under report. The position of technical staff during the year 2023-24 is given in Annexure-I.

**iii) Budget**

Sanctioned budget from 2019-20 to 2023-24 is given below: (Rs. Million)

| Sr. # | Detail | 2019-20 | 2020-21 | 2021-22 | 2022-23 | 2023-24 |
|---|---|---|---|---|---|---|
| **1** | Pay & Allowances | 73.79 | 72.71 | 79.11 | 99.58 | 126.99 |
| **2** | Medical | 0.50 | 0.50 | 0.50 | 0.5 | 0.5 |
| **3** | Traveling Allowance | 2.20 | 1.50 | 1.50 | 0.7 | 0.7 |
| **4** | Group Insurance | 0.599 | 0.57 | 0.51 | 0.54 | 0.61 |
| **5** | Utility Bills* | 11.81 | 1.360 | 13.85 | 15.65 | 18.55 |
| **6** | Contingencies | 42.97 | 33.59 | 21.78 | 23.95 | 25.25 |
| | **Total** | **131.87** | **110.24** | **117.25** | **140.93** | **172.60** |

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

**iv) Income**

Income of the Institute from 2019-20 to 2023-24 is given below: (Rs. Million)

| Sr. # | Head | 2019-20 | 2020-21 | 2021-22 | 2022-23 | 2023-24 |
|---|---|---|---|---|---|---|
| **1** | Farm Produce | 3.378 | 1.190 | 3.081 | 3.940 | 1.400 |
| **2** | Non-Farm Produce | 1.328 | 1.380 | 0.842 | 0.100 | 0.000 |
| | **Total** | **4.706** | **2.570** | **3.923** | **4.040** | **1.400** |

## II RESEARCH ACTIVITIES

### i) Research Experiments

The research experiments conducted during 2023-24 by various sections are as follows:

**Agronomy Section**

| Sr.# | Title of Study/Experiment |
|---|---|
| **1** | Effect of time of sowing on productivity of advanced genotypes |
| **2** | Effect of time of sowing on productivity of transgenic genotypes |
| **3** | Effect of planting geometry on productivity of transgenic genotypes |
| **4** | Impact of various levels of nitrogen in combination with potassium on yield performance of newly developed genotypes |
| **5** | Yield response to residues management and tillage systems in cotton-wheat cropping system |
| **6** | Optimizing the time of mepiquat chloride application in cotton at various planting geometries |
| **7** | Agro-economic feasibility for cotton-based intercropping system |
| **8** | Screening of pre-emergence weedicides in cotton |

**Plant Breeding & Genetics Section**

| Sr.# | Title of Study/Experiment |
|---|---|
| **1** | Testing of New Strains Developed at CCRI, Multan |
| **2** | Micro Varietal Trials |
| **3** | Standards Varietal Trials |
| **4** | Testing of Promising Strains of Cotton Breeders under NCVT Program |
| **5** | Development of new Breeding materials for variety evolution |
| **6** | $F_2$ Generation Block |
| **7** | Spot Examination trial at Punjab Seed Corporation Farm, Khanewal |
| **8** | Early Generation Seed (*Bt*. and Non *Bt.*) |
| **9** | Pre-basic & Basic Seed Production |
| **10** | Fresh crosses |
| **11** | Maintenance of genetic stock |
| **12** | Study of Gene Flow/ out crossing |
| **13** | Performance of exotic Vs local cotton varieties under the agro-climatic condition of Multan |
| **14** | Ratooning and screening of ICARDA Cotton germplasm for development of CLCuV resistance/ tolerance strains. |
| **15** | Study of phenotypic diversity |

**Cytogenetics Section**

| Sr.# | Title of Study/Experiment |
|---|---|
| 1 | Collection and maintenance of *Gossypium* germplasm |
| 2 | Interspecific hybridization |
| 3 | Colchiploidy |
| 4 | Search for *Bt*. homozygous resistance against CLCuD under field conditions |
| 5 | Testing of Cyto-material in Micro-Varietal Trials |
| 6 | Testing of Cyto-material in varietal trial |
| 7 | Mapping population development for fiber quality |
| 8 | Early generation system |
| 9 | Evaluation of new strain under varied ecological zones |
| 10 | Biotechnological studies |

**Entomology Section**

| Sr.# | Title of Study/Experiment |
|---|---|
| 1 | Studies on Pink bollworm |
| 2 | Monitoring of population dynamics of different lepidopterous pests |
| 3 | National Coordinated Varietal Trials |
| 4 | Impact of cotton sowing period on sucking pests, natural enemies' population tendency |
| 5 | Incidence of arthropods abundance on light and normal green cotton leaves in relation to commercial aspect |
| 6 | Cotton pests management through augmentative releases of *Rhynocoris marginatus* |
| 7 | Monitoring of insecticide resistance |
| 8 | Screening of new and commercially available insecticides |
| 9 | Studying effect of Methyl Jasmonate (plant volatile) on cotton pests and their predators |

**Plant Pathology Section**

| Sr.# | Title of Study/Experiment |
|---|---|
| 1 | Monitoring and collection of cotton diseases in the cotton belt of Punjab |
| 2 | Evaluation of breeding material against CLCuD. |
| 3 | Epidemiological studies of CLCuD |
| 4 | Evaluation of advanced strains of cotton in NCVT against cotton diseases |
| 5 | Management of cotton diseases |

**Plant Physiology/Chemistry Section**

| Sr.# | Title of Study/Experiment |
|---|---|
| 1 | Studies on genotype - environment interactions |
| 2 | Soil health and plant nutrition |
| 3 | Plant-water relationships |
| 4 | Seed physiology |

**Transfer of Technology Section**

| Sr.# | Title of Study/Experiment |
|---|---|
| 1 | Integrated multi-media publicity campaign |
| 2 | TeleCotton SMS Service |

**Fibre Technology Section**

| Sr.# | Title of Study/Experiment |
|---|---|
| 1 | Testing of lint samples |
| 2 | Testing of commercial Samples |
| 3 | Enhancing Nutrient-Use-Efficiency (NUE) by synchronizing application rate and methods |
| 4 | Effect of different Intercrops in cotton on fibre characteristics |
| 5 | Quality survey of lint collected from ginning factories |
| 6 | ICA-Bremen Cotton Round Test Program, Faser Institute, Germany |
| 7 | Collaborative study with academia, ginning, spinning and other cotton stakeholders |

**ii) Approval of Cotton Varieties**

The Punjab Seed Council (PSC) accorded approval of 2 cotton varieties (*Bt*.CIM-775 and Cyto-511) for commercial cultivation.

***Bt*.CIM-775**

Lint %age: 42.3

Staple Length: 28.0

Micronaire: 4.8

Strength: 28.6

***Bt*.Cyto-511**


Lint %age: 38.0

Staple Length: 28.0

Micronaire: 4.5

Strength: 29.95

The varieties have cleared all their regional and adaptability trials. All the varieties have excellent fibre quality traits with high yield potential. The approval and cultivation of these varieties will pave the way for enhancing cotton productivity in the country.

**iii) Biological Control with Beneficial Insects**

**a) Assissin Bug**

Assassin Bug technically known *Rhynocoris marginatus* was released in Multan and its surroundings by the Entomology Section of CCRI, Multan on cotton crop. Farmers were advised not to eliminate this insect considering it harmful. It is a beneficial insect so must not be wrongly eliminated as it appears like red cotton bug which is a serious pest on cotton crop.


i) Egg-laying by *R*. *marginatus*


ii) *R. marginatus* feeding on Armyworm larva

**b) Spiders**

Spiders are not insects for technical reasons, but play an important role as biocontrol agents predating successfully on various insect pests of crops especially cotton. Among the spider diversity including other naturally occurring predatory fauna at CCRI, Multan farm, the most dominating is Orb-web spider group, particularly the spider *Neoscona theisi*. Spider are comparatively more capable to resist adverse ecological conditions than other bioagents (Pak. Cottongrower, Jul-Sep, 2022). Whitefly, jassid, moths, boll weevils and flies were found entangled in its webs.

Farmers are informed that spiders do not cause damage to the cotton crop, rather they are beneficial by making the harmful insects their food. Avoid passing through its web, so that the spiders and their eggs in the crop are safe.

**iv) Newly Reported Cotton Pest**

**a) Painted Bug**

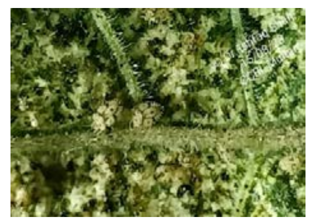
A new sucking insect Painted Bug have been observed on the cotton crop, which is usually a pest that damages vegetables. Nymphs and the adults suck cell sap from leaves and the developing plant parts. The nymphs and adult bugs excrete resineous material. Studies regarding its host range and damage intensity etc need to be carried out to further identify its significance in pests category.

**b) Lace Bug**

Lace Bug (*Urentius hystricellus*) family Tingidae, (confirmed by the Entomology Section, Central Cotton Research Institute, Multan), is being observed. This insect causes serious damage to the cotton leaves by sucking the sap. Although its presence is mentioned on the lower part of the leaves in the literature, but we have seen its attack on the upper part of the leaf as well, where it gets its food. The affected part appears as spots. Later this part turns yellow and dries up. Small piles of waste faecal are also present in the affected area. Spraying and other measures taken to destroy other cotton pests also control the lace bug very well. Therefore, farmers do not need to worry much for its attack.


Feeding on upper part of leaf


No attack on lower part of leaf


Adults and faecal residue on leaf

**v) Cotton Biotechnology**

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

| Name of Gene | Function |
|---|---|
| Cry2A | Pink Bollworm Resistance |
| DREB2 | Abiotic Stresses including Drought Tolerance |
| MYB (Family Gene) | Fibre Improvement |

Genetic transformation of Cry2A, DREB2, and Gt-Gene for bollworm, abiotic stress drought and glyphosate resistance genes, respectively into commercial cultivars, have been accomplished and are presently under evaluation for gene stability and other molecular analysis to develop resistance against bollworms, abiotic stress and herbicides.

**vi) Cold Room for Storage of Cotton Germplasm**

The Institute has developed sub-zero cotton seed storage facility for long-term storage that comprises more than 6,143 accessions (Local: 1,290 and Exotic: 4,853) that have been collected from various national and international resources. The seed of different varieties is preserved on short (25 years), medium-term (50 years) and long term (100 years) basis and is in hand to be used by researchers to develop new varieties. The germplasm is shared with various local / international organizations / universities for breeding purposes.

**vii) Activities under Cotton Project "Better Cotton Initiative (BCI) for Sustainable Cotton Production in Pakistan"**

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

The project activities were carried out partially due to limited release of funds. The major activities included registration of 48,319 farmers for BCI practices covering an area of 157,030 acres, 10 farmers training programs, 08 Better Cotton Knowledge Network (BKN) meetings with BCI officials and 24 monthly meetings with BCI staff during the period. The periodic progress of the BCI project is given below:

| Activity | 2019-20 | 2020-21 | 2022-23 | Total |
|---|---|---|---|---|
| Farmers Registered | 14,799 | 8,932 | 24,588 | 48,319 |
| Area Covered (Acres) | 25,565 | 7,116 | 124,350 | 157,030 |

In addition, technical material in Urdu and Sindhi languages were also printed for distribution among the farmers during training programs conducted at CCRI, Multan and in the project areas.

## III COTTON PROMOTION & DEVELOPMENT ACTIVITIES

**i) OIC Cotton Capacity Building Program (COTTON-CAB)**

Central Cotton Research Institute Multan in collaboration with SESRIC Turkey organized training course on "Productivity Enhancement of Cotton by Using Modern Agronomic Practices" under the OIC Cotton Capacity Building Programme (COTTON-CAB) for the benefit of National Cotton Institutions in OIC African Member Countries from Feb 14-16, 2023. The training course was also coordinated by Islamic Development (IsDB), Food & Agriculture Organization (FAO) of the United Nations and African Association. 37 participants from African countries including Nigeria, Togo, Uganda, Cote-D'Ivoir, Mozambique, Namibia, and from Turkey & Azerbaijan attended the training program. 09 experts from PCCC and 04 from MNSUAM delivered lectures on various cotton agronomic practices. Participants appreciated the resourcefulness of experts.



**ii) World Cotton Day**

The Central Cotton Research Institute (CCRI), Multan celebrated the World Cotton Day (WCD**)** on October 7, 2023 with great enthusiasm and in a befitting manner. The day is being celebrated with reassurance for the betterment of cotton crop in the country. The following major activities were carried out:

- Cotton Walk for commemorating importance of cotton crop in economy
- Exhibition of farm machinery and stalls of companies
- Seminar challenges confronting cotton production, measures for its revival
- Perspectives of stakeholders (Farmers, ginning, textile, pesticide, seed and fertlizer)

The event highlighted the issues in cotton production and trade and recommended measures for boosting cotton production in the country. The collaborative and joint efforts by the government functionaries, stakeholders and cotton trading bodies will bring back the momentum of cotton production to the level where it was a few years before and prosperity for the nation at large. The year 2019 led to launch the initiative of declaring World Cotton Day by the ICAC and WTO, followed by events and celebrations around the world commemorating the importance of cotton crop. The United Nations has also declared 7$^{th}$ October as the UN World Cotton Day in 2021. Pakistan being a leading cotton producing country holds responsibility to showcase solidarity with world cotton community. Cotton is not only the lifeline for Pakistan's economy but also has a unique association with mankind.

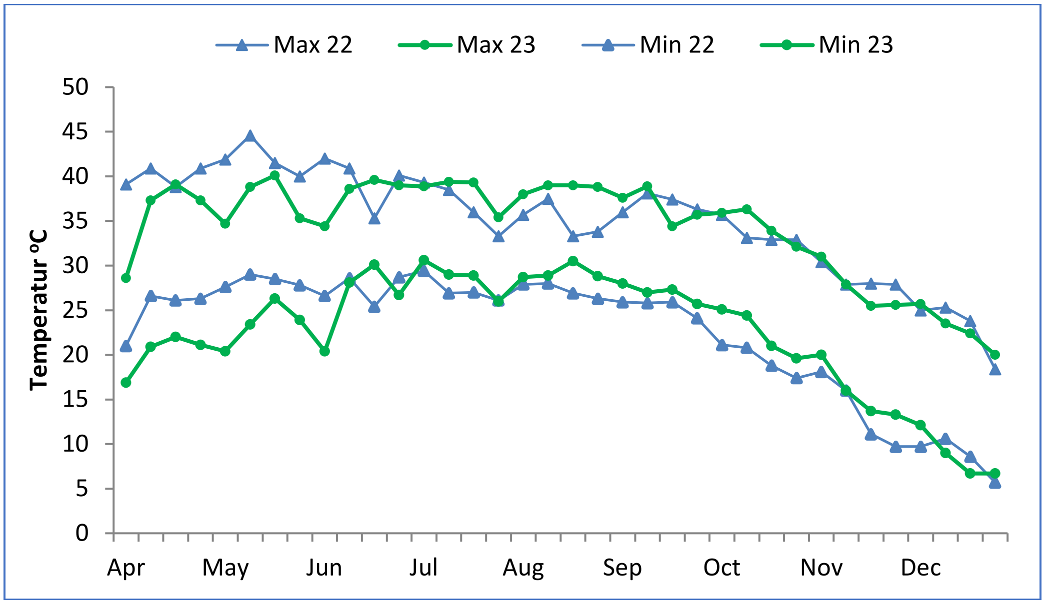
**iii) Website & Social Media**

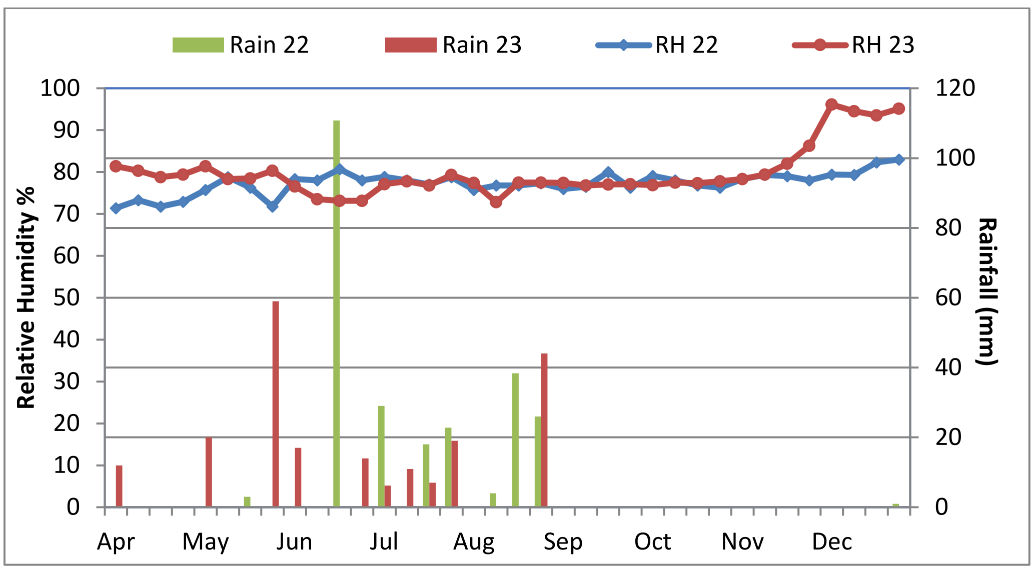
The Institute also initiated highlighting of cotton research and development activities carried out during crop season 2023-24 utilizing social media tools (www.fb.com.pk/CCRIM.PK). This has attracted cotton farmers, researchers, and students very effectively. The followers and members appreciated the activities carried out by the Institute. The Institute has also upgraded the website (www.ccri.gov.pk) of the Institute highlighting major cotton research and development activities, brief programs of various disciplines, cotton market rates, weather situation and other related activities.

## IV) COTTON CROP CONDITION

**i) Weather Condition**

The pattern of maximum temperatures during cotton crop season 2023-24 remained higher especially between May-August. The annual average maximum temperature during 2023-24 remained 34.36°C while it was 35.0°C during last year. Similarly, the annual average minimum temperature during current year remained at 22.42°C while it was 22.5°C during last year. The minimum relative humidity remained 79.8% while it remained 96.1% at maximum level, during current season. A total of 209.2 mm rainfall was recorded during the current crop season as compared to 253.0 mm rainfall during the last year (Annexure-II).




**ii) Cotton Crop Condition**

Cotton crop 2023 bounced back after continuous decline over the past few years. The year 2023 remained blissful for the revival of cotton crop in the country. The country harvested substantially higher cotton production to the level of 8.345 million bales against 4.280 million bales during last year depicting an increase of 75.28% (Source: PCGA Arrivals 03.02.2024). This robust recovery in cotton production is attributed mainly to the favorable weather (lesser rains and moderate temperatures). In addition, the Economic Coordination Committee (ECC) has also approved intervention price of Rs. 8,500 per 40 kgs for the crop season 2023-2024 crop on 14.03.2023. This price is higher than Rs. 5700 per 40kg announced for the 2022-2023 crop. This single timely act of government encouraged farmers to cultivate cotton more than 10% of the preceding area.

Moreover, the induction of Trading Corporation of Pakistan has also helped to maintain the cotton prices to the range of Rs.7800-8500 (seedcotton) and lint prices to Rs.17,500 to 18,500 per 40 kgs during the season. All these factors helped to increase the cotton production. Government is making all out efforts to increase the cotton production to meet domestic industrial demand and export requirements. Moreover, the Government is also exploring opportunities and new markets for enhancing exports.

**Targets 2023-24**

| Province | Area (Mil. Ha) | Production (Mil. Bales) | Yield (kg/ha) |
|---|---|---|---|
| Punjab | 2.018 | 8.336 | 702 |
| Sindh | 0.671 | 4.000 | 1013 |
| KPK | 0.002 | 0.004 | 336 |
| Balochistan | 0.073 | 0.430 | 998 |
| **Pakistan** | **2.764** | **12.770** | **785** |

Source: Daily Market Report, PCCC

**Cotton Area Target Vs Sowing 2023**

| Province | Target 2023-24 | Area Sown | | % Change Over | |
|---|---|---|---|---|---|
| | | 2023-24 | 2022-23 | Target | Last Year |
| Punjab | 2.018 | 1.680 | 1.4850 | 83.25 | + 13.1 |
| Sindh | 0.671 | 0.610 | 0.590 | 90.91 | + 3.4 |
| Khyber Pakhtunkhwa | 0.002 | 0.00018 | 0.00018 | 9.0 | + 0.0 |
| Balochistan | 0.073 | 0.0768 | 0.0685 | 105.21 | + 12.1 |
| **Total** | **2.764** | **2.367** | **2.144** | **85.64** | **+ 10.4** |

Source: Daily Market Report, PCCC

**Cotton Arrivals 2023-24**

| Province | 2023-24 | 2022-23 | % Change |
|---|---|---|---|
| Punjab | 4,238,434 | 2,893,094 | + 46.50% |
| Sindh | 4,111,119 | 1,870,515 | + 119.79% |
| **Pakistan** | **8,349,553** | **4,763,609** | **+ 75.28%** |

Source: PCGA 03.02.2024

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# V. SECTIONAL PROGRESS REPORT

## 1. AGRONOMY

The main focused study areas of this section include soil, water, nutrients, weed management, planting time optimization and planting techniques for candidate and benchmark genotypes (GMOs and Non-GMOs) developed by CCRI, Multan with climatic vagaries. In addition to these. The performance of genotypes is being tested in High Density Planting System (HDPS). The feasibility study on mung bean, sesame, corn and fodder maize as an intercrop in cotton is also being tested to improve the economic returns of the cotton growers. The long-term experimentation is being carried out to improve the soil health and productivity of wheat-cotton cropping system through residue incorporation. The weed control efficiency of the registered and candidate herbicides is also being tested. The daily record of various weather data is the regular activity of this section. The internship training is an important activity of this section to train the agricultural graduates from various universities. Research facilities extended to M.Phil and Ph.D scholars is another landmark of this section. The training of agricultural officers, extension workers, field staff of pesticide and seed companies, NGOs, farmers and agriculture graduates is a regular seasonal feature. Moreover, radio programs are arranged to guide the farming community. The section also participates in the biweekly advisory meetings to guide the farmers time to time during the season as per crop need.

### 1. Effect of time of sowing on productivity of transgenic cotton

Four transgenic cotton genotypes i.e., *Bt.* Cyto-545, *Bt.* Cyto-547, *Bt.*CIM-762 and *Bt.*CIM-990, with one standard *Bt.*CIM-663 were evaluated at three different sowing dates starting from April 01 to June 01 at one-month interval. The experimental design was split plot, sowing dates were kept in main plot and genotypes were in sub-plots with four repeats. The net plot size was 20 ft x 33 ft. Bed-furrows were prepared after land preparation in dry condition. Sowing was done by manual dibbling of seeds at 22.5 cm plant to plant distance followed by irrigation. Dual Gold 960 EC @ 2L per hectare was sprayed after sowing on moist beds. Other cultural practices and plant protection measures were adopted as per the need of the crop. The data on plant height, number of bolls and boll weight were recorded before final picking. Five plants were randomly selected for plant height and number of bolls per plant. All the bolls from three randomly selected plants were counted, picked and weighed. The average boll weight was measured by dividing the total seed cotton weight by the total number of bolls. The whole plot was manually picked and seed cotton weight was converted on hectare basis. Data on plant height, boll number, boll weight, seed cotton yield and CLCuD incidence 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 date | Genotypes | Plant height (cm) | Number of bolls plant$^{-1}$ | Boll weight (g) | Seed cotton yield (kg ha$^{-1}$) | CLCuD incidence (%) at 105 DAS* |
|---|---|---|---|---|---|---|
| April 01 | Bt.Cyto-545 | 139.5 | 32 | 2.82 | 3212 | 4.3 |
| | Bt.Cyto-547 | 165.1 | 34 | 2.80 | 3336 | 0.0 |
| | Bt.CIM-762 | 138.5 | 31 | 2.75 | 3125 | 1.0 |
| | Bt.CIM-990 | 145.0 | 33 | 2.79 | 3273 | 0.0 |
| | Bt.CIM-663 | 143.4 | 27 | 2.83 | 2721 | 1.4 |
| May 01 | Bt.Cyto-545 | 121.0 | 22 | 2.91 | 2298 | 10.8 |
| | Bt.Cyto-547 | 151.2 | 26 | 2.89 | 2640 | 0.0 |
| | Bt.CIM-762 | 117.5 | 22 | 2.87 | 2180 | 16.1 |
| | Bt.CIM-990 | 126.5 | 25 | 2.95 | 2498 | 1.9 |
| | Bt.CIM-663 | 124.6 | 20 | 2.94 | 2075 | 46.6 |
| June 01 | Bt.Cyto-545 | 78.1 | 13 | 2.97 | 1280 | 100.0 |
| | Bt.Cyto-547 | 93.5 | 14 | 2.99 | 1320 | 47.4 |
| | Bt.CIM-762 | 83.5 | 12 | 2.98 | 1189 | 100.0 |
| | *Bt*.CIM-990 | 91.5 | 13 | 3.01 | 1310 | 18.8 |
| | *Bt*.CIM-663 | 70.0 | 12 | 2.98 | 1185 | 89.8 |

*DAS =Days After Sowing

**Sub-effects**

| Sowing date | Plant height (cm) | Number of bolls plant$^{-1}$ | Boll weight (g) | Seed cotton yield (kg ha$^{-1}$) | CLCuD incidence (%) at 100 DAS |
|---|---|---|---|---|---|
| April 01 | 146.3 | 31 | 2.80 | 3133 | 1.3 |
| May 01 | 128.2 | 23 | 2.91 | 2338 | 15.0 |
| June 01 | 83.3 | 13 | 2.99 | 1257 | 71.2 |

| Genotypes | Plant height (cm) | Number of bolls plant$^{-1}$ | Boll weight (g) | Seed cotton yield (kg ha$^{-1}$) | CLCuD incidence (%) at 100 DAS |
|---|---|---|---|---|---|
| *Bt*.Cyto-545 | 112.9 | 22 | 2.90 | 2263 | 38.4 |
| *Bt*.Cyto-547 | 136.6 | 25 | 2.89 | 2432 | 15.8 |
| *Bt*.CIM-762 | 113.2 | 22 | 2.87 | 2165 | 39.0 |
| *Bt*.CIM-990 | 121.0 | 24 | 2.92 | 2360 | 6.9 |
| *Bt*.CIM-663 | 112.7 | 20 | 2.92 | 1994 | 46.0 |

**C.D 5%**

| | | | | | |
|---|---|---|---|---|---|
| Sowing Date (SD) | 24.41 | 3.93 | Ns | 396.64 | 7.42 |
| Genotype (G) | 8.95 | 1.51 | Ns | 158.16 | 5.14 |
| SD x G | Ns | Ns | Ns | Ns | 10.77 |

The plant height, bolls per plant and seed cotton yield decreased while, boll weight increased with the delay in sowing (Figs. 8, 9, 10, 11). The maximum plant height (146.3 cm), bolls plant$^{-1}$ (31) and seed cotton yield (3133 kg ha$^{-1}$) were harvested from April 01 sown crop (Table 1.1). Among all sowing dates maximum boll weight (2.99 g) was produced in June 01 sown crop. On overall average basis of sowing dates, *Bt.*Cyto-547 produced 3.1%, 7.5%, 12.3% and 22.0% significantly more seed cotton yield than *Bt*.CIM-990, *Bt*.Cyto-545, *Bt*.CIM-762 and *Bt*.Cyto-663 respectively.

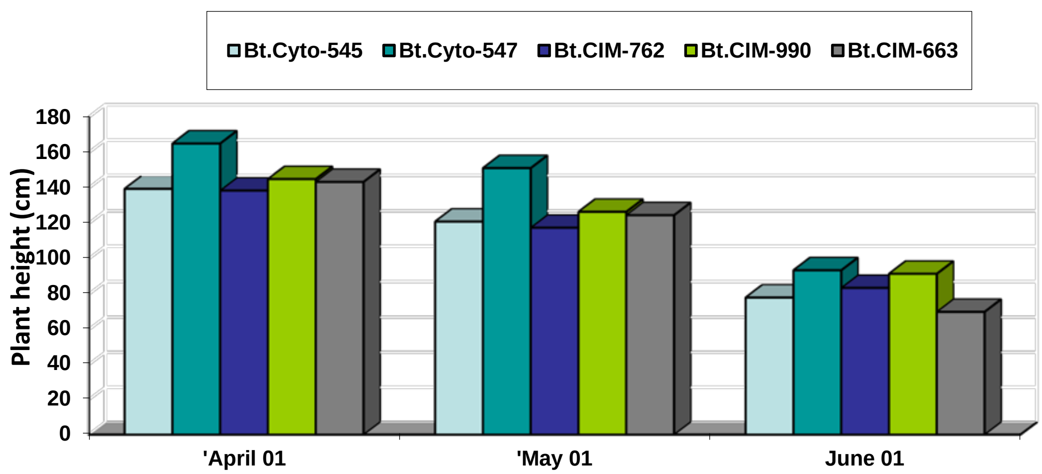



**Fig. 1 Plant height as affected by interactive effects of sowing dates and genotypes**

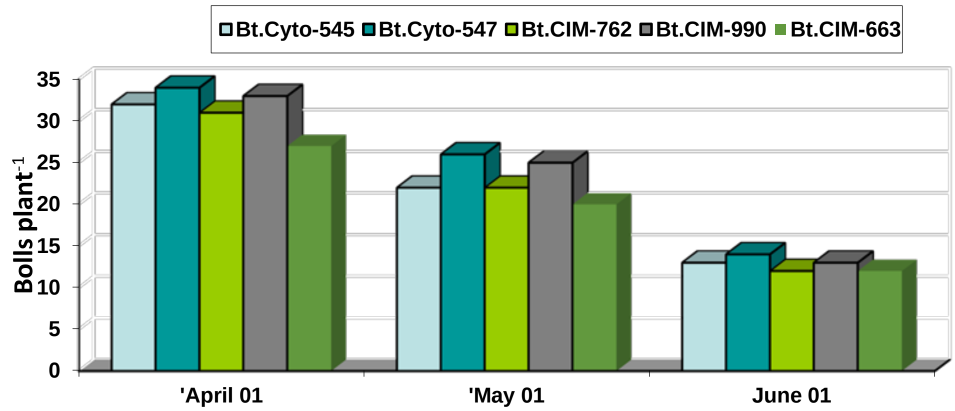



**Fig. 2** Bolls plant$^{-1}$ as affected by interactive effects of sowing dates and genotypes

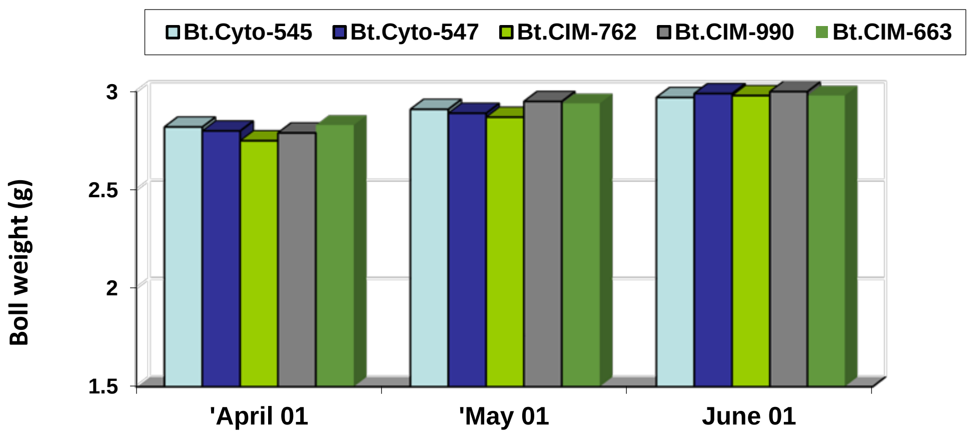



**Fig. 3** Boll weight as affected by interactive effects of sowing dates and genotypes

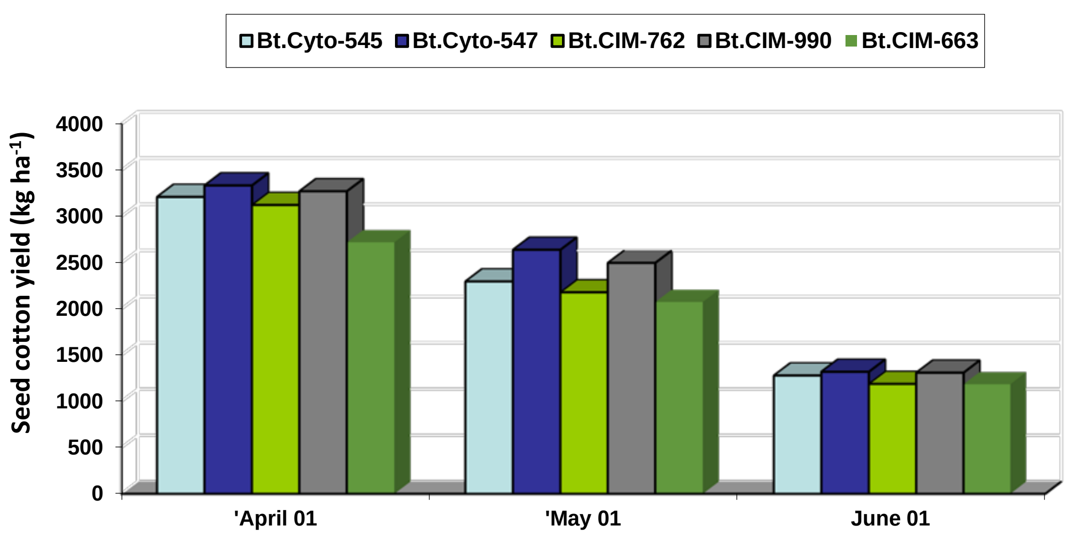
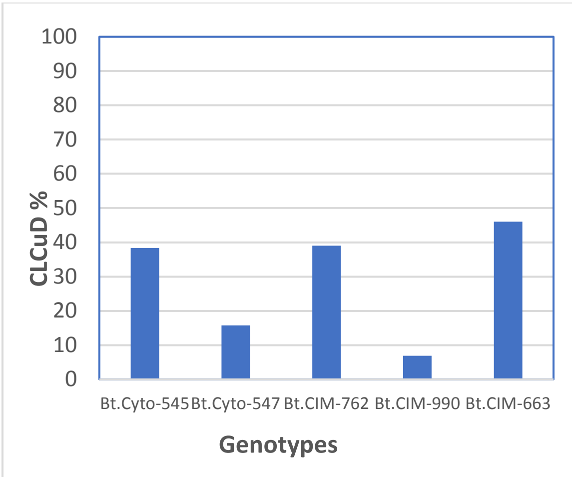



**Fig. 4** Seed cotton yield as affected by interactive effects of sowing dates and genotypes



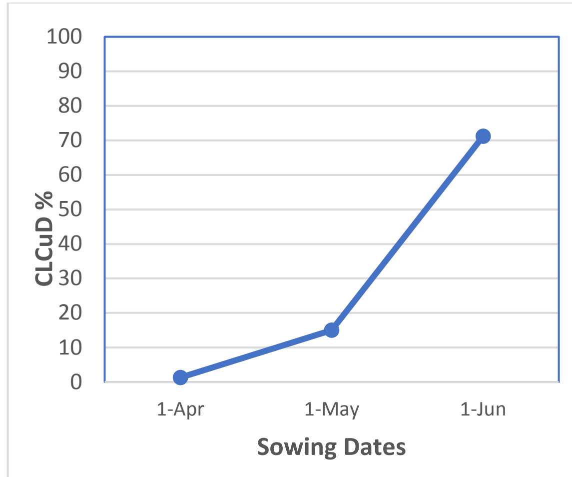




**Fig. 5 CLCuD incidence in different sowing dates at 100 DAS**

**Fig. 6 CLCuD incidence in different genotypes at 100 DAS**

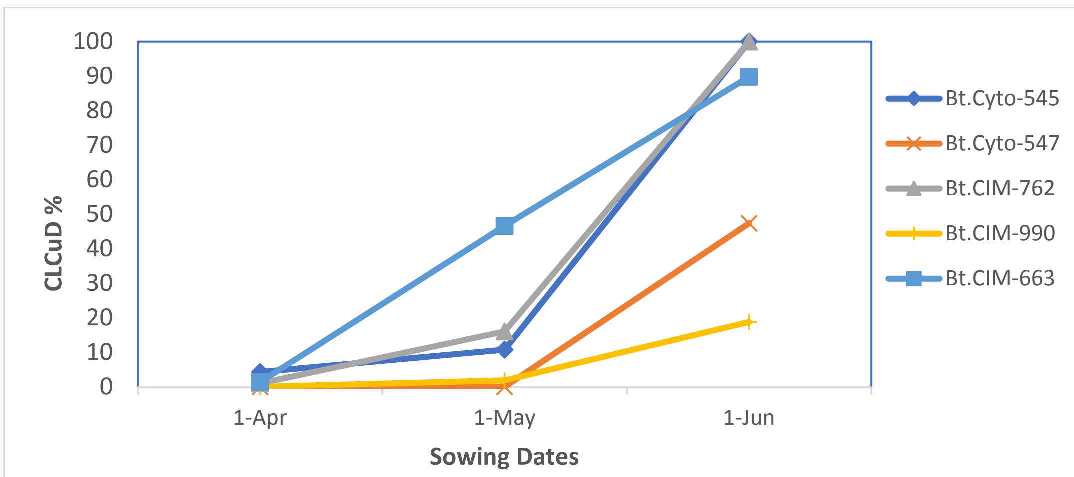



**Fig. 7 Interactive effects of sowing dates and genotypes on CLCuD incidence at 105 DAS**

The data on CLCuD indicated that the disease incidence increased as the sowing was delayed from April 01 to June 01. The incidence of CLCuD at 105 days old crop was observed 1.3%, 15.0% and 71.2% in April 01, May 01 and June 01 sown crops respectively (Fig. 5). On the average basis of sowing dates, genotype *Bt.*CIM-990 showed 8.9%, 31.5%, 32.1% and 39.1% less incidence of CLCuD than *Bt*.Cyto-547, *Bt.*Cyto-545, *Bt*.CIM-762 and *Bt*.CIM-663, respectively (Fig. 6). The interaction between sowing dates and genotypes is illustrated in Fig. 7.

**1.2 Effect of planting geometry on productivity of transgenic genotypes**

The experiment had a Randomized Complete Block Design (RCBD) with split plot arrangements repeated thrice. The four intra-row spacing were allocated to main plots while four genotypes were applied to subplots. Each subplot consisted of four rows with 75 cm inter-row spacing and was 10 m long. All plots were managed uniformly regarding land preparation, sowing method, irrigation, pest control and fertilization. The land was prepared with disk plough (once) followed by tiller (twice), rotavator (once) to break the clods, uprooting/destroying the roots and crop leftovers, and then bed furrows were made. Cotton was sown with dibbling method in the 1st week of May. All experimental plots received 150 kg N ha$^{-1}$ as urea and 60 kg P ha$^{-1}$ as triple super phosphate. All the phosphorous was applied at sowing, while N was applied in three split doses, 50 kg at sowing, 50 kg at flowering, and 50 kg at boll formation stage. Weeds were controlled with post-sowing herbicides. All the cultural and pest control measures were adopted uniformly.

**Table 1.2 Effect of planting geometry on plant height, seed cotton yield and yield components**

| Intra-row spacing | Genotype | Plant height (cm) | Bolls plant$^{-1}$ | Boll weight (g) | Seed cotton yield kgha$^{-1}$ |
|---|---|---|---|---|---|
| 15.0 cm | *Bt*.Cyto-537 | 95.7 | 9 | 3.15 | 881 |
| | *Bt*.Cyto-545 | 92.0 | 14 | 3.02 | 1093 |
| | *Bt*. CIM-762 | 85.2 | 8. | 2.72 | 784 |
| | *Bt*. CIM-990 | 104.3 | 10 | 3.03 | 990 |
| 22.5 cm | *Bt*.Cyto-537 | 110.5 | 10 | 2.69 | 1405 |
| | *Bt*.Cyto-545 | 99.0 | 8 | 2.92 | 2006 |
| | *Bt*. CIM-762 | 86.7 | 8 | 2.99 | 989 |
| | *Bt*. CIM-990 | 111.8 | 9 | 2.72 | 1804 |
| 30.0 cm | *Bt*.Cyto-537 | 104.2 | 7 | 2.78 | 718 |
| | *Bt*.Cyto-545 | 83.5 | 10 | 2.83 | 1285 |
| | *Bt*. CIM-762 | 73.5 | 9 | 2.81 | 795 |
| | *Bt*. CIM-990 | 112.8 | 7 | 2.76 | 940 |
| 37.5 cm | *Bt*.Cyto-537 | 92.5 | 6 | 2.22 | 627 |
| | *Bt*.Cyto-545 | 86.2 | 7 | 2.90 | 1112 |
| | *Bt*. CIM-762 | 83.8 | 7 | 2.55 | 705 |
| | *Bt*. CIM-990 | 97.5 | 9 | 2.73 | 819 |

**Sub-effects**

| Intra-row spacing | Plant height (cm) | Bolls plant$^{-1}$ | Boll weight (g) | Seed cotton yield kgha$^{-1}$ |
|---|---|---|---|---|
| 15 cm | 94.3 | 10 | 2.98 | 937 |
| 22.5 cm | 102.0 | 9 | 2.83 | 1551 |
| 30.0 cm | 93.5 | 8 | 2.80 | 935 |
| 37.5 cm | 90.0 | 7 | 2.60 | 816 |

| Genotypes | Plant height (cm) | Bolls plant$^{-1}$ | Boll weight (g) | Seed cotton yield kgha$^{-1}$ |
|---|---|---|---|---|
| *Bt*.Cyto-537 | 100.7 | 8 | 2.71 | 908 |
| *Bt*.Cyto-545 | 90.2 | 10 | 2.92 | 1374 |
| *Bt*. CIM-762 | 82.3 | 8 | 2.77 | 818 |
| *Bt*. CIM-990 | 106.6 | 9 | 2.81 | 1138 |

**C.D 5%**

| | | | | |
|---|---|---|---|---|
| Intra-row spacing (IS) | 0.52 | 0.80 | 0.05 | 10.18 |
| Genotypes (G) | 0.44 | 0.34 | 0.03 | 18.26 |
| IS X G | 0.88 | 0.68 | 0.06 | 36.51 |

Main effects indicated that number of bolls, boll weight and seed cotton yield were significantly influenced by intra-row spacing and highest could be achieved from 22.5 cm spacing. Results further revealed that seed cotton yield initially increased with increase in intra-row spacing and peaked at 22.5 cm thereafter it declined with further increase in intra-row spacing. Sub-effects of genotypes revealed that *Bt*.Cyto-545 significantly produced the highest seed cotton yield as compared to *Bt*.CIM-762, *Bt*.Cyto-537 and *Bt*.CIM-990 with an increase of 60%, 51% and 21% respectively on averaged basis. Interactive effects revealed that *Bt*.Cyto-545 with 22.5 cm spacing produced more bolls per plant, weight boll$^{-1}$ and seed cotton yield as compared to other treatments.

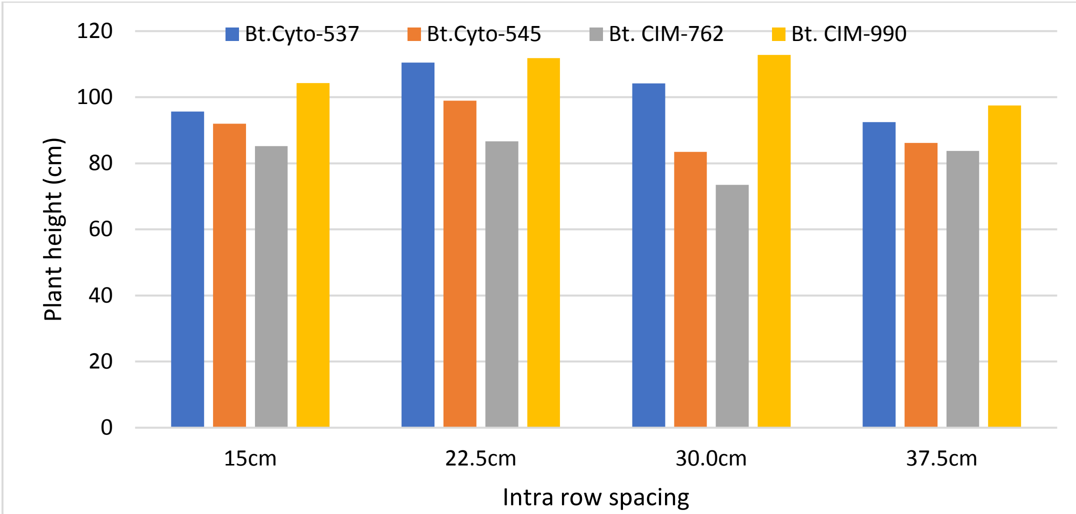



**Fig. 8** **Plant height as affected by interactive effects of planting geometry and genotypes**

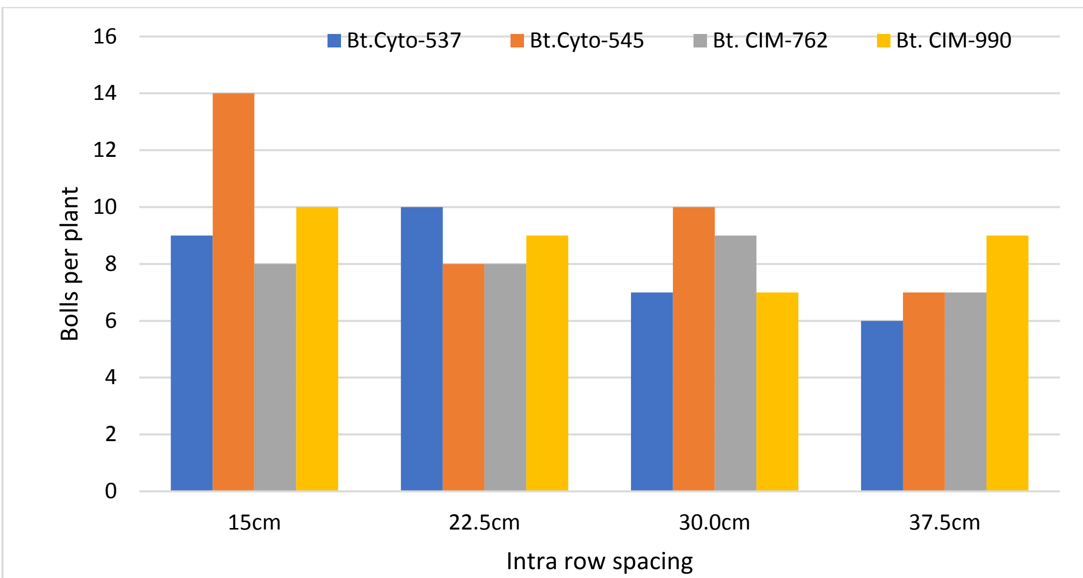



**Fig. 9** **Boll per plant as affected by interactive effects of planting geometry and genotypes**

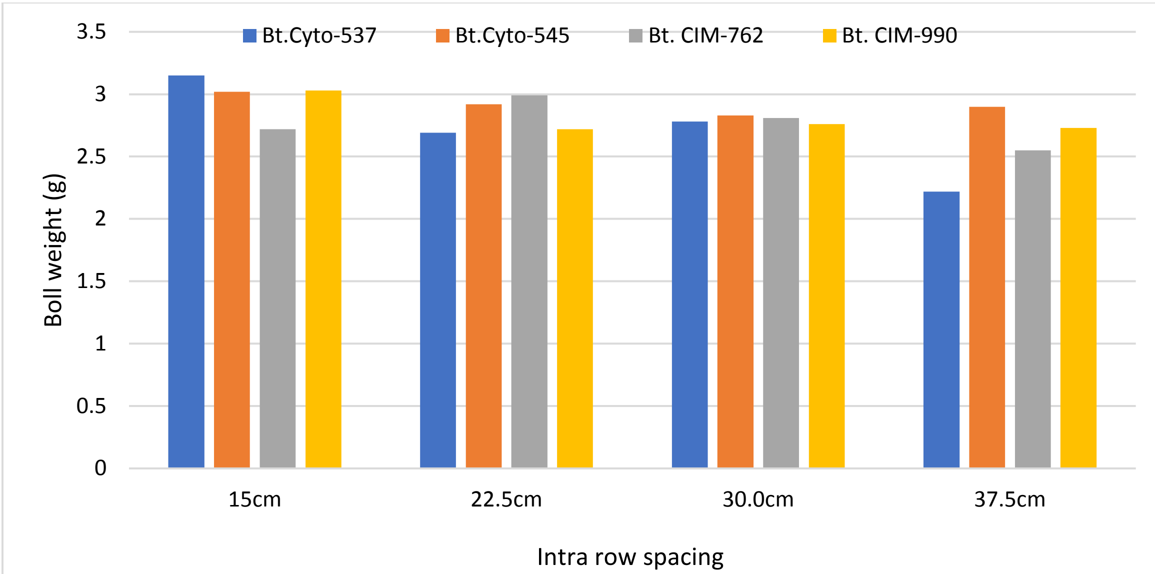



**Fig. 10 Bolls weight as affected by interactive effects of planting geometry and genotypes**

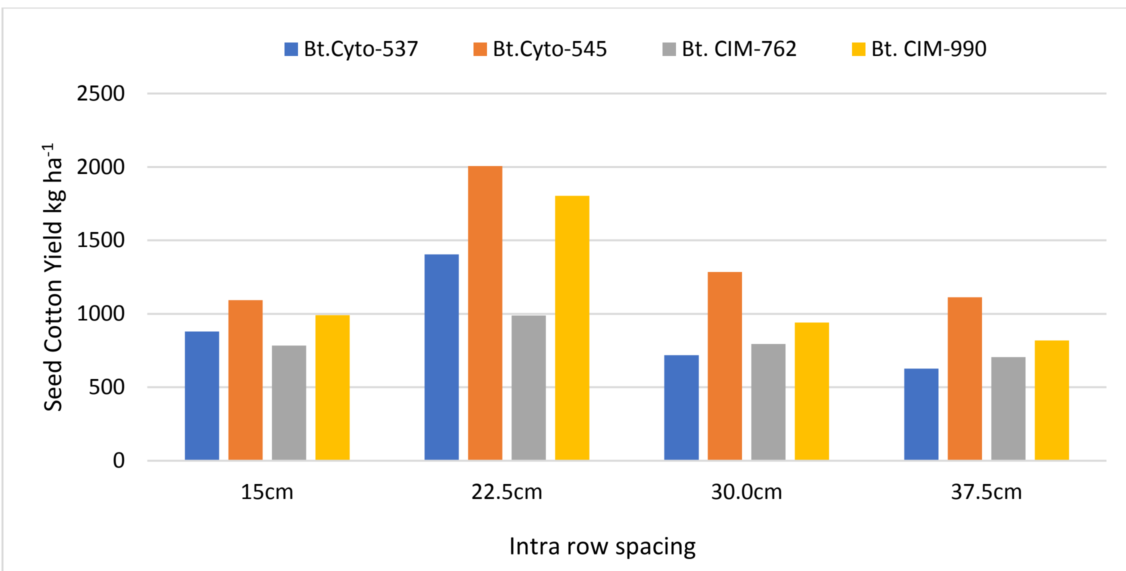



**Fig. 11 Seed cotton yield as affected by interactive effects of planting geometry and genotypes**

### 1.3 Impact of various levels of nitrogen in combination with potassium on yield performance of newly developed genotypes

The nutrients supply is an integral part of crop production, affecting both the quantity and quality of various crops. The application of the right dose of fertilizer is crucial to meet the crop nutrient requirement and to minimize the environmental impact of the fertilizer. Since multiple nutrients are required for crop growth and development, the rate of one nutrient application may have impact on the other nutrient requirement. Therefore, balanced nutrition is required to optimize the combination of various nutrients. In this study, the crop responses to nitrogen in relation to varying rate of potassium were assessed with respect to crop growth and yield. The performance of two genotypes including *Bt.* CIM-975 and *Bt.* Cyto-541 is being evaluated at various combinations of nitrogen and potassium (0-0, 100-0, 100-50, 100-100, 150-0, 150-75 and 150-150 kg, N and K ha$^{-1}$) is being evaluated. The crop was sown on 14-04-2023. The treatments were arranged according to Randomized Complete Block Design (RCBD) with split plot arrangement. The genotypes were kept in main plots and fertilizer combinations were allocated to sub-plots. There were three replications of each treatment. The net plot size is 15 x 64 ft. The bed furrows were prepared in dry conditions and seeds were dibbed at 22.5 cm apart in 75.5 cm wide rows. The first split of nitrogen and potassium was applied on June 06th, 2023. The second and third application was carried out on 2nd August 2023 and 25th August 2023, respectively. The plant height was recorded from 05 randomly selected plants before picking. The data on the No. of bolls were recorded by counting all the open bolls from 05 plants and averaged. These bolls were further picked, weighted and average boll weight was recorded. The crop was manually picked single time and seed cotton was recorded by picking all the plants from individual plot. It was weighted and converted on hectare basis.

The interactive effects of the genotypes and fertilizers were non-significant for various recorded parameters (Table 1.3a). The fertilizer means values across genotypes revealed that all the recorded parameters were significantly affected by the fertilizer combinations. All the fertilizer combinations produced superior values for recorded parameters over control. The addition of potassium along with 100 and 150 kg N ha$^{-1}$ did not produce statistically higher values for plant height. However, its impacts were more visible for seed cotton yield. The maximum plant height, boll weight, and seed cotton yield were recorded from 150 kg N and 150 Kg K ha$^{-1}$. However, the highest No. of bolls were achieved from 100 kg N and 100 kg K ha$^{-1}$ (Table 1.3b). The addition of equal proportion of nitrogen and potassium (100-100 kg ha$^{-1}$) seems to be better option for harvesting higher yield. The genotype means across fertilizer combination demonstrated significant differences in plant height, boll weight, and seed cotton yield. The genotype *Bt*. Cyto-541 produced significantly higher boll weight and seed cotton yield. The higher yield of *Bt*. Cyto-541 is mainly attributed due to its higher boll size. In contrast, the plant height and No. of bolls were higher in *Bt*. CIM-975 over *Bt*. Cyto-541 (Table 1.3c).

**Table 1.3a Effect of various levels of nitrogen and potassium on plant height, yield and yield components of various genotypes**

| Genotypes | Fertilizer (N-K kg ha$^{-1}$) | Plant height (cm) | No. of bolls (Plant$^{-1}$) | Boll weight (g) | Seed cotton yield (kg ha$^{-1}$) |
|---|---|---|---|---|---|
| *Bt.* CIM-975 | 0-0 | 144.7 | 21.0 | 1.97 | 1728.5 |
| | 100-0 | 156.0 | 23.8 | 1.99 | 1971.5 |
| | 100-50 | 155.8 | 26.7 | 2.00 | 2233.1 |
| | 100-100 | 158.3 | 28.4 | 2.02 | 2391.9 |
| | 150-0 | 151.7 | 22.7 | 2.05 | 1934.1 |
| | 150-75 | 159.3 | 25.3 | 2.07 | 2195.7 |
| | 150-150 | 162.7 | 26.9 | 2.08 | 2345.2 |
| *Bt.* Cyto-541 | 0-0 | 136.7 | 21.1 | 2.80 | 2476.0 |
| | 100-0 | 146.3 | 23.5 | 2.83 | 2775.0 |
| | 100-50 | 149.9 | 25.0 | 2.84 | 2961.9 |
| | 100-100 | 151.7 | 26.0 | 2.86 | 3092.7 |
| | 150-0 | 145.7 | 24.3 | 2.86 | 2905.8 |
| | 150-75 | 148.0 | 25.9 | 2.87 | 3102.0 |
| | 150-150 | 153.3 | 26.5 | 2.88 | 3167.4 |
| LSD 5% | | NS | NS | NS | NS |

**Table 1.3b Effect of various levels of nitrogen and potassium on plant height, yield and yield components across genotypes**

| Fertilizer (N-K kg ha$^{-1}$) | Plant height (cm) | No. of bolls (Plant$^{-1}$) | Boll weight (g) | Seed cotton yield (kg ha$^{-1}$) |
|---|---|---|---|---|
| 0-0 | 140.7 C | 21.1 C | 2.39 D | 2102.3 B |
| 100-0 | 151.2 AB | 23.6 BC | 2.41 CD | 2373.2 AB |
| 100-50 | 152.8 AB | 25.9 AB | 2.42 B-D | 2597.5 A |
| 100-100 | 155.0 AB | 27.2 A | 2.44 A-C | 2742.3 A |
| 150-0 | 148.7 BC | 23.5 BC | 2.46 A-C | 2420.0 AB |
| 150-75 | 153.7 AB | 25.6 AB | 2.47 AB | 2648.9 A |
| 150-150 | 158.0 A | 26.7 AB | 2.48 A | 2756.3 A |
| LSD 5% | 8.49 | 3.50 | 0.05 | 418.72 |

The values presented by various letters significantly differ at 5% probability level

**Table 1.3c. Effect of various genotypes on plant height, yield and yield components across fertilizer level**

| Genotypes | Plant height (cm) | No. of bolls ($Plant^{-1}$) | Boll weight (g) | Seed cotton yield (kg $ha^{-1}$) |
|---|---|---|---|---|
| *Bt*. CIM-975 | 155.5 A | 25.0 | 2.03 B | 2114.3 B |
| *Bt*. Cyto-541 | 147.4 B | 24.6 | 2.85 A | 2925.8 A |
| LSD 5% | 5.89 | NS | 0.04 | 367.23 |

The values presented by various letters significantly differ at 5% probability level

## 1.4 Yield response to residues management and tillage systems in cotton-wheat cropping system

The significant biomass of the wheat-cotton cropping system is produced in addition to grains and seed cotton yield. This biomass is rich in many nutrients which may supplement crop nutrients while decomposing in the soil. Furthermore, residue incorporation is considered one of strategies to restore soil health. However, its benefits may further depend upon the depth of tillage. Therefore, the present study aims to explore the impact of residues in combination with various tillage practices on growth and yield of crop and soil characteristics. The experiment was designed to evaluate the impact of the cotton sticks and wheat straw incorporation in combination with conventional tillage and conventional tillage + chiseling on soil health and crop yield. The treatments included were no residue incorporation ($T_1$), cotton sticks incorporation ($T_2$), cotton sticks & wheat straw incorporation ($T_3$) and wheat straw incorporation ($T_4$). The wheat straw has been incorporated at the rate of 2700 kg $ha^{-1}$ in soil along with different tillage treatments. The cotton cultivars *Bt.*CIM-990 has been sown on $19^{th}$ May 2023. The experiment was laid out according to Randomized Complete Block Design (RCBD) with split plot arrangement. The tillage practices were assigned to main plots and residues were allocated to sub-plot. The cultural practices were carried out as per the need of the crop. The plant height was measured from 05 randomly selected plants. These plants were also used for counting the No. of bolls. All the open bolls were counted, picked, and weighted for average boll weight. The whole plot was manually picked for seed cotton yield followed by weighing which was further converted on hectare basis. The composite soil samples were collected at harvesting and soil analysis was performed using standard procedure.

There was non-significant interaction between tillage practices and crop residues for all recorded parameters (Table 1.4a). The mean values of tillage across residues demonstrated significant impact on plant height, boll weight and seed cotton yield. The application of chisel plough along with conventional tillage produced statistically higher values over the conventional tillage alone (Table 1.4b). The data pertaining to the impact of crop residues is presented in table 1.4c. It shows that plant height, boll weight, and seed cotton yield were significantly affected by various residues treatments. The maximum values of these parameters were recorded in combination with cotton sticks and wheat straw residue incorporation. All the residues produced higher values over the control. There were non-significant differences for these parameters between cotton sticks alone and the combination with both wheat and cotton straw residues. The data pertaining to soil characteristics revealed that combine application of cotton sticks and wheat straw produced higher values of organic matter, available phosphorus and potassium. The lowest EC and PH values were recorded in cotton sticks and wheat straw, respectively. All the residues incorporation improved the soil health over the control (Table 1.4d).

**Table 1.4a Interactive effects of tillage and crop residues on plant height, yield and yield components**

| Tillage | Residues | Plant height (cm) | No. of bolls ($plant^{-1}$) | Boll weight (g) | Seed cotton yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|
| Chisel and conventional tillage | Cotton sticks | 118.0 | 22.7 | 2.58 | 2210.1 |
| | Cotton sticks and wheat straw | 123.2 | 23.4 | 2.60 | 2307.1 |
| | Wheat straw | 116.0 | 22.0 | 2.56 | 2119.3 |
| | No residue | 110.0 | 21.2 | 2.55 | 1990.8 |
| Conventional tillage | Cotton sticks | 111.2 | 21.6 | 2.55 | 2091.3 |
| | Cotton sticks and wheat straw | 122.6 | 22.8 | 2.56 | 2207.7 |
| | Wheat straw | 101.0 | 20.6 | 2.54 | 2001.4 |
| | No residue | 96.0 | 20.4 | 2.52 | 1916.4 |
| LSD 5% | | NS | NS | NS | NS |

**Table 1.4b Effects of tillage practices on plant height, yield and yield components**

| Tillage | Plant height (cm) | No. of bolls ($plant^{-1}$) | Boll weight (g) | Seed cotton yield (kg $ha^{-1}$) |
|---|---|---|---|---|
| Chisel and conventional tillage | 116.8 a | 22.3 | 2.57 a | 2156.9 a |
| Conventional tillage | 107.7 b | 21.3 | 2.54 b | 2054.2 b |
| LSD 5% | 6.98 | Ns | 0.003 | 79.00 |

The values represented by different letters are statistically significant at 5% probability level

**Table 1.4c Effects of crop residues on plant height, yield and yield components**

| Residues | Plant height (cm) | No. of bolls ($plant^{-1}$) | Boll weight (g) | Seed cotton yield (kg $ha^{-1}$) |
|---|---|---|---|---|
| Cotton sticks | 114.6 ab | 22.2 | 2.57 ab | 2150.7 ab |
| Cotton sticks and wheat straw | 122.9 a | 23.1 | 2.58 a | 2257.4 a |
| Wheat straw | 108.5 bc | 21.3 | 2.55 bc | 2060.4 bc |
| No residue | 103.0 c | 20.8 | 2.54 c | 1953.6 c |
| LSD 5% | 8.86 | Ns | 0.01 | 152.3 |

The values represented by different letters are statistically significant at 5% probability level

**Table 1.4d Soil analysis**

| Residues incorporation | Texture | Saturation (%) | EC ($dsm^{-1}$) | pH | Organic matter (%) | Available phosphorus (mg $kg^{-1}$) | Available potassium (mg $kg^{-1}$) |
|---|---|---|---|---|---|---|---|
| Cotton sticks | Loam | 40.7 | 3.70 | 8.02 | 0.85 | 8.10 | 261.2 |
| Cotton sticks and wheat straw | Loam | 40.8 | 3.78 | 8.01 | 0.88 | 8.28 | 273.6 |
| Wheat straw | Loam | 40.4 | 3.83 | 8.04 | 0.78 | 7.99 | 255.1 |
| No residue | Loam | 39.5 | 4.11 | 8.26 | 0.65 | 7.83 | 245.8 |

## 1.5 Optimizing the time of mepiquat chloride application in cotton at various planting geometries

Since cotton is indeterminate crop, therefore, maintaining a balance between vegetative and reproductive growth is crucial for achieving the higher yield targets. It becomes more important when crop is sown in narrow spaces. The mepiquat chloride (MC) is well known chemical growth regulator, and its application is taken as integral component of crop management. However, optimizing the time of its application especially crop planted at various geometries is crucial to harvest its potential. Therefore, this experiment was planned to investigate the impact of MC on yield improvement of various planting geometries. The experiment was laid out to evaluate the impact of time of mepiquat chloride (Control, 80 DAS, 100 DAS, and 120 DAS) on growth and yield performance of *Bt*. Cyto-535, sown at 45 cm, 60 cm and 75 cm row spaces and 10 cm, 20 cm and 30 cm plant spaces. The crop was sown on May 12, 2023. The land was prepared in dry conditions and Dual Gold (800 ml per acre) was sprayed on moist beds within 24 hours of sowing. The experiment was laid out according to Randomized Complete Block Design (RCBD) with split plot arrangement by allocating row spacing into main plot, plant spacing to sub-plot and growth regulators to the sub-sub plot. The treatments were replicated three times. All the cultural practices were carried out similarly for the all plots except treatments. The data on plant population was recorded by counting all the plants and plant height was recorded from 05 randomly selected plants. The bolls ($m^{-2}$) were recorded by counting all the open bolls from an area of one meter sq. The boll weight was recorded by picking all the bolls from five plants which were weighted and average boll weight was recorded by dividing the total weight by the total picked bolls. All the open bolls from whole plot were picked and weighted for recording seed cotton yield.

The interactive effect of row and plant spaces (RS × PS) revealed significant impact on plant population and plant height (Table 1.5a). The plant population decreased with increasing the plant spaces irrespective of row spacing. The maximum plant population was recorded with 10-cm plant spacing and 45 cm row spacing. The minimum plant population was obtained in 30-cm plant spacing and 75 cm row spacing. The plant height decreased with widening the plant spacing in 45 cm and 60 cm row spacing. However, it was initially decreased in 75 cm row spacing by increasing plant spacing from 10 cm to 20 cm, however, further increase in plant spacing from 20 cm to 30 cm produced the opposite results. The data regarding the interactive effects of row spacing and growth regulators (RS × GR) exhibited non-significant impacts on the recorded data (Table 1.5b). The data given in table 1.5c demonstrated non-significant interaction between plant spacing and growth regulators (PS × GR) for the recorded observations. It was observed that interactions among row spacings, plant spacings, and growth regulators (RS × PS × GR) were non-significant for all the recorded parameters (Table 1.5d).

The mean data of row spacing across the plant spacing and growth regulators revealed that plant population was significantly reduced by increasing the row spacing and vice versa for the plant height. The maximum No. of bolls ($m^{-2}$) and seed cotton yield was obtained in 60-cm apart rows. It was also observed that both the 45-cm and 60-cm apart rows produced higher No. of bolls and seed cotton yield in comparison with 75-cm wider rows. The boll weight was gradually improved with increasing the row spacing (Table 6.5e). The mean data of plant spacing across row spacing and growth regulators demonstrated the maximum plant population, plant height, No. of bolls ($m^{-2}$), boll weight (g) and seed cotton yield was recorded in 10 cm plant spacing. These parameters were reduced with every successive increase in plant spacing (Table 6.5f). The mean values of growth regulator across plant and row spacing indicated the significant impact on plant height, No. of bolls (m-2), and seed cotton yield. The growth regulators application reduced the plant height over control. The maximum seed cotton yield along with No. of bolls were recorded when growth regulator was applied at 120 days after sowing (DAS). The data also showed that growth regulator application at 120-DAS did not produce higher yield over control (Table 1.5g).

**Table 1.5a Interactive effects of row spacing (RS) and plant spacing (PS) on plant population, plant height, yield and yield components**

| Row spacing | Plant spacing | Plant population ($ha^{-1}$) | Plant height (cm) | No. of bolls per meter sq | Boll weight (g) | Seed cotton yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|
| 45-cm | 10-cm | 204891.9 A | 79.5 CD | 128.9 | 2.59 | 2841.6 |
| | 20-cm | 101656.9 C | 75.4 DE | 121.8 | 2.59 | 2677.6 |
| | 30-cm | 67605.2 E | 72.9 CDE | 117.0 | 2.6 | 2569.6 |
| 60-cm | 10-cm | 157593.2 B | 86.6 B | 139.7 | 2.62 | 3118.2 |
| | 20-cm | 77613.1 D | 81.2 C | 129.8 | 2.61 | 2874.6 |
| | 30-cm | 50703.9 F | 75.0 DE | 122.9 | 2.61 | 2748.4 |
| 75-cm | 10-cm | 104048.9 C | 93.2 A | 113.4 | 2.60 | 2512.6 |
| | 20-cm | 51625.8 F | 89.3 AB | 106.4 | 2.62 | 2373.4 |
| | 30-cm | 33387.3 G | 91.6 AB | 95.5 | 2.63 | 2145.2 |
| LSD 5% | | 3024.8 | 4.1403 | NS | NS | NS |

Data presented by different letters is significant at 5% probability level

**Table 1.5b Interactive effects of row spacing (RS) and growth regulators (GR) on plant population, plant height, yield and yield components**

| Row spacing | Growth regulator | Plant population ($ha^{-1}$) | Plant height (cm) | No. of bolls per meter sq | Boll weight (g) | Seed cotton yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|
| 45-cm | Control | 125133.3 | 79.3 | 116.4 | 2.58 | 2556.0 |
| | 80-DAS | 124358.1 | 70.8 | 134.1 | 2.58 | 2938.5 |
| | 100-DAS | 125133.3 | 74.0 | 124.9 | 2.61 | 2765.0 |
| | 120-DAS | 124247.4 | 79.5 | 114.9 | 2.58 | 2525.5 |
| 60-cm | Control | 95760.2 | 84.5 | 126.7 | 2.60 | 2823.7 |
| | 80-DAS | 95677.1 | 75.8 | 136.7 | 2.63 | 3066.7 |
| | 100-DAS | 95511.0 | 80.5 | 135.6 | 2.61 | 3015.5 |
| | 120-DAS | 94265.2 | 82.9 | 124.1 | 2.61 | 2748.9 |
| 75-cm | Control | 63186.8 | 95.5 | 103.1 | 2.61 | 2287.2 |
| | 80-DAS | 62921.0 | 86.8 | 111.1 | 2.61 | 2474.4 |
| | 100-DAS | 62921.0 | 89.6 | 104.9 | 2.62 | 2346.6 |
| | 120-DAS | 63053.9 | 93.6 | 101.4 | 2.63 | 2266.6 |
| LSD 5% | | NS | NS | NS | NS | NS |

**Table 1.5c** **Interactive effects of plant spacing (PS) and growth regulators (GR) on plant population, plant height, yield and yield components**

| Plant spacing | Growth regulator | Plant population ($ha^{-1}$) | Plant height (cm) | No. of bolls per meter sq | Boll weight (g) | Seed cotton yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|
| 10-cm | Control | 155552.8 | 89.3 | 121.5 | 2.60 | 2708.5 |
| | 80-DAS | 154949.3 | 81.3 | 138.1 | 2.58 | 3042.1 |
| | 100-DAS | 156089.9 | 85.3 | 130.1 | 2.61 | 2895.3 |
| | 120-DAS | 155453.2 | 89.8 | 119.7 | 2.61 | 2650.7 |
| 20-cm | Control | 77815.2 | 85.7 | 115.9 | 2.59 | 2558.6 |
| | 80-DAS | 77272.6 | 77.3 | 126.2 | 2.62 | 2823.4 |
| | 100-DAS | 76929.3 | 80.5 | 121.6 | 2.61 | 2688.4 |
| | 120-DAS | 75844.1 | 84.3 | 113.6 | 2.60 | 2497.0 |
| 30-cm | Control | 50712.2 | 84.3 | 108.8 | 2.60 | 2399.9 |
| | 80-DAS | 50734.3 | 74.8 | 117.6 | 2.61 | 2614.2 |
| | 100-DAS | 50546.1 | 78.2 | 113.7 | 2.62 | 2543.4 |
| | 120-DAS | 50269.2 | 81.9 | 107.1 | 2.61 | 2393.4 |
| LSD 5% | | NS | NS | NS | NS | NS |

*DAS: Days After Sowing

**Table 1.5d** **Interactive effects of plant spacing (PS), row spacing (RS), and growth regulators (GR) on plant population, plant height, yield and yield components**

| Row spacing | Plant spacing | Growth regulator | Plant population ($ha^{-1}$) | Plant height (cm) | No. of bolls per meter sq | Boll weight (g) | Seed cotton yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| 45-cm | 10-cm | Control | 204642.7 | 82.0 | 120.2 | 2.59 | 2680.2 |
| | | 80-DAS | 203978.3 | 73.0 | 143.7 | 2.57 | 3135.1 |
| | | 100-DAS | 206303.8 | 77.2 | 133.1 | 2.61 | 2971.0 |
| | | 120-DAS | 204642.7 | 85.8 | 118.7 | 2.57 | 2580.1 |
| | 20-cm | Control | 102985.8 | 78.7 | 115.5 | 2.58 | 2524.2 |
| | | 80-DAS | 101656.9 | 71.4 | 131.8 | 2.60 | 2920.4 |
| | | 100-DAS | 101324.7 | 73.6 | 127.1 | 2.58 | 2775.2 |
| | | 120-DAS | 100660.3 | 77.8 | 112.6 | 2.59 | 2490.7 |
| | 30-cm | Control | 67771.3 | 77.1 | 113.4 | 2.56 | 2463.6 |
| | | 80-DAS | 67439.1 | 68.2 | 126.9 | 2.56 | 2760.0 |
| | | 100-DAS | 67771.3 | 71.2 | 114.5 | 2.63 | 2548.8 |
| | | 120-DAS | 67439.1 | 75.0 | 113.2 | 2.59 | 2505.8 |
| 60-cm | 10-cm | Control | 157966.9 | 90.2 | 132.5 | 2.63 | 2994.7 |
| | | 80-DAS | 157219.4 | 81.2 | 150.2 | 2.61 | 3360.8 |
| | | 100-DAS | 157717.8 | 86.1 | 145.0 | 2.61 | 3215.8 |
| | | 120-DAS | 157468.6 | 88.9 | 131.0 | 2.62 | 2901.6 |
| | 20-cm | Control | 78236.0 | 84.1 | 128.4 | 2.58 | 2831.0 |
| | | 80-DAS | 78734.3 | 76.0 | 135.3 | 2.64 | 3037.7 |
| | | 100-DAS | 78236.0 | 80.5 | 130.2 | 2.63 | 2890.2 |
| | | 120-DAS | 75246.1 | 84.1 | 125.2 | 2.58 | 2739.3 |
| | 30-cm | Control | 51077.6 | 79.2 | 119.3 | 2.60 | 2645.5 |
| | | 80-DAS | 51077.6 | 70.1 | 124.5 | 2.63 | 2801.7 |
| | | 100-DAS | 50579.3 | 74.8 | 131.7 | 2.60 | 2940.4 |
| | | 120-DAS | 50081.0 | 75.7 | 116.2 | 2.62 | 2605.9 |
| 75-cm | 10-cm | Control | 104048.9 | 95.8 | 111.8 | 2.57 | 2450.4 |
| | | 80-DAS | 103650.2 | 89.6 | 120.3 | 2.57 | 2630.5 |
| | | 100-DAS | 104248.2 | 92.7 | 112.2 | 2.61 | 2499.0 |
| | | 120-DAS | 104248.2 | 94.5 | 109.4 | 2.64 | 2470.4 |
| | 20-cm | Control | 52223.8 | 94.1 | 103.6 | 2.62 | 2320.7 |
| | | 80-DAS | 51426.5 | 84.6 | 111.6 | 2.63 | 2512.0 |
| | | 100-DAS | 51227.1 | 87.5 | 107.5 | 2.61 | 2399.9 |
| | | 120-DAS | 51625.8 | 91.1 | 102.9 | 2.62 | 2260.9 |
| | 30-cm | Control | 33287.7 | 96.5 | 93.8 | 2.63 | 2090.6 |
| | | 80-DAS | 33686.3 | 86.2 | 101.5 | 2.64 | 2280.8 |
| | | 100-DAS | 33287.7 | 88.7 | 94.8 | 2.63 | 2140.9 |
| | | 120-DAS | 33287.7 | 95.0 | 91.8 | 2.63 | 2068.6 |
| LSD 5% | | NS | NS | NS | NS | NS | NS |

*DAS: Days After Sowing

**Table 1.5e Effects of row spacing (RS) on plant population, plant height, yield and yield components**

| Row spacing | Plant population ($ha^{-1}$) | Plant height (cm) | No. of bolls per meter sq | Boll weight (g) | Seed cotton yield ($kg\ ha^{-1}$) |
|---|---|---|---|---|---|
| 45-cm | 124718.0 A | 75.9 B | 122.6 B | 2.59 B | 2696.3 B |
| 60-cm | 95303.4 B | 80.9 B | 130.8 A | 2.61 A | 2913.7 A |
| 75-cm | 63020.7 C | 91.4 A | 105.1 C | 2.62 A | 2343.7 C |
| LSD 5% | 1093.0 | 5.2899 | 7.067 | 0.003 | 110.33 |

Data presented by different letters is significant at 5% probability level

**Table 1.5f Effects of plant spacing (PS) on plant population, plant height, yield and components**

| Plant spacing | Plant population ($ha^{-1}$) | Plant height (cm) | No. of bolls per meter sq | Boll weight (g) | Seed cotton yield ($kg\ ha^{-1}$) |
|---|---|---|---|---|---|
| 10-cm | 155511.3 A | 86.4 A | 127.3 A | 2.60 | 2824.1 A |
| 20-cm | 76965.3 B | 82.0 B | 119.3 B | 2.61 | 2641.8 B |
| 30-cm | 50565.5 C | 79.8 B | 111.8 C | 2.61 | 2487.7 C |
| LSD 5% | 1746.3 | 2.39 | 3.9081 | NS | 70.364 |

Data presented by different letters is significant at 5% probability level *DAS: Days after sowing

**Table 1.5g Effects of growth regulators (GR) on plant population, plant height, yield and components**

| Growth Regulator | Plant population ($ha^{-1}$) | Plant height (cm) | No. of bolls per meter sq | Boll weight (g) | Seed cotton yield ($kg\ ha^{-1}$) |
|---|---|---|---|---|---|
| Control | 94693.4 | 86.4 A | 115.4 B | 2.60 | 2555.7 B |
| 80-DAS | 94318.7 | 77.8 C | 127.3 A | 2.61 | 2826.6 A |
| 100-DAS | 94521.8 | 81.4 B | 121.8 A | 2.61 | 2709.0 C |
| 120-DAS | 93855.5 | 85.3 A | 113.5 B | 2.61 | 2513.7 C |
| LSD 5% | NS | 3.1765 | 6.1550 | NS | 81.917 |

Data presented by different letters is significant at 5% probability level *DAS: Days after sowing

## 1.6 Agro-economic feasibility for cotton based intercropping systems.

The cotton genotype *Bt*.Cyto-535 was sown on 25th May 2023 to evaluate the impact of various intercrops including mung bean (AZRI-06) and sesame (T-6). The experimental design was Randomized Complete Block Design. The net plot size was 32 ft x 100 ft. Bed-furrows were prepared after land preparation in dry condition by employing 60 cm distance in rows. Cotton delinted seeds and intercrops' seed were sown at 15 cm and 10.0 cm plant to plant distance respectively by dibbling method followed by irrigation. Dual Gold 960 EC @ 2 L per hectare was sprayed after sowing on moist beds. Nitrogen at the rate of 150 kg $ha^{-1}$ was applied in three split doses. Other cultural practices and plant protection measures were adopted as per the need of the crop. The data on plant height, number of bolls and boll weight were recorded before final picking. Five plants were randomly selected for plant height and number of bolls per plant. All the bolls from three randomly selected plants were counted, picked and weighed. The average boll weight was measured by dividing the total seed cotton with the total number of bolls. The whole plot for different intercrops along with cotton and control (cotton alone) was manually harvested and seed cotton & inter crop yield weights were converted on hectare basis. The data on plant height, number of bolls, boll weight, intercrop yield and seed cotton yield are given in Table 1.6 and 1.6 (a).

**Table 1.6 Impact of different intercrops on plant height, number of bolls, boll weight and seed cotton yield**

| Intercrops | Plant height (cm) | Bolls per plant | Boll weight (g) | Seed cotton yield ($Kg\ ha^{-1}$) |
|---|---|---|---|---|
| Cotton alone | 89.2 | 7.0 | 2.95 | 1531 |
| Cotton + Mung bean | 98.3 | 10.2 | 3.08 | 1153 |
| Cotton + Sesame | 107.8 | 11.3 | 3.20 | 1340 |
| C.D.5% | 2.189 | 0.471 | 0.030 | 43.175 |

The data presented in Table 1.6 (a) revealed that among all the treatments, the maximum plant height, boll numbers and boll weight per plant were observed in cotton + sesame while maxiumum seed cotton yield was obtained in cotton alone treatment. In comparison with other intercrop treatments, cotton alone produced 14.0% and 33.0% higher seed cotton yield as compared to cotton + sesame and cotton + mung bean intercrops, respectively. The cotton alone produced significantly higher seed cotton yield as compared to all other treatments. As far as the economic returns of intercrops are concerned, cotton + sesame intercrop produced the highest economic returns exhibiting the yields of (1340 & 498 kg $ha^{-1}$

respectively) with the highest income of (Rs. 284,750/- + Rs. 174,300/- respectively) as compared to other treatments under study. However, as far as the performance of different treatment is concerned, cotton + sesame produced 72.0% and 117.0% high income as compared to cotton + mung bean and cotton alone, respectively.

**Table 1.6 (a) Impact of different intercropping on economic returns**

| Intercrops | Seed cotton yield (Kg ha$^{-1}$) | Intercrop yield (Kg ha$^{-1}$) | Income (Rs. ha$^{-1}$) | | Total income (Rs. ha$^{-1}$) | Cost (Rs. ha$^{-1}$) | | Total cost (Rs. ha$^{-1}$) | Net Income |
|---|---|---|---|---|---|---|---|---|---|
| | | | Cotton | Intercrops | | Cotton | Intercrops | | |
| Cotton alone | 1531 | - | 325338 | - | 325338 | 202983 | - | 202983 | 122355 |
| Cotton + Mung bean | 1153 | 416 | 245013 | 83200 | 328213 | 101492 | 65000 | 166492 | 161721 |
| Cotton + Sesame | 1340 | 498 | 284750 | 174300 | 459050 | 101492 | 80000 | 181492 | 277558 |

## 1.7 Internship

Agronomy Section provided research facilities to one Ph.D. scholar from faculty of Agricultural Science and Technology, Bahauddin Zakariya University. In addition, this facility was extended to ten students of B.Sc. (Hons.) Agriculture (Agronomy) from different universities across Pakistan. These students participated in ongoing research activities and availed internship training under the supervision of experts.

## 1.8 Cost of production of one acre cotton for the year 2023-24 is given below

| Sr. No. | Operations and Inputs | Number/ Quantity | Rate (Rs) | Amount (Rs.) |
|---|---|---|---|---|
| 1 | Seedbed Preparation | | | **10350.00** |
| | a) Cultivation (Ploughing + planking) | 3 | 1500/cultivation | 4500.00 |
| | b) Leveling | 1 | 1500/leveling | 1500.00 |
| | c) Bed and furrow making | 1 | 2000/acre | 2000.00 |
| | d) Pre-emergence Weedicides | 800ml | 2200/800 ml | 2200.00 |
| | e) Bund making | 1 | 150/acre | 150.00 |
| 2 | Seed | | | **4216.00** |
| | a. Cost | 8 kg. | 20000/40 kg | 4000.00 |
| | b. Transportation | - | 80/40 kg | 16.00 |
| | c. Delinting | - | 1000/40 kg | 200.00 |
| 3 | Sowing | 2 men day | 965/man day | **1930.00** |
| 4 | Thinning | 2 men day | 965/man day | **1930.00** |
| 5 | Interculturing and earthing up | 4 | 1500/acre | **6000.00** |
| 6 | Irrigation | | | **15993.00** |
| | a. Land preparation (3 hours) | 2/3 canal | | |
| | b. *Rouni* (4 hours) | 1/3 tubewell | 1300/hour of tubewell | 12133.00 |
| | c. Post planting irrigation (21hours) | | | |
| | d. Cleaning of water channel and labour charges for irrigation | 4 men day | 965/man day | 3860.00 |
| 7 | *Abiana* (Water rates) | - | 150/acre | **150.00** |
| 8 | Fertilizer | | | **22285.00** |
| | a. DAP (Di-Amonium Phosphate) | 1 bag | 12300/bag | 12300.00 |
| | b. Urea | 3.0 bags | 2900/bag | 8700.00 |
| | c. Transportation | 4.0 bags | 80/bag | 320.00 |
| | d. Fertilizer Application Charges | 1man day | 965/day | 965.00 |
| 9 | Plant Protection | | | **11600.00** |
| | a. Sucking | 4 | 2200/spray | 8800.00 |
| | b. Bollworm | 2 | 1400/spray | 2800.00 |
| 10 | Harvesting (Picking charges) | 900 Kg | 30.0/kg | **27000.00** |
| 11 | Stick Cutting | 2 men day | 965/man day | +1930.00 |
| | Value of cotton sticks | | | -1930.00 |
| 12 | Managerial Charges for 1 acre | 7 months | 35000/month/100 acre | **2450.00** |
| 13 | Land Rent | 7 months | 55,000/acre/annum | **32083.00** |
| 14 | Unforeseen Expenses | - | 4000/acre | **4000.00** |

| | | | | |
|---|---|---|---|---|
| 15 | Production Expenditure<br>a. Including Land Rent<br>b. Excluding Land Rent | - | - | <br>**139987.00**<br>**107904.00** |
| 16 | Mark-up on Investment<br>a. Including Land Rent<br>b. Excluding Land Rent | 7 months | 22% for one year | <br>**30797.00**<br>**23739.00** |
| 17 | Total Expenditure<br>a. Including Land Rent<br>b. Excluding Land Rent | -- | | <br>**170784.00**<br>**131643.00** |
| 18 | Income of Seed Cotton | 900 kg | 8500/40 kg | **191250. 00** |
| 19 | Market expenses | 900 kg | 200/40 kg | **4500. 00** |
| 20 | Cost of Production at Farm level<br>a. Including Land Rent<br>b. Excluding Land Rent | - | Per 40 kg | <br>**7590.00**<br>**5851.00** |
| 21 | Cost of production at Market<br>a. Including Land Rent.<br>b. Excluding Land Rent. | - | Per 40 kg | <br>**7790.00**<br>**6051.00** |

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## 2. PLANT BREEDING & GENETICS SECTION

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

The promising hybrids, *Bt.* and the non-*Bt*. strains (in coded form) of all the cotton breeders of the country were evaluated under National Coordinated Variety Testing (NCVT) Program of Pakistan Central Cotton Committee. The prominent commercial varieties (*Bt.* and non-*Bt.*) were also tested for their performance under the local agro-climatic conditions of Multan zone in standard varietal trials. Exotic varieties were tested against local varieties to compare their yield performances. The breeding materials in different filial generations were screened out for selection into next generation. Major emphasis was laid on the selection of material having resistance/tolerance against biotic (Cotton Leaf Curl Virus (CLCuV), Pink bollworm etc and abiotic factors (tolerance against heat-drought and weedicides etc.) with excellent fibre characteristics. The genetic stock of World Cotton collections comprising of 6243 cultivars of four cultivated species of *Gossypium* genus from 41 countries of the World are being preserved for short (25 years), medium (50 years) and long (100 years) duration as well as for utilization in breeding program by cotton breeders in the country and abroad. Promising lines e.g., *Bt*.CIM-990 was tested for 2$^{nd}$ year while *Bt*.CIM-762 was tested for 1$^{st}$ year in NCVT during 2023-24. Trainings were also imparted to small farmers, progressive growers from core and non-core zones of the cotton belts along with technical staffs of different seed companies. Students from different universities were also trained through internship training program. Summary is given 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-793 to *Bt.*CIM-801, were evaluated against a commercial variety *Bt.*CIM-663 at CCRI, Multan. Data on seed cotton yield and other parameters are given in Table 2.1. The strain *Bt.*CIM-797 produced the highest seed cotton yield of 2477 kg ha$^{-1}$ followed by *Bt.*CIM-794 having yield 2281 kg ha$^{-1}$ while the standard variety *Bt.*CIM-663 yielded 2020 kg ha$^{-1}$.

The new strain *Bt.*CIM-800 produced the highest lint percentage of 42.9 followed by *Bt.*CIM-801 having lint percentage values of 41.4 compared with the standard *Bt.*CIM-663 i.e. 41.0 (Table 2.1). The new strain *Bt.*CIM-795 produced the maximum staple of 29.3mm, followed by *Bt.*CIM-794 with 28.9mm while the standard *Bt.*CIM-663 produced 27.4 mm of staple length (Table 2.1). All the new strains possess desirable micronaire value ranging from 3.9 to 4.5 in comparison to *Bt.*CIM-663 with 4.0. The fiber strength of all the new strains and standard are in the desirable range i.e. 26.6 to 28.3 g tex$^{-1}$ (Table 2.1). The boll weight of all the tested strains ranged between 2.8 to 3.0gm against the value 2.8gm of commercial variety Bt.CIM-663 while the maximum plant population was reported in Bt.CIM-799 i.e. 29953 followed by Bt.CIM-801 (29714)

**Table 2.1.Performance of Advanced Strains in Varietal Trial-1 at CCRI, Multan**

| Sr. # | Strains | Seedcotton Yield (kg ha$^{-1}$) | Lint (% age) | Staple length (mm) | Micro-naire value | Fibre strength (g tex$^{-1}$) | Av. boll wt. (g) | Plant Pop. (ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1. | *Bt*.CIM-793 | 2145 | 38.6 | 28.6 | 4.0 | 27.8 | 3.0 | 27089 |
| 2. | *Bt*.CIM-794 | 2281 | 40.9 | 28.9 | 3.9 | 27.1 | 3.0 | 28282 |
| 3. | *Bt*.CIM-795 | 1601 | 38.4 | 29.3 | 4.5 | 28.1 | 2.8 | 24583 |
| 4. | *Bt*.CIM-796 | 2182 | 40.1 | 28.1 | 3.9 | 27.3 | 2.8 | 24105 |
| 5. | *Bt*.CIM-797 | 2477 | 38.5 | 28.7 | 4.0 | 27.8 | 2.9 | 28521 |
| 6. | *Bt*.CIM-798 | 2272 | 38.8 | 28.0 | 4.5 | 26.6 | 3.0 | 23031 |
| 7. | *Bt*.CIM-799 | 2173 | 41.0 | 27.6 | 4.5 | 27.0 | 3.0 | 29953 |
| 8. | *Bt*.CIM-800 | 2198 | 42.9 | 28.5 | 4.4 | 27.7 | 2.9 | 28640 |
| 9. | *Bt*.CIM-801 | 2121 | 41.4 | 28.8 | 4.0 | 28.3 | 2.9 | 29714 |
| 10. | *Bt*.CIM-663 | 2020 | 41.0 | 27.4 | 4.0 | 26.8 | 2.8 | 30907 |

Sowing Date 19.05.2023; CD (5%) for seed cotton; Strains= 245.65; CV %= 11.75

### 2.1.2 Varietal Trial-2

**Objective: Testing and evaluation of promising strains with high ginning out turn for the Development of commercial varieties**

Nine new strains with medium-long staple viz., *Bt*.CIM-783, *Bt*.CIM-784, *Bt*.CIM-787, *Bt*.CIM-803, *Bt*.CIM-806, *Bt*.CIM-814, *Bt*.CIM-815, *Bt*.CIM-816 and *Bt*.CIM-817 were tested at CCRI, Multan against a commercial variety *Bt*.CIM-663. Data presented in **Table 2.2** showed that the new strain *Bt*.CIM-783 produced the highest seed cotton yield of 2371 kg $ha^{-1}$, followed by *Bt*.CIM-784 with 2351 kg $ha^{-1}$ while the standard varieties *Bt*.CIM-663 produced 1384 kgha-$^{1}$.

The strain *Bt*.CIM-803 had the highest lint percentage of 43.8 followed by 42.1 % of *Bt*.CIM-783 in comparison to the commercial variety *Bt*.CIM-663 produced 41.4 lint percentages. The strain *Bt*.CIM-806 produced the longest staple of 29.0 mm followed by *Bt*.CIM-803 having 28.8 mm (Table 2.2) while the standard *Bt*.CIM-663 produced 26.9 mm staple length. All the strains possess desirable micronaire value ranging from 3.8 to 4.8. The fibre strength of the strains ranged from 26.0 to 29.7 g.$tex^{-1}$ (Table 2.2). The boll weight of all the tested strains ranged between 2.9 to 3.9g against the value 2.9g of commercial variety *Bt*.CIM-663 while the maximum plant population was reported in *Bt*.CIM-803 i.e. 31025 followed by *Bt*.CIM-806 and *Bt*.CIM-816 (30845).

**Table 2.2 Performance of Advanced Strains in Varietal Trial-2**

| Sr. # | Strains | Seedcotton Yield (kg $ha^{-1}$) | Lint (% age) | Staple length (mm) | Micro-naire value | Fibre strength (g $tex^{-1}$) | Av. boll wt. (g) | Plant Pop. ($ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1 | *Bt*.CIM-783 | 2371 | 42.1 | 28.3 | 4.3 | 28.2 | 2.9 | 23134 |
| 2 | *Bt*.CIM-784 | 2351 | 39.3 | 28.1 | 4.5 | 28.2 | 3.0 | 26272 |
| 3 | *Bt*.CIM-787 | 2217 | 40.1 | 28.5 | 4.4 | 29.1 | 3.3 | 27886 |
| 4 | *Bt*.CIM-803 | 2064 | 43.8 | 28.8 | 4.3 | 29.4 | 3.2 | 31025 |
| 5 | *Bt*.CIM-806 | 1769 | 42.0 | 29.0 | 4.5 | 29.7 | 3.9 | 30845 |
| 6 | *Bt*.CIM-814 | 1295 | 37.9 | 28.3 | 3.8 | 29.3 | 3.5 | 19458 |
| 7 | *Bt*.CIM-815 | 1304 | 41.4 | 28.4 | 4.8 | 28.7 | 3.1 | 28962 |
| 8 | *Bt*.CIM-816 | 1628 | 41.1 | 28.7 | 4.7 | 28.9 | 3.3 | 30845 |
| 9 | *Bt*.CIM-817 | 1335 | 40.9 | 27.7 | 4.7 | 28.1 | 3.1 | 28245 |
| 10 | *Bt*.CIM-663 | 1384 | 41.4 | 26.9 | 4.8 | 26.0 | 2.9 | 33356 |

Sowing Date 17.05.2023; CD (5%) for seed cotton; Strains= 255.948; CV %= 8.356

### 2.1.3 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 *Bt*.CIM-807, *Bt.*CIM-808, *Bt*.CIM-809, *Bt.*CIM-810, *Bt*.CIM-811, *Bt.*CIM-812, *Bt*.CIM-813 were evaluated against a commercial variety *Bt.*CIM-663 at CCRI, Multan. Data on seed cotton yield and other parameters are given in Table 2.3. The strain *Bt*.CIM-807 produced the highest seed cotton yield of 2012 kg $ha^{-1}$ followed by *Bt*.CIM-809 having yield of 1968 kg $ha^{-1}$ while the standard *Bt.*CIM-663 produced yield of 1727 kg $ha^{-1}$. (Table 2.3).

**Table 2.3. Performance of Advanced Strains in Varietal Trial-3**

| Sr. # | Strains | Seedcotton Yield (kg $ha^{-1}$) | Lint (% age) | Staple length (mm) | Micro-naire value | Fibre strength (g $tex^{-1}$) | Av. boll wt. (g) | Plant Pop. ($ha^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1 | *Bt.*CIM-807 | 2012 | 41.5 | 28.9 | 3.9 | 28.9 | 2.9 | 33128 |
| 2 | *Bt.*CIM-808 | 1802 | 44.0 | 27.3 | 4.9 | 25.6 | 2.5 | 29411 |
| 3 | *Bt.*CIM-809 | 1968 | 42.6 | 27.9 | 4.5 | 27.0 | 3.0 | 34114 |
| 4 | *Bt.*CIM-810 | 1735 | 42.3 | 27.6 | 4.2 | 26.2 | 2.9 | 30411 |
| 5 | *Bt.*CIM-811 | 1622 | 39.3 | 27.1 | 3.8 | 25.7 | 2.4 | 27680 |
| 6 | *Bt.*CIM-812 | 1859 | 38.9 | 28.3 | 3.5 | 27.2 | 2.4 | 32038 |
| 7 | *Bt.*CIM-813 | 1918 | 42.6 | 28.7 | 4.1 | 27.8 | 2.6 | 34563 |
| 8 | *Bt.*CIM-663 | 1727 | 39.6 | 26.5 | 4.3 | 26.1 | 2.5 | 29721 |

Sowing Date 23.05.2023; CD (5%) for seed cotton; Strains= 150.6; CV %= 4.70

The strain *Bt*.CIM-808 produced the highest lint %age of 44.0, followed by *Bt*.CIM-809 and *Bt*.CIM-813 having lint percentage value of 42.6 while the standard *Bt*.CIM-663 produced 39.6 % lint percentage. *Bt.*CIM-807 produced the longest staple of 28.9 mm, followed by *Bt*.CIM-813 with 28.7 mm while the standards *Bt*.CIM-663 produced 26.5 mm staple length (Table 2.3).

All new strains possess desirable micronaire values ranging from 3.9 to 4.9 except *Bt*.CIM-812 and *Bt*.CIM-811. The fibre strength of all the new strains and standard is in the range of 25.6 to 28.9 g/tex. The maximum boll weight of 3.0 grams was found in strain *Bt*.CIM-809 followed by *Bt*.CIM-810 of 2.9 grams while the standards *Bt.*CIM-663 having 2.5 grams boll weight. Maximum plant population was shown by strain *Bt*.CIM-813 34563 per hectare followed by *Bt*.CIM-809 (34114) while the standard *Bt.*CIM-663 having population of 29721 (Table 2.3).

### 2.1.4 Varietal Trial-4

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

Seven medium staple promising *Bt.* Strains *Bt.*CIM-758, *Bt*.CIM-759, *Bt*.CIM-762, *Bt*.CIM-778, *Bt*.CIM-781, *Bt*.CIM-782 and *Bt*.CIM-792 are evaluated against a commercial variety *Bt*.CIM-663 at CCRI, Multan. Data on seed cotton yield and other parameters are given in Table 2.4. The strain *Bt.*CIM-781 produced the highest seed cotton yield of 2189 kg ha$^{-1}$ followed by *Bt*.CIM-782 having yield of 2153 kg ha$^{-1}$ while standard *Bt.*CIM-663 produced 1921 kg ha$^{-1}$ yield (Table 2.4).

**Table 2.4 Performance of Advanced Strains in Varietal Trial-4 at CCRI, Multan.**

| Sr. # | Strains | Seedcotton Yield (kg ha$^{-1}$) | Lint (% age) | Staple length (mm) | Micro-naire value | Fibre strength (g tex$^{-1}$) | Av. boll wt. (g) | Plant Pop. (ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1 | *Bt*.CIM-758 | 1969 | 37.5 | 27.5 | 4.0 | 28.7 | 3.7 | 29714 |
| 2 | *Bt*.CIM-759 | 2088 | 38.0 | 28.0 | 4.0 | 28.4 | 3.6 | 28759 |
| 3 | *Bt*.CIM-778 | 1933 | 42.8 | 28.2 | 4.4 | 26.3 | 3.6 | 33771 |
| 4 | *Bt*.CIM-762 | 2076 | 42.7 | 28.7 | 4.1 | 28.9 | 3.5 | 30669 |
| 5 | *Bt*.CIM-792 | 2088 | 41.5 | 27.9 | 4.7 | 25.4 | 3.8 | 33413 |
| 6 | *Bt*.CIM-781 | 2189 | 43.2 | 28.9 | 4.1 | 29.0 | 3.9 | 34122 |
| 7 | *Bt*.CIM-782 | 2153 | 43.6 | 28.5 | 4.1 | 29.3 | 4.0 | 33549 |
| 8 | *Bt*.CIM-663 | 1921 | 43.0 | 27.8 | 4.7 | 26.0 | 3.8 | 23867 |

* Sowing Date= 24.05.2023; CV = 6.7%; CD (5%) for seed cotton= 148.73

The new strains *Bt*.CIM-782 produced the highest lint percentage of 43.6 followed by *Bt.*CIM-781 having lint percentage value of 43.2 against the commercial variety *Bt*.CIM-663 i.e. 43.0 (Table 2.4). The new strains *Bt*.CIM-781 produced the longest staple of 28.9 mm, followed by *Bt.*CIM-762 with 28.7 mm while the standard *Bt.*CIM-663 produced 27.8 mm staple length (Table 2.4). All the new strains possess desirable micronaire values ranging from 4.0 to 4.7 including the standard *Bt*.CIM-663. The fibre strength of all the new strains and standard is also in the desirable range i.e. 25.4 to 29.3. (Table 2.4). The maximum boll weight was found in *Bt*.CIM-782 (4.0g) followed by *Bt*.CIM-781 (3.9g) against the commercial variety *Bt*.CIM-663, (3.8). The maximum plant population was observed in *Bt*.CIM-781 (34122) followed by *Bt*.CIM-778 i.e. 33771 (Table 2.4).

### 2.2.1 Micro Varietal Trial-1

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

Nine newly bulked strains numbering from MV-1/23 to MV-9/23 were tested against a commercial variety *Bt.*CIM-663 at CCRI, Multan. The strain MV-6/23 surpassed all the strains and standard variety in seed cotton yield by producing 3276 kg ha$^{-1}$ followed by MV-2/23 with 3270kg ha$^{-1}$ compared with 2696 kg ha$^{-1}$ of *Bt.*CIM-663 (Table 2.5). The strain MV-1/23 produced the highest GOT of 42.4% followed by 42.0 percent in MV-9/23 while the commercial variety *Bt*.CIM-663 produced the GOT of 41.1%. The strain MV-8/23 produced the longest staple of 28.5 mm, followed by 28.4 mm in MV-6/23 compared with the fibre length of 27.6 mm in commercial variety *Bt.*CIM-663. Micronaire values of all the strains are in acceptable limit. The strain MV-2/23 maintained the maximum fibre strength of 28.9 g/tex, followed by 28.6 g/tex in MV-8/23 while standard *Bt.*CIM-663 had 28.1 g/tex. The maximum boll weight 3.1 grams was shown by MV-3/23 while the maximum plant population 35508 plants per hectare was observed in MV-7/23.

**Table 2.5 Performance of Advanced Strains in Micro Varietal Trial-1 at CCRI, Multan**

| Sr. # | Strains | Seedcotton Yield (kg ha$^{-1}$) | Lint (% age) | Staple length (mm) | Micro-naire value | Fibre strength (g tex$^{-1}$) | Av. boll wt. (g) | Plant Pop. (ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1 | MV-1/23 | 3156 | 42.4 | 27.8 | 4.6 | 27.4 | 2.9 | 30666 |
| 2 | MV-2/23 | 3270 | 41.8 | 28.0 | 4.2 | 28.9 | 2.9 | 25107 |
| 3 | MV-3/23 | 2091 | 40.9 | 28.1 | 3.9 | 26.5 | 3.1 | 32818 |
| 4 | MV-4/23 | 3110 | 40.2 | 28.1 | 4.1 | 26.3 | 3.0 | 27259 |
| 5 | MV-5/23 | 3219 | 39.6 | 28.2 | 4.4 | 27.8 | 2.9 | 23134 |
| 6 | MV-6/23 | 3276 | 38.4 | 28.4 | 4.2 | 27.0 | 2.9 | 31921 |
| 7 | MV-7/23 | 3083 | 39.6 | 28.3 | 4.4 | 27.5 | 2.9 | 35508 |
| 8 | MV-8/23 | 3092 | 40.8 | 28.5 | 4.3 | 28.6 | 3.0 | 24031 |
| 9 | MV-9/23 | 2895 | 42.0 | 28.0 | 4.6 | 28.0 | 2.9 | 31025 |
| 10 | CIM-663 | 2696 | 41.1 | 27.6 | 4.1 | 28.1 | 2.8 | 32280 |

Sowing Date 19-05-2023; CD (5%) for seed cotton; Strains= 374.08; CV %= 14.14

### 2.2.2 Micro Varietal Trial-2

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

Nine newly bulked strains numbering from MV-10/23 to MV-18/23 were tested against a commercial variety *Bt*.CIM-663 at CCRI, Multan. The new strain MV-16/23 surpassed all the strains and standard variety in seed cotton yield by producing 2679 kg ha$^{-1}$, followed by MV-11/23 with 2144 kg ha$^{-1}$ compared with 1983 kg ha$^{-1}$ of *Bt.*CIM-678 (Table 2.6). The strain MV-16/23 produced the highest lint percentage of 43.8 followed by 42.4 percent lint in MV-14/23 while the commercial variety *Bt*.CIM-663 produced the lint percentage of 41.9. The strain MV-16/23 produced the longest staple of 29.3 mm, followed by 28.8 mm in MV-17/23 compared with the fibre length of 26.6 mm in commercial variety *Bt*.CIM-663. All the strains have desirable micronaire while fiber strength values are also in desirable range. The maximum boll weight 3.7 grams was shown by MV-16/23 while the maximum plant population 42323 plants per hectare was observed in MV-17/23 and MV-18/23.

**Table 2.6 Performance of Advanced Strains in Micro-Varietal Trial-2 at CCRI, Multan**

| Sr. # | Strains | Seedcotton Yield (kg ha$^{-1}$) | Lint (% age) | Staple length (mm) | Micro-naire value | Fibre strength (g tex$^{-1}$) | Av. boll wt. (g) | Plant Pop. (ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1 | MV-10/23 | 2060 | 41.0 | 28.0 | 4.0 | 28.8 | 2.9 | 40529 |
| 2 | MV-11/23 | 2144 | 40.9 | 28.0 | 4.6 | 28.0 | 3.2 | 28693 |
| 3 | MV-12/23 | 2133 | 41.5 | 27.7 | 4.6 | 29.0 | 3.6 | 38377 |
| 4 | MV-13/23 | 1833 | 39.3 | 28.3 | 4.6 | 28.9 | 3.5 | 39633 |
| 5 | MV-14/23 | 1705 | 42.4 | 28.6 | 4.8 | 28.9 | 3.2 | 32101 |
| 6 | MV-15/23 | 2019 | 42.1 | 28.6 | 4.9 | 29.0 | 2.6 | 34970 |
| 7 | MV-16/23 | 2679 | 43.8 | 29.3 | 4.3 | 29.4 | 3.7 | 39095 |
| 8 | MV-17/23 | 1795 | 41.6 | 28.8 | 4.3 | 28.8 | 3.5 | 42323 |
| 9 | MV-18/23 | 1733 | 39.6 | 28.1 | 4.3 | 28.3 | 3.4 | 42323 |
| 10 | CIM-663 | 1983 | 41.9 | 26.6 | 4.8 | 27.8 | 3.2 | 39095 |

Sowing Date 17.05.2023; CD (5%) for seed cotton= 314.960; CV %= 9.07

### 2.2.3 Micro Varietal Trial-3

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

Seven newly bulked strains numbering from MV-19/23 to MV-25/23 were tested against a commercial variety *Bt.*CIM-663 at CCRI, Multan. Data presented in Table 2.7 indicated that the new strain MV-20/23 surpassed all the new strains yielding 2087 kg. ha$^{-1}$ followed by strain MV-19/23 produced 1995 kg ha$^{-1}$ while the standard *Bt.*CIM-663 yielding 1673 kg ha$^{-1}$.

The new strain MV-21/23 produced the lint percentage of 46.7 followed by MV-22/23 with 44.2 % in comparison to *Bt.*CIM-663 having 40.0 lint percentage. The strain MV-23/23 has the longest staple of 29.1 mm followed by MV-20/23 with the staple of 28.8 mm compared with the staple length of 26.7 mm in standard variety *Bt.*CIM-663. All the genotypes have desirable micronaire value except MV-23/23 and the fineness of standard CIM-663 is 4.4. All the strains were showing fibre strengths ranging from 27.2 to 30.2 g tex$^{-1}$. The maximum boll weight was shown by strain MV-20/23 as 3.1 grams followed by MV-21/23 having 3.0 grams while the standards *Bt.*CIM-663 having 2.5 grams boll weight. The maximum plant population was shown by strain MV-19/23 of 35921 per hectare followed by MV-20/23 having 34101 while the standards *Bt.*CIM-663 having population of 28458 per hectare (Table 2.7).

**Table 2.7 Performance of Advanced Strains in Micro-Varietal Trial-3 at CCRI, Multan**

| Sr. # | Strains | Seed Cotton yield (kg ha$^{-1}$) | Lint (% age) | Staple Length (mm) | Micro naire value | Fibre Strength (g tex$^{-1}$) | Av. boll weight (g) | Plant Pop. (ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1 | MV-19/23 | 1995 | 39.5 | 27.5 | 4.2 | 27.2 | 2.7 | 35921 |
| 2 | MV-20/23 | 2087 | 43.8 | 28.8 | 4.0 | 28.5 | 3.1 | 34101 |
| 3 | MV-21/23 | 1830 | 46.7 | 27.7 | 4.3 | 27.8 | 3.0 | 32079 |
| 4 | MV-22/23 | 1541 | 44.2 | 27.3 | 4.0 | 27.8 | 2.4 | 29052 |
| 5 | MV-23/23 | 1690 | 41.9 | 29.1 | 3.6 | 30.2 | 2.6 | 28335 |
| 6 | MV-24/23 | 1755 | 43.3 | 27.4 | 4.4 | 28.4 | 2.6 | 27076 |
| 7 | MV-25/23 | 1494 | 40.1 | 27.1 | 3.9 | 29.8 | 2.4 | 25824 |
| 8 | Bt.CIM-663 | 1673 | 40.0 | 26.7 | 4.4 | 26.7 | 2.5 | 28458 |

Sowing Date= 16.05.2023; CD (5%) for seed cotton= 257.38; CV%= 8.42

### 2.2.4 Micro-Varietal Trial-4

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

Nine newly bulked elite *Bt.* strains from MV-26/23 to MV-34/23 were tested against a commercial variety *Bt.*CIM-663 at CCRI, Multan. Data on yield and other parameters are presented in Table 2.8. The strain MV-30/23 out-yielded all the strains and standard variety by producing 2477 kg ha$^{-1}$ seed cotton, followed by MV-31/23 having seed cotton yields of 2413 kgha$^{-1}$ against commercial variety *Bt.*CIM-663 which produced 2323 kg ha$^{-1}$. The strain MV-34/23 produced the higher lint percentage of 43.0 followed by MV-26/23 with 42.8% compared with that of 40.4% by *Bt.*CIM-663. The strain MV-28/23 produced the longest staple of 28.8 mm, followed by the 28.4 mm of strain MV-30/23 compared with the 27.7 mm of *Bt.*CIM-663. All the strains have desirable micronaire values ranging from 4.0 to 4.7 except MV-33/23 which is 5.1. The fibre strength of all the new strains was observed within the range i.e. 27.3 to 29.2. Maximum boll weight 3.1 grams was shown by MV-26/23 and MV-32/23 (Table 2.8). The maximum plant population 35203 plants per hectare was observed in MV-34/23.

**Table 2.8 Performance of advanced strains in Micro-Varietal Trial-4 at CCRI, Multan**

| Sr.# | Strains | Seedcotton Yield (kg ha$^{-1}$) | Lint (% age) | Staple Length (mm) | Micro naire value | Fibre Strength (g/tex) | Av. boll weight (g) | Plant Pop. (ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1 | MV-26/23 | 2149 | 42.8 | 27.8 | 4.6 | 28.5 | 3.1 | 27327 |
| 2 | MV-27/23 | 2388 | 42.0 | 28.0 | 4.5 | 27.8 | 3.0 | 29237 |
| 3 | MV-28/23 | 1699 | 40.9 | 28.8 | 4.1 | 28.9 | 2.9 | 26134 |
| 4 | MV-29/23 | 2235 | 39.6 | 28.3 | 4.2 | 28.5 | 3.0 | 27447 |
| 5 | MV-30/23 | 2477 | 40.1 | 28.4 | 4.0 | 29.2 | 3.0 | 27208 |
| 6 | MV-31/23 | 2413 | 40.7 | 27.8 | 4.2 | 28.8 | 3.0 | 31027 |
| 7 | MV-32/23 | 2287 | 40.7 | 28.1 | 4.6 | 28.4 | 3.1 | 29595 |
| 8 | MV-33/23 | 2358 | 42.1 | 27.5 | 5.1 | 28.0 | 3.0 | 28401 |
| 9 | MV-34/23 | 2187 | 43.0 | 27.7 | 4.3 | 27.3 | 3.0 | 35203 |
| 10 | *Bt*.CIM-663 | 2323 | 40.4 | 27.7 | 4.7 | 27.6 | 2.8 | 20764 |

Sowing Date 19.05.2023; CD (5%) for seed cotton= 210.65; CV %= 8.18

## 2.3 Coordinated Variety Testing Program

### 2.3.1 National Coordinated Varietal Trials (Set-B)

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

Twenty-four strains from different cotton breeders of the country were received under coded numbers from Director Research PCCC for evaluation at CCRI, Multan. The data presented in Table 2.9 showed that the KZ-181 produced the highest seed cotton yield of 2138 kg ha$^{-1}$, followed by CEMB-Tech-Pak having 2013 kg ha$^{-1}$ seed cotton yield while Babar-GTG-155 produced lowest yield 744 kg ha$^{-1}$. Data also revealed that the strain Cyto-545 produced the highest lint percentage of 42.0, followed by MNH-Sultan with 41.9%. Strain CAPTIAN-200 produced the longest staple with 28.5 mm length followed by CIM-600 (Std) with 28.4 mm and the lowest staple length 24.7 was reported in IUB-23. All strains have micronaire values ranging from 3.5 to 5.1. Maximum fibre strength was maintained by VH-447 having 30.0 g tex$^{-1}$, followed by CKC-3 (Std) with 28.5 g tex$^{-1}$. The maximum boll weight 3.1 grams was shown by CRIS-697 (Table 2.9). The maximum plant population 40208 plants per hectare was observed in BH-227.

**Table 2.9 Performance of different Bt. Strains in National Coordinated Varietal Trial (Set-B) at CCRI, Multan**

| Sr. # | Strains | Seedcotton Yield (kg ha$^{-1}$) | Lint (% age) | Staple length (mm) | Micro-naire value | Fibre strength (g tex$^{-1}$) | Av. boll wt. (g) | Plant Pop. (ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1 | BH-227 | 1528 | 40.6 | 24.8 | 4.5 | 22.8 | 2.5 | 40208 |
| 2 | CAPTIAN-200 | 2008 | 41.3 | 28.5 | 4.0 | 28.4 | 2.8 | 37695 |
| 3 | CEMB-Tech-Pak | 2013 | 41.1 | 27.7 | 3.9 | 27.8 | 3.0 | 38054 |
| 4 | CRIS-697 | 1198 | 39.9 | 26.2 | 4.0 | 24.9 | 3.1 | 39370 |
| 5 | CIM-600 (Std) | 1786 | 38.6 | 28.4 | 3.8 | 28.3 | 3.0 | 39849 |
| 6 | Cyto-545 | 1842 | 42.0 | 26.5 | 4.9 | 23.6 | 3.0 | 36857 |
| 7 | FBG-Platinum | 1692 | 38.8 | 27.6 | 4.8 | 26.9 | 2.6 | 39969 |
| 8 | FH-1133 | 1663 | 41.5 | 26.0 | 5.1 | 24.0 | 2.8 | 39131 |
| 9 | Inqalab-101 | 1699 | 40.8 | 27.3 | 4.1 | 27.4 | 2.9 | 37815 |
| 10 | CKC-3 (Std) | 1876 | 40.7 | 28.0 | 4.3 | 28.5 | 2.4 | 36139 |
| 11 | IUB-23 | 944 | 41.8 | 24.7 | 4.3 | 23.4 | 2.7 | 33028 |
| 12 | ISQ-White-Gold | 1739 | 41.6 | 27.6 | 4.2 | 28.4 | 2.4 | 39729 |
| 13 | KZ-181 | 2138 | 41.8 | 27.6 | 4.2 | 27.4 | 2.8 | 39729 |
| 14 | MNH-Sultan | 1870 | 41.9 | 26.3 | 5.2 | 23.4 | 2.8 | 38174 |
| 15 | SS-32 | 1754 | 40.6 | 27.1 | 4.9 | 26.8 | 2.7 | 37097 |
| 16 | NIAB-868 | 1767 | 40.2 | 28.1 | 4.0 | 28.3 | 2.6 | 39251 |
| 17 | Sahara-500 | 1660 | 40.4 | 27.2 | 4.6 | 26.8 | 2.9 | 38413 |
| 18 | SAS-3 | 1820 | 41.0 | 28.0 | 3.5 | 27.6 | 2.7 | 37695 |
| 19 | SS-102 | 1741 | 39.7 | 26.9 | 3.8 | 26.3 | 2.8 | 37575 |
| 20 | Tara-340 | 1805 | 41.0 | 28.2 | 4.5 | 28.1 | 2.8 | 39011 |
| 21 | VH-447 | 1458 | 41.7 | 27.0 | 3.8 | 30.0 | 2.9 | 38174 |
| 22 | YBG-2626 | 1746 | 40.8 | 26.2 | 4.1 | 25.0 | 2.8 | 38533 |
| 23 | Babar-GTG-155 | 744 | 41.0 | 27.1 | 4.0 | 27.2 | 2.7 | 37575 |
| 24 | SLH-94 | 1479 | 40.3 | 27.1 | 4.4 | 26.1 | 2.7 | 39011 |

Sowing date: 15.05.2023

## 2.4 Testing of Commercial Varieties

### 2.4.1 Standard Varietal Trial-1

**Objective: To test the performance of commercial varieties (Non GMO) of CCRI, Multan under the agro-climatic conditions of Multan.**

Seven commercial Non *Bt.* varieties of the CCRI, Multan were tested at CCRI, Multan. Data recorded on seed cotton yield and other parameters are presented in Table 2.10. The results indicated that varieties Cyto-124 excelled among all varieties by producing seed cotton yield 2032 kg ha$^{-1}$ followed by CIM-610 with 2030 kg ha$^{-1}$ seed cotton production. Variety Cyto-124 had the highest lint percentage of 39.6, followed by CIM-610 having lint percentage of 39.3 The variety CIM-482 maintained the staple length of 27.4 mm, followed by CIM-610 with 26.6 mm staple length. Micronaire values of all the varieties were according to the standard except CIM-610. Fibre strength of all the genotypes was in the desirable range while maximum boll weight 2.9 grams was shown by CIM-608. The maximum plant population 33535 plants per hectare was observed in CIM-608 (Table 2.10).

**Table 2.10 Performance of commercial varieties in Standard Varietal Trial-I at CCRI, Multan**

| Sr. # | Varieties | Year of released | Seed Cotton Yield (kg ha$^{-1}$) | Lint (% age) | Staple length (mm) | Micro-naire value | Fibre Strength (g tex$^{-1}$) | Av. Boll wt. (g) | Plant Pop. (ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | CIM-496 | 2005 | 1957 | 38.7 | 24.7 | 4.9 | 24.7 | 2.8 | 27259 |
| 2 | CIM-573 | 2012 | 1871 | 39.0 | 26.0 | 3.9 | 27.3 | 2.6 | 24748 |
| 3 | CIM-482 | 2000 | 1761 | 38.3 | 27.4 | 4.2 | 28.3 | 2.8 | 31383 |
| 4 | CIM-608 | 2013 | 1833 | 39.1 | 25.8 | 3.9 | 26.7 | 2.9 | 33535 |
| 5 | CIM-610 | 2018 | 2030 | 39.3 | 26.6 | 3.8 | 27.6 | 2.7 | 27976 |
| 6 | CIM-620 | 2016 | 1801 | 38.3 | 26.3 | 4.4 | 27.3 | 2.6 | 31204 |
| 7 | Cyto-124 | 2015 | 2032 | 39.6 | 26.4 | 4.1 | 27.8 | 2.8 | 28514 |

Sowing date= 19.05.2023; CD (5%) for seed cotton= 288.35; CV%= 8.90

### 2.4.2. Standard Varietal Trial-2

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

Eight *Bt.* commercial varieties of the CCRI, Multan were tested at CCRI, Multan. Data recorded on seed cotton yield and other parameters are presented in **Table 2.11**. The results indicated that variety *Bt.*Cyto-535 excelled among all varieties by producing seed cotton yield of 2409 kg ha$^{-1}$, followed by the variety *Bt.*CIM-343 with 2352 kg ha$^{-1}$ while *Bt.*CIM-785 produced lowest (1422) seed cotton production. *Bt*.CIM 678 had the highest GOT% of 45.4, followed by *Bt.*CIM-343 showing 44.6%. Longest staple length of 27.1 was observed in *Bt*.CIM-598. Micronaire and fiber strength of all the varieties were up to the standard. Maximum boll weight 3.0 grams was shown by Bt.Cyto-535. The maximum plant population 38779 plants/ha observed in Bt.CIM-343.

**Table 2.11 Performance of commercial varieties in Standard Varietal Trial-2 at CCRI, Multan**

| Sr. # | Strains | SeedCotton Yield (kg ha$^{-1}$) | Lint (% age) | Staple Length (mm) | Micro-naire Value | Fiber Strength (g tex$^{-1}$) | Av. Boll weight (g) | Plant Pop. (ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|
| 1. | *Bt.*Cyto-535 | 2409 | 40.6 | 27.0 | 4.5 | 27.9 | 3.0 | 34116 |
| 2. | *Bt.*CIM-663 | 2016 | 40.6 | 25.1 | 4.3 | 25.7 | 2.9 | 37523 |
| 3. | *Bt.*CIM-678 | 1834 | 45.4 | 25.2 | 3.7 | 26.2 | 2.3 | 36268 |
| 4. | *Bt.*CIM-785 | 1422 | 42.0 | 25.4 | 4.8 | 25.7 | 2.6 | 29453 |
| 5. | *Bt.*CIM-600 | 1830 | 38.7 | 26.1 | 3.8 | 27.1 | 2.3 | 33757 |
| 6. | *Bt.*CIM-343 | 2352 | 44.6 | 25.8 | 4.0 | 26.9 | 2.1 | 38779 |
| 7. | *Bt.*Cyto-537 | 1825 | 41.5 | 26.2 | 5.1 | 25.1 | 2.9 | 37703 |
| 8. | *Bt.*CIM-598 | 1574 | 42.3 | 27.1 | 4.1 | 28.2 | 2.3 | 30171 |

Sowing date= 16.05.2023; CD (5%) for seed cotton= 302.97; CV%= 9.07

## 2.5 Breeding Material

### 2.5.1 Selection from Breeding Material

Single plants were selected from the filial generation in different segregating populations for further testing and screening against biotic and abiotic stresses. Furthermore, single plants were also selected from advanced breeding materials i.e. Varietal, Micro-varietal Trials and Early generation Seed Production genotypes for the purpose of purifying. The details of breeding material planted and number of plants selected during 2023-24 are given in Table 2.12.

**Table 2.12 Details of single plants selected from breeding material**

| Generation/Trial | No. of plants Selected | Range | |
|---|---|---|---|
| | | Lint (%age) | Staple length (mm) |
| VT | 289 | 37.8-42.5 | 28.4-30.1 |
| MVT | 395 | 39.4-42.7 | 28.3-30.9 |
| $F_6$ single lines | 675 | 37.2-43.2 | 27.2-29.2 |
| $F_5$ single lines | 810 | 38.0-42.2 | 27.2-30.2 |
| $F_4$ generation | 1451 | 38.5-42.1 | 28.7-30.1 |
| $F_3$ generation | 1536 | 37.2-41.5 | 27.1-30.2 |
| $F_2$ generation | 2317 | 36.9-41.3 | 27.6 - 29.9 |
| Others | 513 | 37.3-43.2 | 27.4-31.7 |

### 2.5.2. Hybridization program

Detail of the crossing program of the Section for the development of breeding material to evolve cotton varieties of high yield potential equipped with desirable fibre traits and wider adoptability along with inbuilt resistance/tolerance against insect-pest and weedicides. Details are given in Table 2.14 to 2.18.

**Table-2.14 Cross Reference Chart of $F_1$ Hb-1 of Breeding and Genetics Section at CCRI, Multan during 2023-24**

| Hybrid No. | Parentage | Hybrid No. | Parentage |
|---|---|---|---|
| H-2294 | SS-102 x CKC-6 | H-2299 | Cyto-535 x CKC-5 |
| H-2296 | SS-32 x CKC-6 | H-2300 | CKC-6 x B-2240 |
| H-2295 | SS-32 x CKC-5 | H-2301 | CKC-5 x B-2240 |
| H-2297 | SS-102 x CKC-5 | H-2302 | CKC-3 x B-2240 |
| H-2298 | Cyto-535 x CKC-6 | H-2303 | FH-333 x CKC-6 |

**Table-2.15 Cross Reference Chart $F_1$ Hb-2 of Breeding and Genetics Section at CCRI, Multan during 2023-24**

| Hybrid No. | Parentage | Hybrid No. | Parentage |
|---|---|---|---|
| H-2303 | H-2371 x H-2240 | H-2311 | H-2378 x CM-11/23 |
| H-2304 | H-2372 x CKC-6 | H-2312 | H-2371 x CM-19/23 |
| H-2305 | H-2373 x CIM-790 | | |
| H-2306 | H-2373 x CIM-791 (Big Boll) | H-2313 | H-2372 x Cyto-547 |
| H-2307 | H-2374 x CIM-790 | H-2314 | H-2373 x H-2377 |
| H-2308 | H-2375 x H-2385 | H-2315 | CIM-651 x Cyto-547 |
| H-2309 | H-2376 x H-2377 | H-2316 | CIM-651 x H-2373 |
| H-2310 | H-2377 x Okara Leaf | H-2317 | CIM-651 x Okara Leaf |

**Table-2.16 Cross Reference Chart of $F_1$ Hb-3 of Breeding and Genetics Section at CCRI, Multan during 2023-24**

| Sr. No. | Parentage | Sr. No. | Parentage |
|---|---|---|---|
| H-2318 | Pronto X GH-Uhud | H-2329 | GH-Sanabal x G. Okra |
| H-2319 | SAS-1 x GH-Sanabal | H-2330 | FH-189 x Cyto-537 |
| H-2320 | Pronto x GH-Sultan | H-2331 | GH-Sanabal x MNH-1090 |
| H-2321 | CKC-2 x MNH-1090 | H-2332 | GH-Sultan x MNH-1090 |
| H-2322 | NIAB-868 x Cyto-537 | H-2333 | NIAB-868 x GH-Snabal |
| H-2323 | NIAB-868 x Cyto-537 | H-2334 | Cyto-533 x MNH-1090 |
| H-2324 | GH-Sanabal x GH-Hamalia | H-2335 | SAS-1 x GH-Hadi |
| H-2325 | GH-Sanabal x MNH-1090 | H-2336 | SAS-1 x GH-Sanabal |
| H-2326 | SASI x Cyto-537 | H-2337 | Cyto-535 x MNH-1090 |
| H-2327 | GH-Sanabal x MNH-1090 | H-2338 | GH-Hadi x Cyto-533 |
| H-2328 | GH-Sanabal x CIM-343 | | |

**Table-2.17 Cross Reference Chart $F_1$ Hb-3 of Breeding and Genetics Section at CCRI, Multan during 2023-24**

| Hybrid No. | Origin | Hybrid No. | Origin |
|---|---|---|---|
| H-2339 | CIM-343 x MNH-1090 | H-2344 | 431/SDK x MNH-1050 |
| H-2340 | CIM-785 x MNH-1090 | H-2345 | MNH-1050 x CIM-663 |
| H-2341 | CIM-789 x MNH-1090 | H-2346 | MNH-1090 x CIM-506 |
| H-2342 | Cyto-511 x MNH-1090 | H-2347 | MNH-1090 x Samroz-317 |
| H-2343 | CIM-663 x MNH-1050 | H-2348 | Okra x MNH-1090 |

**Table-2.18 Cross Reference Chart $F_1$ Hb-5 of Breeding and Genetics Section at CCRI, Multan during 2023-24**

| Hybrid No. | Origin | Hybrid No. | Origin |
|---|---|---|---|
| H-2349 | CIM-632 x CKC6 | H-2354 | CIM-990 x FH-333 |
| H-2350 | CKC3 x 2240 | H-2355 | CIM-995 x FH333 |
| H-2351 | CIM-632 x FH-333 | H-2356 | CKC6 x C-22 |
| H-2352 | MNH-1090 x CKC3 | H-2357 | SLAD-115 xC-22 |
| H-2353 | CM-28 x Super Gold | H-2358 | CIM-221 x C20 |

## 2.6 Maintenance of Genetic Stock of World Cotton Collection

### 2.6.1 Maintenance/Preservation of Cotton Genetic Stock at CCRI, Multan

Six thousand two hundred and forty three genotypes are being maintained at the Gene Bank of World Cotton Germplasm of CCRI, Multan for Long (100 years), medium (50 years) and short-term (25 years). One third of the seed was planted in the field for production of fresh seed as well as to utilize in the hybridization program. Detail of genetic stock is given in Table 2.19. The seed from Gene Bank were also supplied, locally and abroad, to different scientists/students, cotton growers, academia and different institutes/research stations for their research/breeding programs. The detail is given in Table 2.19.

**Table 2.19 Detail of Gene Bank of World Cotton Germplasm**

| | |
|---|---|
| Local genotypes | 1310 |
| Exotic genotypes | 4933 |
| **Total** | **6243** |
| **Species-Wise Detail** | |
| *Gossypium herbaceum* L. | 556 |
| *Gossypium arboreum* L. | 1025 |
| *Gossypium hirsutum* L. | 4553 |
| *Gossypium barbadense* L. | 109 |
| **Total Accessions** | **6243** |

## 2.7 Comparison of exotic versus local cotton varieties at the agro-climatic condition of Multan, Pakistan.

Twelve cotton genotypes including six local and six exotic were tested in the climatic conditions of Multan. The local genotypes produced higher yields than that of the exotic genotypes. Highest yield (1754 Kg $ha^{-1}$) produced by Israr Shaheed variety of Dera Ismail Khan followed Sindh-1 (1435)of Cotton Research Institute Tandojam while all the exotic cotton varieties remained at the bottom position in term of seed cotton yield.

**Table 2.20 Comparison of exotic versus local cotton varieties at the agro-climatic condition of Multan**

| Sr. No. | Name of varieties | Name of country | Seed cotton yield (Kg $ha^{-1}$) |
|---|---|---|---|
| 1 | MNH-1035 | Pakistan (Punjab) | 1148 |
| 2 | Israr Shaheed DIK | Pakistan (K.P.) | 1754 |
| 3 | CIM-663 | Pakistan (Punjab) | 1148 |
| 4 | SLH-Chandi | Pakistan (Sindh) | 1419 |
| 5 | Sindh-1 | Pakistan (Sindh) | 1435 |
| 6 | GH-Sultan | Pakistan (Sindh) | 646 |
| 7 | USA Acala-5-918 | USA | 717 |
| 8 | USSR SA-71 | Russia | 739 |
| 9 | Turkey Carolina Queen | Turkey | 574 |
| 10 | Brazil BPA | Brazil | 857 |
| 11 | France BJA-HC-27-B/163 | France | 736 |
| 12 | Samroz-317 | Turkey | 837 |

**Table 2.22 List of Scientists/ Researchers from whom received germplasm 2022-23**

| Name of Scientist / Research Institute | No. of Stocks |
|---|---|
| Dr. Muhammad Asif Saleem, Supervisor/Assistant Professor, Department of Plant Breeding & Genetics, Bahauddin Zakariya University, Multan. | 16 |
| Dr. Muhammad Asif Saleem, Supervisor/Assistant Professor, Department of Plant Breeding & Genetics, Bahauddin Zakariya University, Multan. | 22 |
| Mr. Farasat Raza, M.SC (Hons) Plant Pathology, B.Z. University, Multan. | 06 |
| The Chairman, Department of Agriculture, Hazara University, Mansehra. | 06 |
| Dr. Babar Hussain, Assistant Professor, Department of Biotechnology, University of Central Punjab, Near Shaukat Khanum Hospital, Lahore. | 13 |
| **Total Accessions** | **63** |

**Table 2.23 List of Scientists/Researchers from whom received (Abroad) the Cotton Germplasm 2023-24**

| | |
|---|---|
| Dr. Paul S Saidia (Ph.D) Centre Director Tari Ukiriguru Tanzania Agriculture Research Institute, Tanzania. | **35** |

## 2.7 Early Generation Seed Production of Commercial Varieties

Single lines of *Bt. and non Bt.* approved varieties were sown at the experimental Farm of Central Cotton Research Institute, Multan. All the agronomic practices and plant protection measures were not followed up to the standard protocol due to financial constraints. Therefore very limited quantities of pre-basic and basic seed were procured. Single plants were also selected from pure and uniform families. These single plants were ginned for further fibre traits testing and multiplication of pure seed. The selected plants will be sown next year. The details about pre-basic and basic seed develop in this trial are given in Table 2.23.

**Table 2.23 Detail of pre-basic seed produced during 2023-24**

| Sr. # | Variety | Total Families | Seed weight (Kg) |
|---|---|---|---|
| 1 | *Bt*.CIM-632 | 39 | 22 |
| 2 | *Bt*.CIM-785 | 26 | 70 |
| 3 | *Bt*.CIM-678 | 39 | 75 |
| 4 | *Bt*.CIM-602 | 26 | 36 |
| 5 | *Bt*.CIM-600 | 26 | 31 |
| 6 | CIM-554 | 13 | 06 |
| 7 | CIM-620 | 13 | 05 |
| 8 | CIM-610 | 13 | 06 |

## 2.8 Study of gene flow in Cotton Crop.

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

## 2.9 Pak-US ICARDA Cotton Project CCRI Multan Component

## 2.10 Ratooning of resistant/tolerant USA cotton germplasm for flower induction

44 accessions of US germplasm were ratooned for the last 6-8 years at the research farm CCRI, Multan. Out of these, 44 accessions square formation and flower induction were started in only a few accessions in December 2023 as detailed in Table 2.24. In Set-D accessions USG-1087/13 one boll was formed. While in Set K only one accession USG-618/14 having flowers and bolls formations were observed. In Set N in only one accession i.e. USG-2269/14 buds formation and flower induction were observed. The seed formed in all bolls were found non-viable due to the harsh climatic conditions of this year.

**Table 2.24 Ratoon Crop of Resistant Accessions of 2023-24 having bud and flower formation**

| Sr. No. | Set No. | Year | No of total Accessions | Resistant accessions | Accessions having buds and flower formation |
|---|---|---|---|---|---|
| 1. | C | 2013 | 200 | 03 | 0 |
| 2. | D | 2013 | 200 | 09 | 04 |
| 3. | K | 2014 | 200 | 03 | 01 |
| 4. | N | 2014 | 600 | 25 | 01 |
| | | **Total** | **1200** | **40** | **06** |

Besides the above facts, Plant Breeding and Genetics were made successes in developing high yielding strains i.e. *Bt.*CIM-762 ($I^{st}$ year) and *Bt*.CIM-990 ($2^{nd}$ year) that were tested in NCVT of Pakistan Central Cotton Committee trails and both of the above two new strains Bt. CIM-990 and Bt.CIM-762 surpassed the standard varieties in respect of seed cotton yield..

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## 3. CYTOGENETICS SECTION

The main objectives of cytogenetic section are:

- Maintenance of wild *Gossypium* germplasm.
- Transferring desirable genes of the wild species to the cultivated cotton for commercial exploitation.
- Karyotypic study of developed inter and intra-specific hybrids.
- Development of long-staple interspecific cultivars with good economic traits.

### 3.1 Maintenance of *Gossypium* Germplasm

Twenty-two species of *Gossypium* genus (cultivated and wild) are being maintained in living herbarium at CCRI, Multan for exploitation in hybridization program. The list is given below.

**Table 3.1 List of wild species maintained at CCRI, Multan during 2023-24**

| Sr. No. | Species Name | Genome | Habit |
|---|---|---|---|
| 1 | *G. hirsutum* L. | AD1 | Cultivated |
| 2 | *G. barbadense* L. | AD2 | Cultivated |
| 3 | *G. tomentosum* | AD3 | Wild |
| 4 | *G. herbaceum* L. | A1 | Cultivated |
| 5 | *G. arboreum* L. | A2 | Cultivated |
| 6 | *G. anomalum* | B1 | Wild |
| 7 | *G. capitis-viridis* | B4 | Wild |
| 8 | *G. sturtianum* | C1 | Wild |
| 9 | *G. australe* | C3 | Wild |
| 10 | *G. thurberi* | D1 | Wild |
| 11 | *G. harknessii* | D2-2 | Wild |
| 12 | *G. klotzschianum* | D3-k | Wild |
| 13 | *G. aridum* | D4 | Wild |
| 14 | *G. gossypioides* | D6 | Wild |
| 15 | *G. lobatum* | D7 | Wild |
| 16 | *G. laxum* | D8 | Wild |
| 17 | *G. stocksii* | E1 | Wild |
| 18 | *G. somalense* | E2 | Wild |
| 19 | *G. areysianum* | E3 | Wild |
| 20 | *G. incanum* | E4 | Wild |
| 21 | *G. longicalyx* | F1 | Wild |
| 22 | *G. bickii* | G1 | Wild |

In addition, twenty-six interspecific hybrids (4 diploids, 6 triploids, 3 tetraploids, 4 pentaploids and 5 hexaploid interspecific hybrids) and 4 tri species combinations are also maintained. (Table 3.2).

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

| Sr. No. | Interspecific Hybrids | No |
|---|---|---|
| 1 | Diploid hybrids | 4 |
| 2 | Triploid | 6 |
| 3 | Tetraploid | 3 |
| 4 | Pentaploid | 4 |
| 5 | Hexaploid | 5 |
| 6 | Tri-species combinations | 4 |
| **Total** | | **26** |

**A. Through Seed**

For the strengthening of *Gossypium* species in living herbarium at CCRI, Multan; seeds of twelve wild species were germinated in an incubator at 28 ± 2ºC and then shifted in earthen pots in glass house. The list of species is given in (Table 3.3).

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

| Sr. No. | Name of Species | No. of seeds planted | No. of seeds germinated |
|---|---|---|---|
| 1 | *G. arboreum* | 10 | 4 |
| 2 | *G. anomalum* | 15 | 6 |
| 3 | *G. capitis-viridis* | 8 | 4 |
| 4 | *G. thurberi* | 19 | 6 |
| 5 | *G. harknessii* | 11 | 2 |

| | | | |
|---|---|---|---|
| 6 | *G. stocksii* | 24 | 6 |
| 7 | *G. somalense* | 13 | 4 |
| 8 | *G. longicalyx* | 16 | 2 |
| 9 | *G. bickii* | 24 | 5 |
| 10 | *G. herbaceum* (Red) | 15 | 3 |
| 11 | *G. herbaceum* (Green) | 15 | 5 |
| 12 | *G. barbadense* | 10 | 2 |
| **Total** | | **355** | **49** |

### B. Through Approach Grafting

Approach grafting has been utilized to maintain the already existing wild species. The detail is given below:

**Table 3.4 List of wild Species and interspecific hybrids maintained through approach grafting**

| Sr. No. | Name of species | No. of Grafts |
|---|---|---|
| 1 | *G. herbaceum (red)* | 10 |
| 2 | *G.capitis veridis* | 6 |
| 3 | *G. lobatum* | 4 |
| 4 | *G. laxum* | 4 |
| 5 | *G. gossipoides* | 7 |
| 6 | *G. longicalyx* | 9 |
| 7 | *G. bickii* | 7 |
| 8 | *G. incanum* | 5 |
| 9 | *G. somalense* | 4 |
| 10 | *G. tomentosum* | 7 |
| 11 | *G. stocksii* | 4 |
| 12 | *G. anomalum* | 8 |
| 13 | *G. areysianum* | 5 |
| 14 | *2(G. arbo. X G. somalense)* 2n | 8 |
| 15 | *(G. hirs. X G. arbo.)* 3n | 7 |
| 16 | *2(G. hirs. X G. ano.)* X *G. barba.4*n | 9 |
| 17 | *G. barba* X *2(G. arbo. X G. stockii) 5*n | 6 |
| 18 | *G. barba* X *2(G. arbo. X G. stockii) 6*n | 4 |
| **Total** | | **114** |

**Fig. 1: Wild species and interspecific hybrids maintained through approach grafting**

### C. Through Cutting

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

**Table 3.5 List of species/hybrids maintained through cuttings**

| Sr. No. | Name of species | No. of Cuttings |
|---|---|---|
| 1 | *G. herbacium* (Red) | 10 |
| 2 | *G. herbacium* (Green) | 1 |
| 3 | *G. barbadense* | 18 |
| 4 | *G. aridum* | 15 |
| 5 | *G. gossypioides* | 08 |
| 6 | *G. captis viridis* | 08 |
| 7 | *G. laxum* | 10 |
| 8 | *G. stocksii* | 10 |
| 9 | *G. laxum* | 21 |
| 10 | *G. lanceolatum* | 11 |
| 11 | *G. areysianum* | 07 |
| 12 | *G. lobatum* | 08 |
| 13 | *G. tomentosum* | 10 |
| 14 | *G. anomalum* | 11 |
| 15 | *G. harknessii* | 16 |
| 16 | *G. klotzschianum* | 13 |
| 17 | *2(G.hirsutum* x *G.anomalum)* | 10 |
| 18 | *2(G.hirsutum* x *G.anomalum)* x *G.barbadense* (5n) | 11 |
| 19 | *2(G.arbo.* x *G.anomalum)* x *G.hirsutum* (5n) | 11 |
| 20 | *2(G.hir.* x *G.stocksii) (*6n) | 10 |
| 21 | *2(G.arbo.* x *G.anomalum)* x *G.hirsutum* (4n) | 12 |
| 22 | *2(G.arbo.* x *G.somalense)* (4n) | 15 |
| 23 | *2(G.hir.* x *G.anomalum)* (3n) | 10 |
| 24 | *2(G.hir.* x *G.anom.)* x *G.hir.* (5n) | 15 |
| 25 | *2(G.arbo.* x *G.anomalum)* (2n) | 22 |
| 26 | *(G. arboreum* x *G.australe)* (2n) | 10 |
| 27 | 2(*G.hir.x G. stocksii*) x *G. hirsutum* (5n) | 21 |
| 28 | 2(*G.hir.x G. anomalum*) (3n) | 22 |
| 29 | *(G.arborerum* x *G.capitis veridis)* x *G. arbo.* | 14 |
| 30 | *(G. arboreum* x *G.herbaceum)* (2n) | 14 |
| 31 | *2(G.arbo.* x *G.anomalum)* x *G. hirsutum* (4n) | 15 |
| 32 | 2(*G. hirsutum* x *G. bickii*) x *G. barba.* (6n) | 17 |
| 33 | 2(*G.arboreum .x G. stocksii*) (4n) | 12 |
| 34 | *(G.arboreum* x *G.thurberii* ) (2n) | 12 |
| 35 | *G.hirsutum* x *G.herkensii* (3n) | 12 |
| 36 | *2(G.hirsutum* x *G.stockii)* (4n) | 10 |
| 37 | *G.hirsutum* x *G.gossypiodes* (3n) | 15 |
| **Total** | | **467** |

**Fig.2 Maintenance of wild species in earthen pots inside glasshouse and field conditions 2023**

## 3.2 Chromosomal Studies

Flowering buds of *G. arboreum* (Fig. 3) treated with colchicine was studied still under microscope, no change was observed in poloidy level however, some plants are under observation. On buds formation, their chromosomal counts will be studied. Interspecific hybrids with morphological traits (Red boll, red stem and red flowers) were fixed in Carnoy's fixative preserved in 70% alcohol and screened at metaphase-1. These plants were normal tetraploid with 52 chromosomes.

**Fig. 3 *G. arboreum* MI= 26**

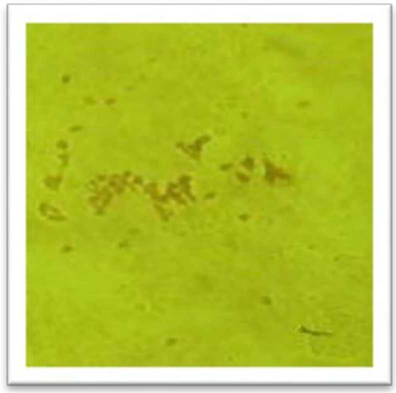

**Fig.4 Interspecific hybrid MI= 52**

### 3.3. Hybridization

Interspecific hybridizations for incorporation of valuable wild species genes for stress resistance into the cultivated cottons were undertaken according to availability of flowers during the season. For intraspecific hybridization, large number of pollinations (4323) were attempted in 100 combinations including interspecific and intraspecific crosses. The boll setting was present in 75 combinations. Boll setting could not be obtained in other combinations either due to incompatibility among different species or sterility barriers existing at pre- and post-fertilization stages in hybridization. The hormones i.e Gibberallic Acid (GA) and Nephthaline Acetic Acid (NAA) were exogenously applied at the rate of 50 and 100mg $L^{-1}$ of water respectively, after 24 hours of pollination. The application continued for 72 hours to retain the crossed bolls.

**Table-3.6 Detail of Hybridization**

| Hybridization | No. of cross combination | No. of crosses attempted |
|---|---|---|
| Intra-specific hybridization | 100 | 4013 |
| Inter-specific hybridization | 6 | 310 |

### 3.4 Selection from Breeding Material

Single plants were selected made from the Cyto breeding material in different interspecific and intraspecific segregating generations for further testing and screening against biotic and abiotic stress. The detail of breeding material planted and number of plants selected during 2023 is given in Table 3.7.

**Table 3.7 Detail of single plants selected from breeding material**

| Generation/Trial | No. of plants Selected | Range | |
|---|---|---|---|
| | | Lint (%age) | Staple length (mm) |
| VT | 311 | 38.7-41.8 | 27.9-31.6 |
| MVT | 293 | 37.9-42.3 | 28.2-29.8 |
| $F_6$ single lines | 135 | 38.4-43.6 | 28.4-31.7 |
| $F_5$ single lines | 510 | 37.9-43.1 | 28.0-32.4 |
| $F_4$ generation | 1560 | 39.5-43.7 | 27.7-30.3 |
| $F_3$ generation | 1905 | 38.4-42.9 | 28.3-31.5 |
| $F_2$ generation | 718 | 36.7-41.5 | 27.3-29.5 |

### 3.5 Performance of New Cyto-strains in Micro Varietal Trials

#### 3.5.1 Micro Varietal Trial-1

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

Six *Bt*. strains having tolerance against cotton leaf curl virus (CLCuD) viz., MV1, MV2, MV3, MV4, MV5 and MV6 were tested in replicated micro-varietal trial on a plot size of 15/ x 12/ along with Cyto-535 as standard. The performance of this material is shown in Table 3.8.

**Table 3.8 Performance of Cyto-strains in Micro Varietal Trial -1 during 2023-24**

| Strain | Yield (kg ha-1) | Plant Pop.(ha-1) | Boll weight (g) | Lint (%) | Length (mm) | Micronaire (µg inch-1) | Strength (g tex-1) |
|---|---|---|---|---|---|---|---|
| MV-1 | 2456 | 42888 | 3.0 | 37.7 | 28.2 | 4.0 | 29.3 |
| MV-2 | 2581 | 41612 | 2.7 | 40.1 | 29.2 | 4.3 | 29.7 |
| MV-3 | 1793 | 43047 | 2.7 | 38.3 | 29.1 | 4.2 | 29.0 |
| MV-4 | 2501 | 42250 | 3.2 | 41.6 | 28.1 | 4.4 | 29.2 |
| MV-5 | 2307 | 44163 | 2.8 | 40.0 | 28.9 | 4.1 | 29.3 |
| MV-6 | 2669 | 42090 | 3.1 | 40.9 | 28.5 | 4.6 | 30.7 |
| Cyto-535 | 2261 | 42888 | 3.0 | 38.3 | 28.7 | 4.0 | 29.5 |

Maximum seed cotton yield was produced by MV-6 (2669 kg ha$^{-1}$) followed by MV-2 (2581 kg ha$^{-1}$) and MV-4 (2501 kg ha$^{-1}$) compared with standard (2261 kg ha$^{-1}$) Table 3.8. The line MV-4 was found to have highest lint% (41.6%) followed by MV-6 (40.9%) compared with standard Cyto-535 (38.3%). The line MV-2 produced the medium long staple of 29.2 mm followed by MV-3 (29.1 mm) compared with 28.7 mm of Cyto-535. All the strains have desirable micronaire values ranging from 4.0 to 4.6 µg inch$^{-1}$. The maximum fibre strength (30.7 g tex$^{-1}$) was produced in MV-6 followed by MV-1 (29.3 g tex$^{-1}$) compared with 29.5 g tex$^{-1}$ of standard Cyto-535.

### 3.5.2 Micro Varietal Trial-2

**Objective: Testing of newly bulked whitefly resistant strains against commercial varieties**

Six *Bt*. strains viz., MV-7, MV-8, MV-9, MV-10, MV-11& MV-12 were tested in replicated micro-varietal trial on a plot size of 15/ x 12/ along with Cyto-535 as standard. Data presented in Table-3.9 exhibited that maximum seed cotton yield was produced by MV-11 (2885 kg ha$^{-1}$) followed by MV-7 (2746kg ha$^{-1}$) compared with Cyto-535 (2045 kg ha$^{-1}$). Maximum lint % was produced by MV-7 (42.7%) followed by MV-12 (42.2%) compared with standard Cyto-535 (38.7%). The line MV-7 produced the medium long staple of 29.4 mm followed by MV-11 (28.9 mm) compared with 28.1 mm of Cyto-535. All the strains have desirable micronaire values ranging from 3.8 to 4.5 µg inch$^{-1}$. The maximum fibre strength (30.8 g tex$^{-1}$) was produced in MV-8 followed by MV-12 (29.8 g tex$^{-1}$) compared with 29.0 g tex$^{-1}$ of standard Cyto-535.

**Table 3.9 Performance of advanced strains in Micro Varietal Trial-2 during 2023-24**

| Strain | Yield (kg ha$^{-1}$) | Plant Population (ha$^{-1}$) | Boll weight (g) | Lint (%) | Fiber Length (mm) | Micronaire (µg inch$^{-1}$) | Strength (g tex$^{-1}$) |
|---|---|---|---|---|---|---|---|
| MV-7 | 2746 | 39221 | 3.3 | 42.7 | 29.4 | 4.5 | 29.7 |
| MV-8 | 1596 | 39380 | 2.8 | 40.1 | 28.8 | 3.8 | 30.8 |
| MV-9 | 2341 | 40815 | 2.8 | 38.7 | 28.7 | 4.3 | 29.1 |
| MV-10 | 2687 | 40496 | 3.3 | 39.9 | 29.1 | 4.7 | 29.3 |
| MV-11 | 2885 | 43047 | 3.4 | 40.4 | 28.9 | 4.5 | 29.5 |
| MV-12 | 2164 | 38902 | 3.2 | 42.2 | 28.7 | 3.9 | 29.8 |
| Cyto-535 | 2045 | 42409 | 3.1 | 38.7 | 28.1 | 3.9 | 29.0 |

### 3.5.3 Micro Varietal Trial-3

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

Six new *Bt* strains having heat tolerance viz., MV-13, MV-14, MV-15, MV-16, MV-17 and MV-18 were tested in replicated micro-varietal trial on a plot size of 15/ x 12/ along with Cyto-535 as standard. Table-3.10 exhibited that maximum seed cotton yield was produced by MV-13 (2709 kg ha$^{-1}$) followed by MV-14 (2641 kg ha$^{-1}$) compared with Cyto-535 (2108 kg ha$^{-1}$). Maximum lint % produced by MV-16 (42.3%) followed by MV-17 (41.1%) compared with standard Cyto-535 (38.4%). The line MV-15 produced the medium long staple of 29.5 mm followed by MV-18 (29.4 mm) compared with 28.5 mm of Cyto-535. All the strains have desirable micronaire values ranging from 3.7 to 4.5 µg inch$^{-1}$. The maximum fibre strength was produced in MV-15 (30.0 g tex$^{-1}$) followed by MV-17 (29.9 g tex$^{-1}$) compared with 28.2 g tex$^{-1}$ of standard Cyto-535.

**Table 3.10 Performance of Cyto-strains in Micro Varietal Trial-3 during 2023-24**

| Strain | Yield (kg $ha^{-1}$) | Plant Population ($ha^{-1}$) | Boll weight (g) | Lint (%) | Fiber Length (mm) | Micronaire (µg $inch^{-1}$) | Strength (g $tex^{-1}$) |
|---|---|---|---|---|---|---|---|
| MV-13 | 2709 | 36032 | 3.3 | 39.9 | 28.7 | 4.2 | 29.2 |
| MV-14 | 2641 | 43685 | 2.8 | 39.3 | 29.1 | 3.9 | 29.5 |
| MV-15 | 2619 | 26785 | 3.6 | 39.4 | 29.5 | 3.7 | 30.0 |
| MV-16 | 2416 | 28698 | 3.0 | 42.3 | 28.9 | 4.5 | 29.7 |
| MV-17 | 2213 | 39221 | 3.2 | 41.1 | 28.8 | 4.3 | 29.9 |
| MV-18 | 2456 | 40815 | 3.0 | 40.9 | 29.4 | 4.0 | 28.5 |
| Cyto-535 | 2108 | 35235 | 3.3 | 38.4 | 28.5 | 4.6 | 28.2 |

### 3.5.4 Micro Varietal Trial-4

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

Five new *Bt* strains MV-19, MV-20, MV-21, MV-22 & MV-23 were tested in replicated micro-varietal trial on a plot size of 15' ×10' along with Cyto-179 as standard. Data presented in Table-3.11 exhibited that maximum seed cotton yield was produced by MV-20 (1574 kg $ha^{-1}$) followed by MV-19 (1435 kg $ha^{-1}$) compared with Cyto-179 (837 kg $ha^{-1}$). Maximum lint % produced by MV-21 (40.6%) followed by MV-23 (39.4%) compared with standard Cyto-179 (38.4%). The line MV-22 produced the medium long staple of 28.7 mm followed by 28.3mm of MV-23 compared with 26.7 mm of Cyto-179. All the strains have desirable micronaire values ranging from 4.0 to 4.6 µg $inch^{-1}$. The maximum fibre strength was produced in MV-20 (29.4 g $tex^{-1}$) followed by MV-19(29.1g $tex^{-1}$) respectively compared with 27.4 g $tex^{-1}$ of standard Cyto-179.

**Table 3.11 Performance of Cyto-strains in Micro Varietal Trial-4 during 2023-24**

| Strain | Yield (kg $ha^{-1}$) | Plant Population ($ha^{-1}$) | Boll weight (g) | Lint (%) | Fiber Length (mm) | Micronaire (µg $inch^{-1}$) | Strength (g $tex^{-1}$) |
|---|---|---|---|---|---|---|---|
| MV-19 | 1435 | 32290 | 2.5 | 38.7 | 27.9 | 4.2 | 29.1 |
| MV-20 | 1574 | 33725 | 2.6 | 39.2 | 28.1 | 4.0 | 29.4 |
| MV-21 | 1296 | 36596 | 2.4 | 40.6 | 28.0 | 4.4 | 28.7 |
| MV-22 | 1195 | 28702 | 2.3 | 39.0 | 28.7 | 4.6 | 28.2 |
| MV-23 | 957 | 29420 | 2.5 | 39.4 | 28.3 | 4.4 | 28.0 |
| Cyto-179 | 837 | 28702 | 2.6 | 38.4 | 26.7 | 4.3 | 27.4 |

### 3.5.5 Micro Varietal Trial-5

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

Five new *Bt* strains having heat tolerance viz., MV-24, MV-25, MV-26, MV-27, MV-28 were tested in replicated micro-varietal trial on a plot size of 15' ×10' along with Cyto-179 as standard. Data presented in Table-3.12 exhibited that maximum seed cotton yield was produced by MV-25 (1626 kg $ha^{-1}$) followed by MV-24 (1196 kg $ha^{-1}$) compared with Cyto-179 (1435 kg $ha^{-1}$). Maximum lint % was produced by MV-28 (40.7%) followed by MV-25 (39.4%) compared with standard Cyto-179 (36.2%). The line MV-27 produced the medium long staple of 29.0 mm followed by MV-24 (28.2 mm) compared with 26.7 mm of Cyto-179. All the strains have desirable micronaire values ranging from 4.0 to 4.4 µg $inch^{-1}$. The maximum fibre strength was produced by MV-28 (29.6 g $tex^{-1}$) followed by MV-25 (29.1 g $tex^{-1}$) compared with 26.7 g $tex^{-1}$ of Cyto-179.

**Table 3.12 Performance of Cyto-strains in Micro Varietal Trial 5 during 2023-24**

| Strain | Yield (kg $ha^{-1}$) | Plant Population ($ha^{-1}$) | Boll weight (g) | Lint (%) | Fiber Length (mm) | Micronaire (µg $inch^{-1}$) | Strength (g $tex^{-1}$) |
|---|---|---|---|---|---|---|---|
| MV-24 | 1196 | 33725 | 2.4 | 39.1 | 28.2 | 4.2 | 29.0 |
| MV-25 | 1626 | 32290 | 2.5 | 39.4 | 27.8 | 4.0 | 29.1 |
| MV-26 | 1135 | 27267 | 2.0 | 38.9 | 27.6 | 4.4 | 29.0 |
| MV-27 | 837 | 27985 | 1.7 | 39.2 | 29.0 | 4.1 | 29.1 |
| MV-28 | 957 | 35160 | 1.9 | 40.7 | 28.1 | 4.0 | 29.6 |
| Cyto-179 | 1435 | 30855 | 2.5 | 36.2 | 26.7 | 4.7 | 26.7 |

### 3.5.5 Micro Varietal Trial-6

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

Five new Bt strains having heat tolerance viz., MV-29, MV-30, MV-31, MV-32, MV-33 were tested in replicated micro-varietal trial on a plot size of 15'×10' along with Cyto-179 as standard. Data presented in Table-3.13 exhibited that maximum seed cotton yield was produced by MV-30 (1794 kg $ha^{-1}$) followed by MV-31 (1674 kg $ha^{-1}$) compared with Cyto-179 (1315 kg $ha^{-1}$). Maximum lint % was produced by MV-31 (39.7%) followed by MV-33 (39.5%) compared with standard Cyto-179 (36.6%). The line MV-32 produced the medium long staple of 28.9 mm followed by MV-30 (28.7 mm) compared with 27.0 mm of Cyto-179. All the strains have desirable micronaire values ranging from 4.0 to 4.7µg $inch^{-1}$. Maximum fibre strength produced by MV-33 (29.6 g $tex^{-1}$) followed by MV-29 (29.2 g $tex^{-1}$) compared with 27.4 g $tex^{-1}$ of standard Cyto-179.

**Table 3.13 Performance of Cyto-strains in Micro Varietal Trial-6 during 2023-24**

| Strain | Yield (kg $ha^{-1}$) | Plant Population ($ha^{-1}$) | Boll weight (g) | Lint (%) | Fiber Length (mm) | Micronaire (µg $inch^{-1}$) | Strength (g $tex^{-1}$) |
|---|---|---|---|---|---|---|---|
| MV-29 | 1554 | 25114 | 2.2 | 39.0 | 28.0 | 4.3 | 29.2 |
| MV-30 | 1794 | 30137 | 3.0 | 38.8 | 28.7 | 4.1 | 28.7 |
| MV-31 | 1674 | 38748 | 2.0 | 39.7 | 27.9 | 4.0 | 28.4 |
| MV-32 | 1195 | 29420 | 2.1 | 38.8 | 28.9 | 4.3 | 29.0 |
| MV-33 | 1626 | 30137 | 2.7 | 39.5 | 28.1 | 4.0 | 29.6 |
| Cyto-179 | 1315 | 25832 | 2.5 | 36.6 | 27.0 | 4.7 | 27.4 |

**Performance of New Cyto-strains in Varietal Trials**

### 3.5.6. Varietal Trial-1

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

Six *Bt*. strains having tolerance against cotton leaf curl virus (CLCuD) viz., V1, V2, V3, V4, V5 and V6 were tested in replicated varietal trial on plot size 15/ x 12/ along with Cyto-535 as standard. The performance of this material is given in Table 3.14. Data presented in Table 3.14 revealed that maximum seed cotton yield was produced by V-3 (2589 kg $ha^{-1}$) followed by V-4 (2485 kg $ha^{-1}$) compared with standard Cyto-535 (2235 kg $ha^{-1}$). Maximum lint % was produced by V-6 (42.0%) and V-3 (41.0%) compared with Cyto-535 (38.5%). The strain V-4 produced the medium long staple of 29.5 mm followed by 28.6 mm of V-1 compared with Cyto-535 (28.3 mm). All strains have desirable micronaire values ranging from 3.8 to 4.6µg $inch^{-1}$. The maximum fibre strength (30.4 g $tex^{-1}$) produced by V-2 followed by V-3 (30.0 g $tex^{-1}$) compared with 28.5 g $tex^{-1}$ of standard Cyto-535.

**Table 3.14 Performance of Cyto-strains in VT-1during 2023-24**

| Strain | Yield (kg $ha^{-1}$) | Plant population ($ha^{-1}$) | Boll wt. (g) | Lint (%) | Fiber Length (mm) | Micronaire (µg $inch^{-2}$) | Strength (g $tex^{-1}$) |
|---|---|---|---|---|---|---|---|
| V-1 | 1922 | 40018 | 3.1 | 39.1 | 28.6 | 4.5 | 29.3 |
| V-2 | 2278 | 40815 | 3.3 | 38.5 | 28.3 | 4.3 | 30.4 |
| V-3 | 2589 | 35235 | 3.2 | 41.0 | 28.0 | 3.8 | 30.0 |
| V-4 | 2485 | 40815 | 3.2 | 40.2 | 29.5 | 4.2 | 29.7 |
| V-5 | 2314 | 40177 | 3.1 | 39.9 | 28.3 | 4.6 | 30.0 |
| V-6 | 2186 | 31090 | 3.1 | 42.0 | 28.1 | 3.9 | 29.7 |
| Cyto-535 | 2235 | 40656 | 3.1 | 38.5 | 28.3 | 4.2 | 28.5 |

### 3.5.7 Varietal Trial-2

**Objective: Testing of Long staple new advanced *Bt* strains against commercial varieties**

Seven *Bt.* strains viz., V-7 to V-13 were screened in a replicated varietal trial on plot size 15' ×12.5' along with Cyto-535 as standard. The performance of this material is given in Table 3.15. Data showed that maximum seed cotton yield was produced by V-11 (3006 kg $ha^{-1}$) followed by V-7 (2833 kg $ha^{-1}$) and V-12 (2619 kg $ha^{-1}$) compared with standard Cyto-535 (2073kg $ha^{-1}$). Maximum lint % was produced by V-11 (39.4%) followed by V-9 (38.8%) compared with standard Cyto-535 (38.9%).

**Table 3.15 Performance of Cyto-strains in VT-2 during 2023-24**

| Strain | Yield (kg $ha^{-1}$) | Plant population ($ha^{-1}$) | Boll wt. (g) | Lint (%) | Fiber Length (mm) | Micronaire (µg $inch^{-1}$) | Strength (g $tex^{-1}$) |
|---|---|---|---|---|---|---|---|
| V-7 | 2833 | 30616 | 2.4 | 37.6 | 29.2 | 4.2 | 29.3 |
| V-8 | 2559 | 31382 | 2.5 | 38.1 | 28.4 | 4.5 | 30.0 |
| V-9 | 2377 | 32147 | 2.8 | 38.8 | 27.9 | 4.0 | 30.9 |
| V-10 | 1784 | 28511 | 2.5 | 38.2 | 30.3 | 4.6 | 31.5 |
| V-11 | 3006 | 26024 | 2.7 | 39.4 | 28.1 | 4.1 | 30.7 |
| V-12 | 2619 | 31765 | 2.6 | 38.1 | 29.1 | 3.9 | 30.0 |
| V-13 | 2175 | 29660 | 2.5 | 38.5 | 28.3 | 4.2 | 28.5 |
| Cyto-535 | 2073 | 27555 | 3.0 | 38.9 | 28.4 | 4.7 | 28.5 |

V-10 produced medium longest staple of 30.3 mm followed by V-7 (29.2 mm) compared with Cyto-535 (28.4 mm). All the strains have desirable micronaire values ranging from 3.9 to 4.5 µg $inch^{-1}$. The maximum fibre strength (31.5 g $tex^{-1}$) was produced by V-10 followed by V-11 (30.7 g $tex^{-1}$) in contrast to standard Cyto-535 (28.5 g $tex^{-1}$).

**Coordinated Variety Testing Program**

### 3.5.9 National Coordinated Varietal Trial (Set-A)

**Objective: Testing of promising Strains of different cotton breeders of Pakistan**

The cotton seed of twenty-four 24 strains was received from Director Research, Pakistan Central Cotton Committee (PCCC) for evaluation. Data on seed cotton production and other parameters are presented in Table 3.16. The results indicated that the strain Cyto-547 produced maximum yield of 2278 kg $ha^{-1}$ followed by Silver Queen-33 with 2081 kg $ha^{-1}$ seed cotton yield. CIM-600 produced lowest yield which is 952 kg $ha^{-1}$. The strain FH-1214 and Cyto-547 produced the highest lint percentage of 42.7%, followed by AS-85 & Silver Queen-33 with 41.6%. The strain Certus-30 produced the highest value of staple length 28.3 mm, followed by VH-461 which has staple length of 28.0mm. Most of the strains had the desirable micronaire value. The majority of the strains have values of fibre strength according to required standard.

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

| Strains | Seedcotton Yield (kg $ha^{-1}$) | Lint (%age) | Staple Length (mm) | Micronaire value | Fibre strength (g/tex) | Boll Weight | Plant Pop. ($ha^{-1}$) |
|---|---|---|---|---|---|---|---|
| AS-85 | 1910 | 41.6 | 25.4 | 4.9 | 24.9 | 2.8 | 38509 |
| BH-228 | 1427 | 38.1 | 26.0 | 3.9 | 25.0 | 2.9 | 31214 |
| CAPTAIN-300 | 1917 | 40.4 | 27.8 | 3.8 | 29.6 | 3.1 | 38031 |
| Certus-30 | 1390 | 37.7 | 28.3 | 3.9 | 29.7 | 2.4 | 33247 |
| CIM-600 (Bt. Std-II) | 952 | 34.8 | 25.8 | 3.5 | 28.8 | 1.8 | 32290 |
| CRIS-700 | 1782 | 41.0 | 25.8 | 4.6 | 26.7 | 2.2 | 40303 |
| Cyto-547 | 2278 | 42.7 | 27.8 | 4.6 | 27.6 | 2.8 | 39705 |
| FBS-SAHEEN | 1504 | 39.3 | 24.9 | 5.1 | 23.2 | 2.7 | 40423 |
| FH-1214 | 1801 | 42.7 | 23.5 | 5.1 | 21.6 | 2.4 | 38150 |
| CKC-3 (Bt. Std-1) | 1759 | 41.2 | 26.2 | 4.5 | 28.0 | 2.2 | 39107 |
| Inqalab-99 | 1703 | 41.4 | 26.3 | 4.5 | 27.4 | 2.6 | 38389 |
| IUB-04 | 1568 | 40.3 | 24.8 | 5.1 | 24.2 | 2.5 | 39825 |
| JSQ-71 | 1627 | 40.2 | 25.6 | 4.0 | 27.8 | 2.6 | 39346 |
| KZ-323 | 1975 | 40.0 | 25.1 | 5.0 | 23.1 | 2.5 | 37911 |
| SS-32 | 1429 | 39.8 | 26.1 | 4.1 | 26.1 | 2.6 | 42336 |
| MNH-Super Gold-2022 | 1746 | 38.8 | 25.5 | 5.1 | 23.4 | 2.9 | 36715 |
| NIBGE-PF-1 | 1242 | 38.1 | 27.5 | 4.5 | 28.8 | 2.5 | 38389 |
| Sahara Klean-10 | 1604 | 40.1 | 24.7 | 4.3 | 25.0 | 2.4 | 39705 |
| Silver Queen-33 | 2081 | 41.6 | 24.7 | 4.9 | 24.9 | 3.0 | 39825 |
| SS-102 | 1545 | 38.5 | 25.7 | 4.1 | 26.2 | 2.2 | 42336 |
| Super Sultan-22 | 1302 | 40.2 | 26.1 | 4.0 | 27.5 | 1.9 | 39227 |
| TARA-337 | 1367 | 41.5 | 24.3 | 5.0 | 27.9 | 2.3 | 42336 |
| VH-461 | 1204 | 39.5 | 28.0 | 4.2 | 28.5 | 2.4 | 39346 |
| YBG-2929 | 1506 | 40.1 | 25.6 | 4.0 | 30.8 | 2.4 | 40423 |

Sowing date= 15.05.2023

### 3.6. Mapping population development for Fiber Quality

**Objectives: Development of mapping population for fiber quality**

$F_4$ population was sown in the field standards agronomic and plant protection measures were applied. DNA extraction was performed from young leaves using CTAB. DNA quantification was checked using 1% gel electrophoresis and Nano-drop Spectrophotometer.

### 3.7 Early Generation Seed (EGS) System

Nineteen single lines from approved varieties of Cyto Section (Cyto-179, Cyto-533, Cyto-535, Cyto-226 and Cyto-124) were sown in the field at maturity. At maturity, single plants were selected which will be used for the production of pre-basic seed.

**Table-3.17 No of families selected in EGS**

| Variety | No of families selected |
|---|---|
| Cyto-179 | 03 |
| Cyto-545 | 02 |
| Cyto-537 | 05 |
| Cyto-535 | 07 |
| Cyto-226 | 01 |
| Cyto-124 | 01 |

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## 4. ENTOMOLOGY SECTION

The following studies were carried out on various aspects under field and laboratory conditions:

- Surveys of cotton growing areas for Pink bollworm infestation (pending, due to unavailability of funds).
- Management of Pink bollworm using attractants and different colored adhesive-cloths sheets.
- Monitoring of Lepidopterous pests with sex pheromone traps.
- Impact of cotton sowing period on sucking insect pests and their natural enemies' population tendency.
- Incidence of arthropods on light and normal green cotton leaves.
- Monitoring of insecticide resistance in cotton pests.
- National Coordinated Varietal Trials (NCVT) on *Bt* & non-*Bt* strains.
- Evaluation of foliar insecticides against sucking insect pests & bollworms.

### 4.1 Management of pink bollworm using sex-attractant and different colored adhesive-cloths sheets

The attraction of pink bollworm moths (both sexes) to green, navy-blue and black adhesive cloths and male moths to pheromone/sex traps was examined in the field. The adhesive cloth sheets of 91.44 Sq.cm each were mounted stretched about 3 feet above the ground with the help of two bamboo sticks fixed in soil. Data of moth catches were recorded at 24 hours intervals from all the traps. Sex lures in traps were replaced with fresh ones fortnightly and adhesive material on cloth sheets was refreshed at about 15-20 days intervals.

The highest mean moth catches were found in November on a green adhesive cloth sheet followed by Navy-blue whereas, the mean highest moth catches on pheromone lure trap were recorded in October. Overall, highest moth attraction was observed to green colour followed by Navy-blue and highest number of moths were caught in November (Fig. 4.1).

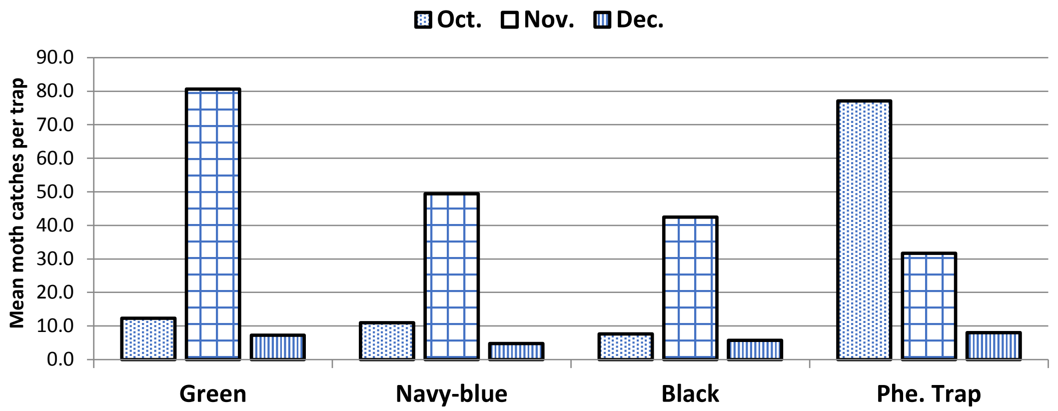


**Fig. 4.1 Mean moth catches in different colored adhesive-cloths sheets and sex trap**

### 4.2 Monitoring of lepidopterous pests

Male Moth's activity of lepidopterous pests viz. *Pectinophora gossypiella*, *Earias insulana, Earias vittella, Spodoptera litura, Spodoptera exigua* and *Helicoverpa armigera,* was monitored with sex pheromone baited traps throughout the year at CCRI, Multan. Overall, increasing population trend was found in *P. gossypiella* and *Spodoptera* spp., whereas declining trend was observed in *E. vittella* and *H. armigera* as compared to the previous year (Table 4.1). Weekly male moth catch activities are given in Fig. 4.2 (a-f).

#### 4.2.1 *Pectinophora gossypiella* (Pink bollworm)

Male Moth's activity started in 3$^{rd}$ week of March and reached at its peak in 4$^{th}$ week of October with fluctuating trend afterward (Fig. 4.2a). Overall, male moth catches were 407.2% higher as compared to the last year (Table 4.1).

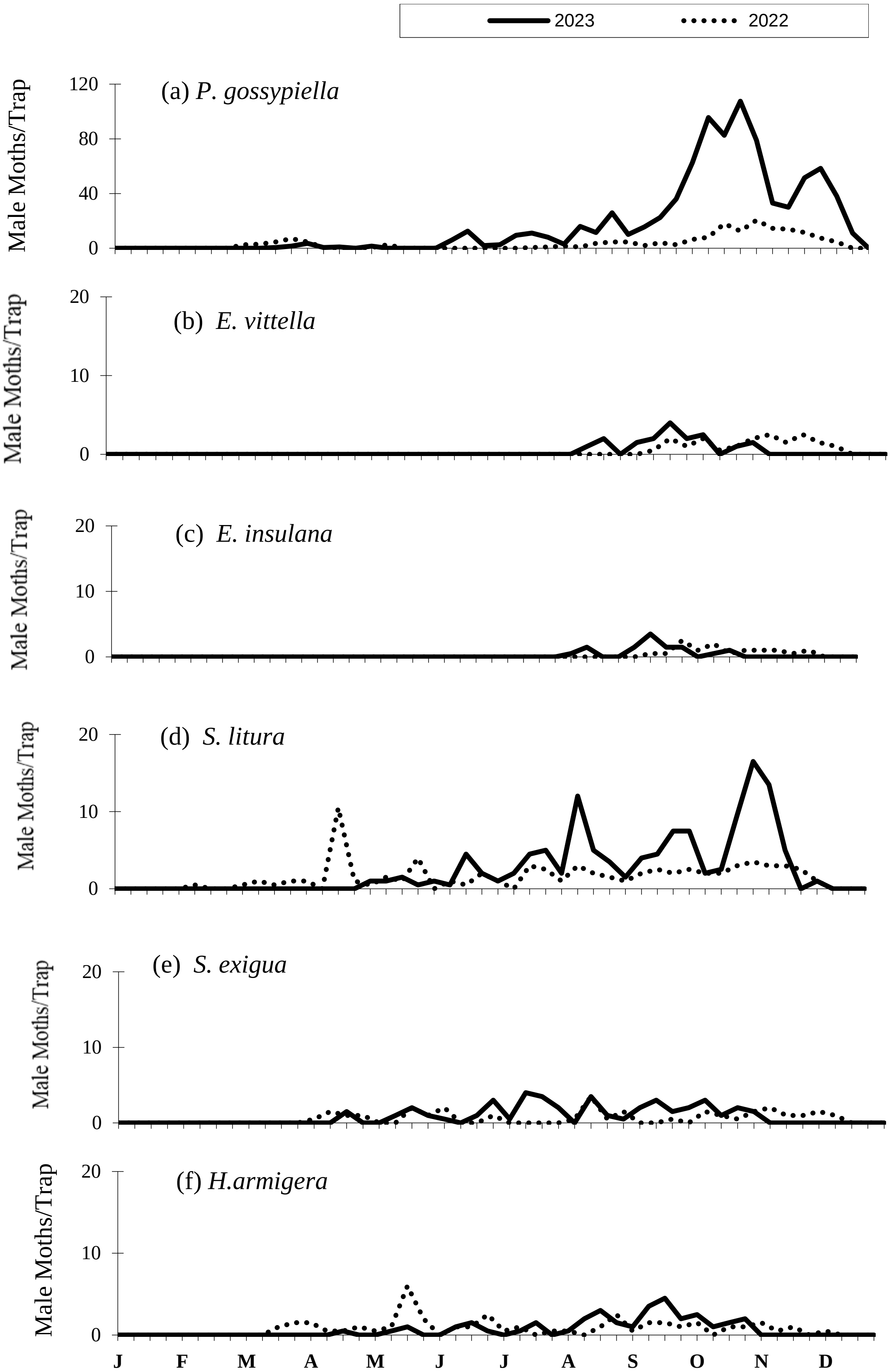


**Fig. 4.2 Weekly male moth catches of Lepidopterous pests in sex pheromone traps at CCRI, Multan.**

### 4.2.2 *Earias vittella* (Spotted bollworm)

Male Moth catches remained zero up to 1st week of August and its peak intensity was noticed in 3rd week of September. Moth's activity was not consistent and exhibited fluctuating trend all over the season (Fig. 4.2b). Overall, male moth catches were 2.8% lower as compared to the last year (Table 4.1).

#### 4.2.3 *Earias insulana* (Spiny bollworm)

Male moth's activity was zero from January to 1st week of August. Afterward, population increased with fluctuating trend and reached its maximum in 3rd week of September (Fig. 4.2c). Whole number of moth catches was similar to that of the previous year (Table 4.1).

#### 4.2.4 *Spodoptera litura* (Armyworm)

Male Moth catches remained zero up to last week of April with fluctuating trend afterwards and its peak was observed in 1st week of November (Fig. 4.2d). Total number of male moth catches were 73.0% higher than the last year (Table 4.1).

#### 4.2.5 *Spodoptera exigua* (Beet armyworm)

Male moth's activity initiated in 3rd week of April with inconsistent trend and its peak was observed in 2nd week of July (Fig. 4.2e). Overall, male moth catches were 49.1% higher than the last year (Table 4.1).

#### 4.2.6 *Helicoverpa armigera* (American bollworm)

Male Moth activity started in 3rd week of April and there was a fluctuating trend in moth activity afterwards. Maximum catches were recorded in 3rd week of September (Fig. 4.2f). Overall, male moth catches were 14.7% lower than the last year (Table 4.1).

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

| Insect pest | CCRI, Multan | | |
|---|---|---|---|
| | 2022 | 2023 | ± %age |
| *P. gossypiella* | 167.5 | 849.5 | 407.2 |
| *E. vittella* | 18.0 | 17.5 | -2.8 |
| *E. insulana* | 11.5 | 11.5 | 0.0 |
| *S. litura* | 70.5 | 122.0 | 73.0 |
| *S. exigua* | 27.5 | 41.0 | 49.1 |
| *H. armigera* | 37.5 | 32.0 | -14.7 |

### 4.3 Impact of cotton sowing period on sucking insect pests and their natural enemies' population tendency

The experimental trial was steered to evaluate the effect of different sowing periods of cotton on buildup of sucking insect pests and their natural enemies and to devise their management strategies. The Set-1 (May) was planted on 10th May and Set-II (June) on 5th June. Two *Bt.* varieties (*Bt*.CIM-663 & *Bt*.CIM-785) and two non-*Bt.* varieties (CIM-554 & CIM-620) were planted in split-plot design with three replicates. Main plots were sowing dates whereas varieties were in subplots. Data on sucking insect pests and predators was started 20 Days After Sowings (DAS) at weekly interval.

Among the sucking pests, the occurrence of jassid was detected in June with peak intensity in July in Set-1. Afterwards, fluctuating trend was noticed throughout the season in this set. In Set-2, jassid appeared in July with peak infestation just at cotton seedling stage. On the whole, seasonal average incidence of jassid was higher in July (Fig. 4.3a). Varieties showed almost similar response to jassid with respect to sowing dates and maximum population of jassid was observed in Set-1 on all the tested varieties. Overall, jassid population was higher in May sown cotton as compared to June sown cotton (Table 4.2).

Whitefly prevalence was noticed during June in Set-1 and during July in Set-2 with increasing trend afterwards. Its peak was observed in September in both Sets while its population was higher in Set-2 (Fig. 4.3b). Varieties showed no profound impact on whitefly intensity. In general, whitefly was lower in May sown cotton as compared to June sown cotton (Table 4.2). Thrips appeared in July and reached at its peak in August in both Set-1 and Set-2. A similar trend of thrips population was observed on all the tested varieties with respect to sowing dates. On the whole, its population was comparatively higher in May sown cotton (Fig. 4.3c; Table 4.2).

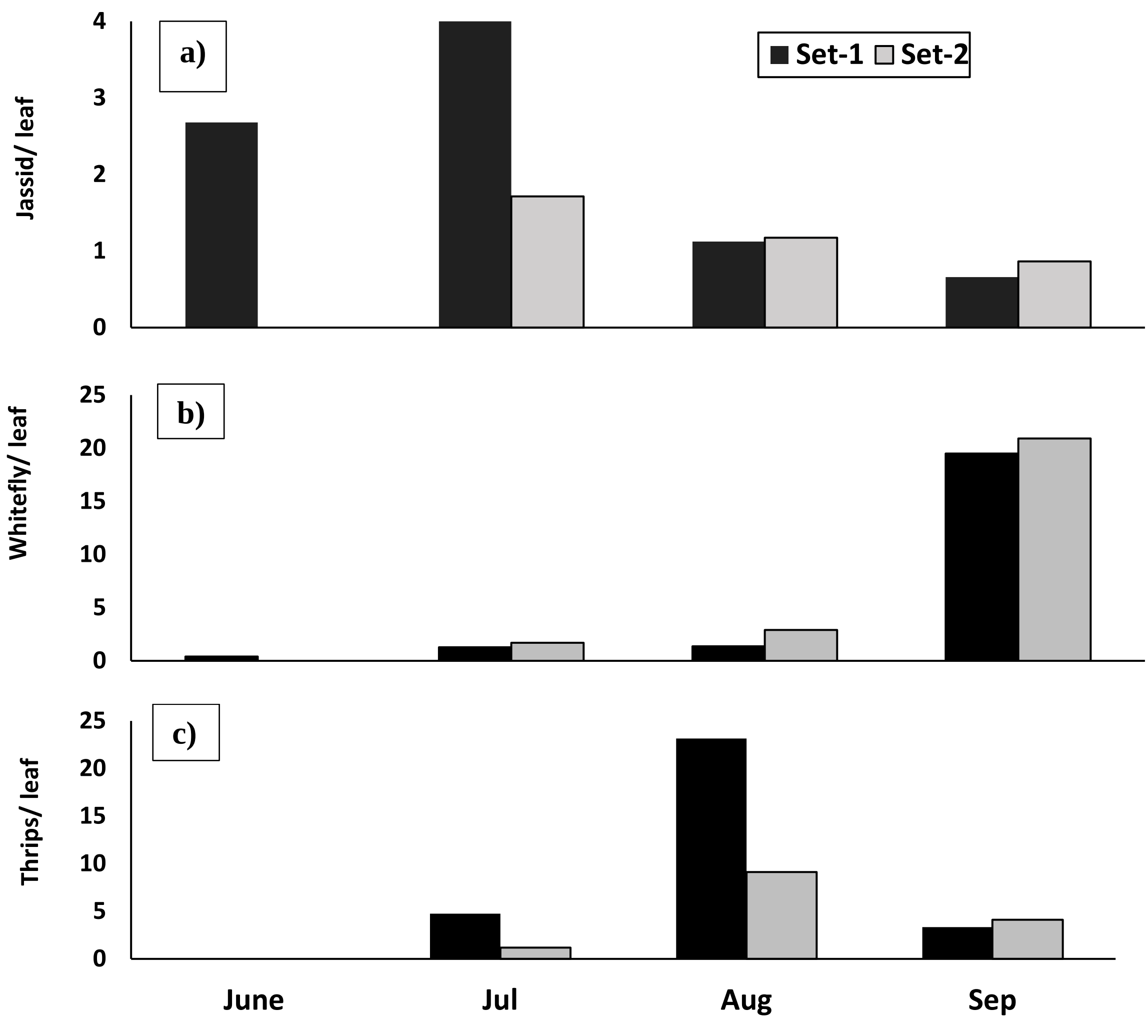


**Fig. 4.3 Impact of cotton sowing period on population dynamics of a) jassid, b) whitefly and c) thrips. Set-1 and Set-2 represent May and June sowing dates, respectively.**

**Table 4.2 Interactive impact of sowing date and varieties on sucking pest's intensity**

| Sowing date | Variety | Sucking pests/leaf | | |
|---|---|---|---|---|
| | | Jassid | Whitefly | Thrips |
| **(Set-1) May** | *Bt*.CIM-663 | 2.0 | 5.6 | 9.7 |
| | *Bt*.CIM-785 | 2.2 | 4.9 | 7.1 |
| | CIM-554 | 2.1 | 5.7 | 6.8 |
| | CIM-620 | 2.1 | 6.4 | 7.6 |
| | **Aver.** | **2.1** | **5.6** | **7.8** |
| **(Set-2) June** | *Bt*.CIM-663 | 1.1 | 9.0 | 4.9 |
| | *Bt*.CIM-785 | 1.4 | 8.4 | 5.1 |
| | CIM-554 | 1.1 | 8.4 | 5.0 |
| | CIM-620 | 1.4 | 8.2 | 4.2 |
| | **Aver.** | **1.3** | **8.5** | **4.8** |

Among the natural enemies, *Chrysoperla carnea* and spiders were dominant predators. Prevalence of *C. carnea* and spiders was observed in June in Set-1 and in July in Set-2 and their population reached at peak during September in both sets. *Orius* spp. and *Geocoris* spp. appeared in July in both sets. Total number of predators was higher in September in both sets (Fig. 4.4 a-e). There was no substantial impact of varieties on predator's incidence as their response was almost alike in the respective sowing dates. Overall, predators' number was higher in June sown cotton while lower in May sown cotton (Table 4.3). In the early stage of crop growth, population of predators was low which increased gradually; therefore, farmers are advised to delay the first spray and apply safer insecticides to protect or conserve natural enemies' population.

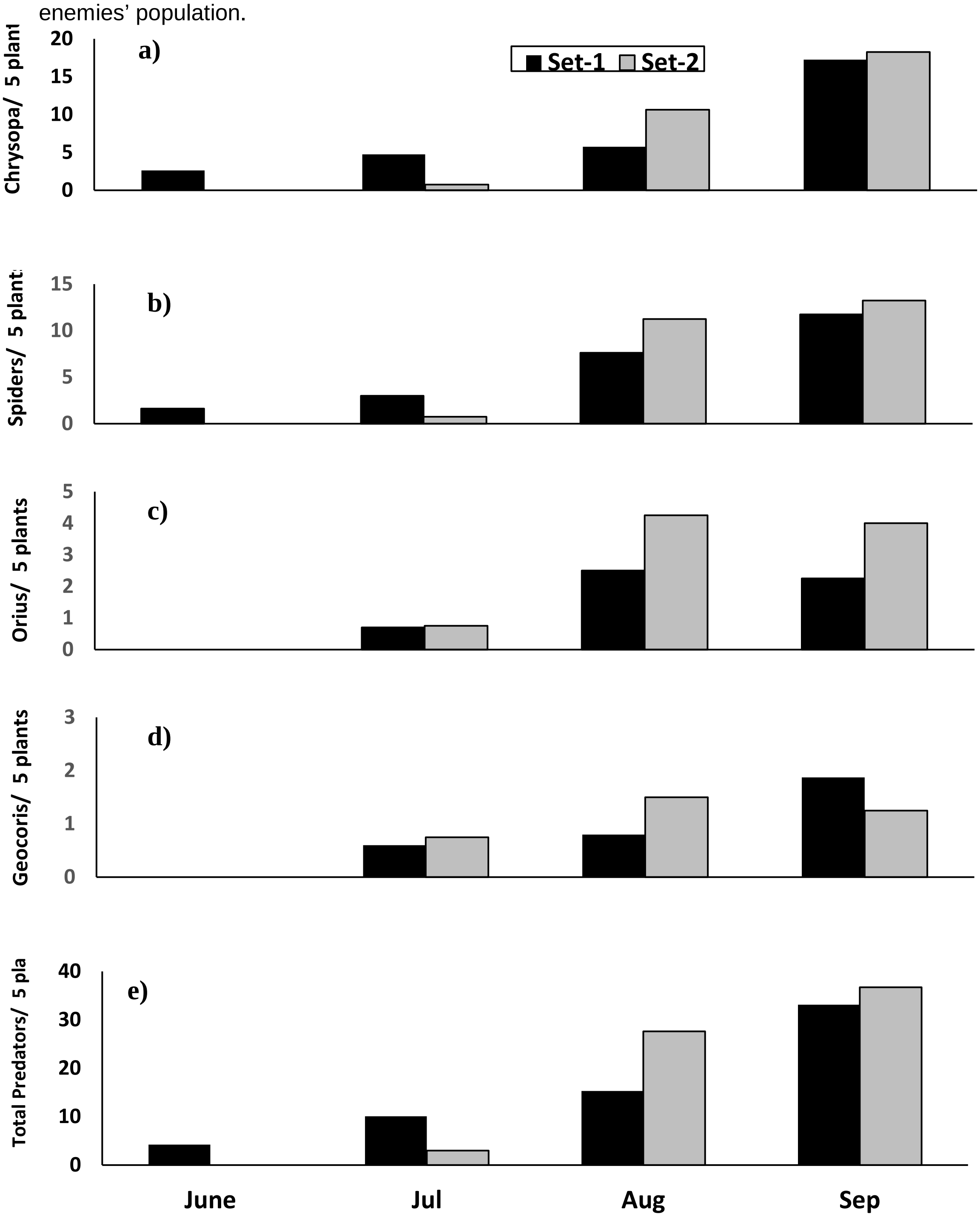


**Fig. 4.4 Impact of cotton sowing period on population dynamics of natural enemies a) *Chrysoperla carnea,* b) spiders, c) *Orius* spp., d) *Geocoris* spp. and e) total predators. Set-1 and Set-2 represent May and June sowing dates, respectively.**

## 4.4 Incidence of arthropods on light and normal green cotton leaves

Light-green (CIM-775, CIM-875 and Sahara-110) and normal-green (CIM-785 and CIM-678) cotton genotypes/varieties were compared under unsprayed and sprayed conditions regarding the incidence of sucking insect pests, CLCV disease, beneficial fauna, alive larvae of pink bollworm and seed cotton yield. Plant protection was carried out on the sprayed block when the pests pressure reached ETL, however, at an early stage of the crop, application of insecticide was done due to heavy infestation of jassid especially thrips on unsprayed block, whereas, standard agronomical practices were employed uniformly both on unsprayed and sprayed blocks.

Table 4.3 Interactive impact of sowing date and varieties on natural enemies intensity

| Sowing date | Variety | Predators/ 5plants | | | | |
|---|---|---|---|---|---|---|
| | | *C. carnea* | Spiders | Orius | Geocoris | Total |
| **Set-1 (May)** | CIM-663 | 6.9 | 6.3 | 1.8 | 1.0 | 16.0 |
| | CIM-785 | 10.0 | 4.8 | 1.1 | 0.9 | 16.8 |
| | CIM-554 | 7.1 | 5.5 | 1.1 | 0.8 | 14.5 |
| | CIM-620 | 5.3 | 7.5 | 1.5 | 0.7 | 15.0 |
| | **Aver.** | **7.3** | **6.0** | **1.4** | **0.9** | **15.6** |
| **Set-2 (June)** | CIM-663 | 10.8 | 10.2 | 4.2 | 0.8 | 26.0 |
| | CIM-785 | 10.7 | 6.8 | 2.2 | 0.3 | 20.0 |
| | CIM-554 | 8.7 | 7.8 | 3.2 | 1.7 | 21.4 |
| | CIM-620 | 10.0 | 8.8 | 2.5 | 1.8 | 23.1 |
| | **Aver.** | **10.1** | **8.4** | **3.0** | **1.2** | **22.6** |

### 4.4.1 Sucking insect-pests

In light-green leaves, resistance against jassid and thrips as compared to normal-green leaves varieties especially under unsprayed conditions. However, whitefly population was above ETL both on light-green and normal-green leaves genotypes/varieties (Fig. 4.5), whereas, under sprayed condition jassid was just below ETL on light-green and above ETL on normal-green varieties. The whitefly was recorded to be above and thrips was below ETL on all the genotypes/varieties. Though comparatively low in sprayed condition, the population pattern was almost the same both under sprayed and unsprayed conditions.

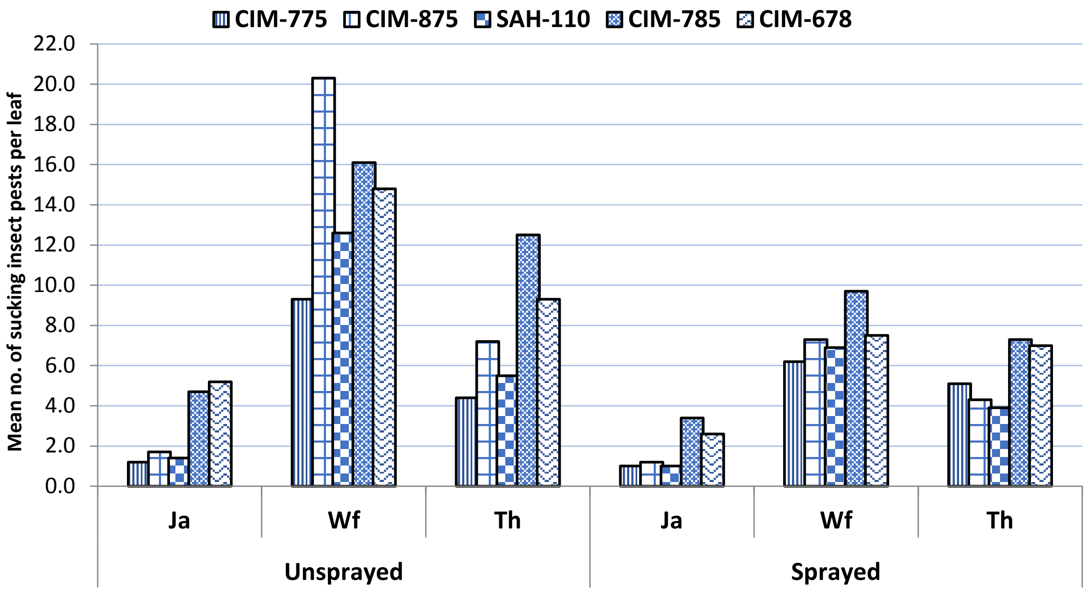


**Fig. 4.5 Mean number of jassid, whitefly and thrips on different cotton genotypes/varieties in unsprayed and sprayed conditions.**

### 4.4.2 CLCV disease

The CLCuV disease was lowest at 60 DAP under sprayed condition on CIM-785 (0.93%) followed by CIM-678 (6.76%) whereas, CIM-775, CIM-875 and Sahara-110 were found with no symptoms of CLCuV. In unsprayed condition at 60 DAP, CIM-775 was found resistant and CIM-678 was susceptible to CLCuV (Fig. 4.6). Overall, unsprayed blocks were resistant to CLCuV disease than sprayed blocks. In all tested genotypes/varieties, CIM-775 and CIM-875 competed well with CLCuV disease in both unsprayed and sprayed conditions, while CIM-678 and CIM-785 were recorded as highly susceptible to CLCuV in both unsprayed and sprayed conditions.

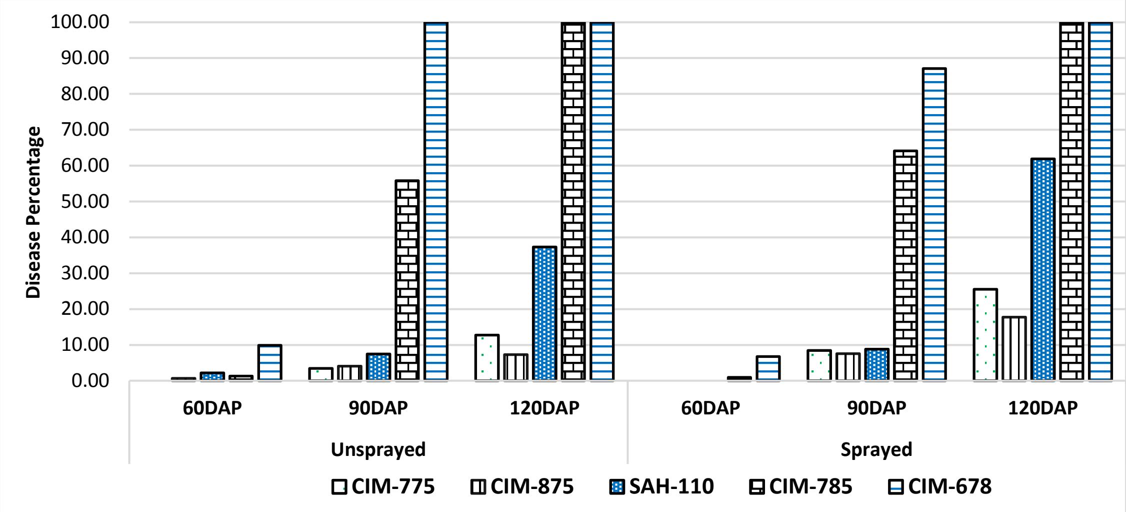


**Fig. 4.6** **Mean percent of CLCuV disease on different cotton genotypes/varieties at unsprayed and sprayed conditions.**

### 4.4.3 Beneficial arthropods

Among beneficial arthropods, the highest population (5.2/5plants) recorded was that of spiders followed by (4.9/5plants) under unsprayed conditions, whereas in sprayed conditions, spiders were comparatively resistant against chemical insecticides being (4.1/5plants) followed by (2.8/5plants). Overall lowest number of beneficial arthropod fauna were recorded under sprayed conditions as compared to unsprayed ones (Fig. 4.7).

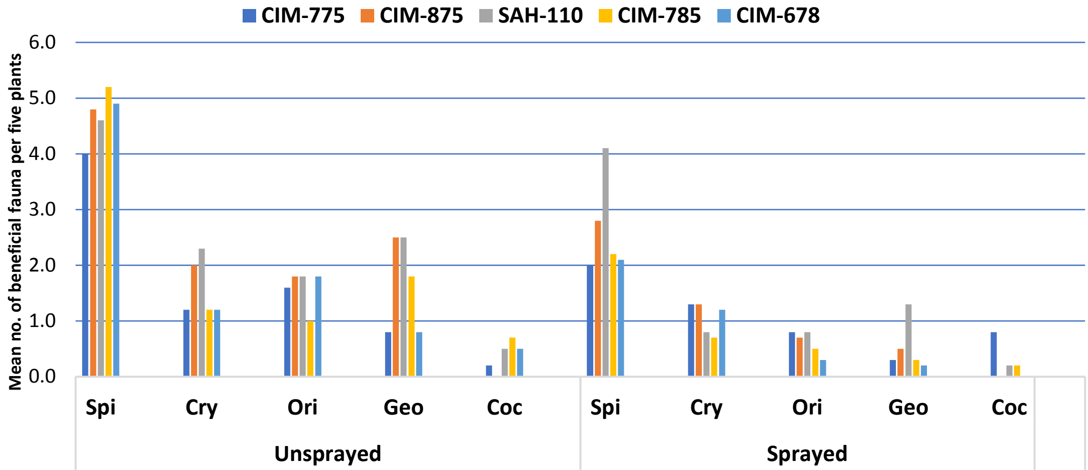


**Fig. 4.7** **Mean number of predators in unsprayed and sprayed blocks.**

### 4.4.4 Alive larvae of Pink bollworm

Overall maximum number of alive larvae of pink bollworm were found in unsprayed as compared to sprayed blocks. In unsprayed block highest number of alive larvae (76.7%) were recorded on CIM-785 followed by (73.3%) on CIM-875 (Fig. 4.8), whereas it was lowest (61.1%) on Sahara-110 followed by (64.4%) on CIM-775. In sprayed block, the highest mean population of alive larvae (22.2%) was recorded each on CIM-875 and CIM-678 followed by (20.0%) on CIM-785 and (14.4%) on Sahara-110. Maximum resistance towards pink bollworm was recorded on Sahara-110.

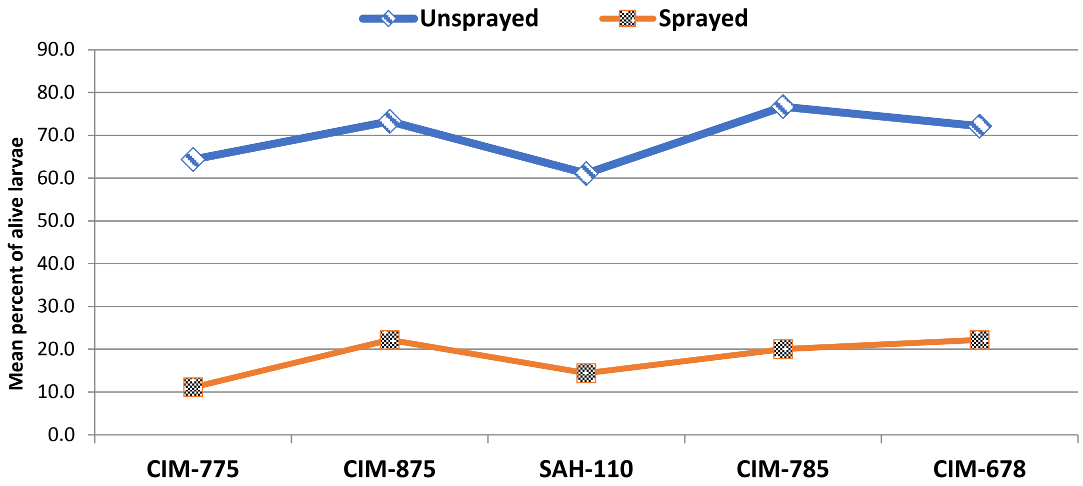


**Fig. 4.8 Incidence of pink bollworm in unsprayed and sprayed blocks.**

## 4.5 Insecticide resistance monitoring

### 4.5.1 Dusky cotton bug *(Oxycarenus hyalinipennis)*

*Oxycarenus hyalinipennis,* dusky cotton bug collected from cotton fields at Multan was exposed to ten insecticides viz. emamectin benzoate, abamectin, cypermethrin, bifenthrin, deltamethrin, chlorpyriphos, triazophos, profenophos, fipronil and clothianidin using leaf dip method. Adults of *O. hyalinipennis* were exposed and observations on mortality were taken 48 hours after treatment for conventional insecticides and 72 hours after treatment for new chemistry insecticides.

$LC_{50}$ values of profenophos and fipronil were comparatively lower in field populations of *O. hyalinipennis* as compared to other insecticides. While abamectin showed very high $LC_{50}$ values followed by chlorpyriphos and bifenthrin as compared to other tested insecticides. These $LC_{50}$ values indicated resistance development to these tested insecticides (Table 4.4). Hence, there is a dire need to develop and imply insecticide resistance management (IRM) strategies to manage insecticidal resistance in *O. hyalinipennis*. Though triazophos is most effective among tested insecticides but few insecticides viz. triazphos, abamectin and bifenthrin are going to be phased out in 2024, therefore it is suggested to use alternative insecticides to replace these insecticides.

**Table 4.4 Response of *Oxycarenus hyalinipennis* to different insecticides**

| Insecticide | Slope ± SE | 95% fiducial limits | LC50 (ppm) |
|---|---|---|---|
| Cypermethrin | 1.87 ± 0.35 | 42.74 – 80.07 | 57.18 |
| Bifenthrin | 1.52 ± 0.28 | 362.91 – 847.90 | 517.04 |
| Deltamethrin | 1.29 ± 0.32 | 12.43 – 33.04 | 22.19 |
| Chlorpyriphos | 1.78 ± 0.29 | 37.14 – 69.43 | 549.57 |
| Triazophos | 1.15 ± 0.18 | 25.64 – 55.61 | 37.83 |
| Profenophos | 1.96 ± 0.38 | 0.34 – 0.66 | 0.49 |
| Fipronil | 1.51 ± 0.27 | 0.46 – 0.97 | 0.69 |
| Clothianidin | 1.33 ± 0.26 | 63.35 – 169.10 | 113.7 |
| Emamectin benzoate | 1.01 ± 0.18 | 5.47 – 13.63 | 8.95 |
| Abamectin | 1.63 ± 0.37 | 1218.39 – 3157.03 | 1752.57 |

## 4.6 National Coordinated Varietal Trial

In Set-1, jassid remained below ETL in all families. Whitefly population was minimum (2.2 per leaf) in JSQ-White and maximum (6.1 per leaf) in MNH-Sult.Thrips remained minimum (1.4 per leaf) in CIM-600 during August and maximum in Tara-337. In Set-2, jassid remained below ETL in all families. Whitefly population was minimum (1.9 per leaf) in Tara-340 and (4.3 per leaf) in SS-102. Minimum and maximum number of thrips were recorded in AS-85 and Sahara-Kle, respectively.

In Set-1, jassid and thrips remained below ETL in all families. Whitefly population remained above ETL in all families during September with minimum population in SAS-3 and maximum in

JSQ-White. In Set II, jassid population remained below ETL in all families. Whitefly population was minimum (6.4 per leaf) in SS-32 while maximum (9.5 per leaf) in FH-1214. Thrips population was minimum (1.4 per leaf) in Inqalab-99 and maximum (6.6 per leaf) in Super Sulta.

**Table 4.5 Seasonal population of sucking insect pests in Set-1 & Set-2 during August**

| Breeding (Field No. 3/10) | | | | Cyto (Field No. 3/9) | | | |
|---|---|---|---|---|---|---|---|
| **Family No.** | **Jassid** | **Whitefly** | **Thrips** | **Family No.** | **Jassid** | **Whitefly** | **Thrips** |
| BH-227 | 0.1 | 3.5 | 2.2 | AS-85 | 0.1 | 4.2 | 1.2 |
| Capatin-20 | 0.2 | 3.6 | 1.6 | BH-228 | 0.1 | 2.2 | 1.6 |
| CEMB-Te | 0.0 | 3.4 | 1.9 | Captain-30 | 0.2 | 2.4 | 1.8 |
| CRIS-697 | 0.4 | 2.8 | 1.5 | Certus-30 | 0.3 | 2.6 | 2.2 |
| CIM-600 | 0.3 | 4.1 | 1.4 | CIM-600 | 0.1 | 2.7 | 3.4 |
| Cyto-545 | 0.1 | 5.1 | 2.1 | CRIS-700 | 0.4 | 2.2 | 3.1 |
| FBG-Platin | 0.0 | 3.3 | 2.2 | Cyto-547 | 0.0 | 3.4 | 3.2 |
| FH-1133 | 0.4 | 3.9 | 2.7 | FBS-Shshe | 0.1 | 2.4 | 3.3 |
| Inqalab-10 | 0.0 | 3.7 | 2.6 | FH-1214 | 0.0 | 3.4 | 1.8 |
| CKC-3 | 0.2 | 2.5 | 3.1 | CKC-3 | 0.2 | 3.6 | 1.6 |
| IUB-23 | 0.1 | 2.9 | 3.4 | Inqalab-99 | 0.0 | 3.1 | 1.5 |
| JSQ-White | 0.6 | 2.2 | 2.5 | IUB-313 | 0.4 | 2.2 | 1.4 |
| KZ-181 | 0.1 | 4.1 | 4.4 | JSQ-71 | 0.0 | 3.3 | 3.5 |
| MNH-Sult | 0.0 | 6.1 | 3.6 | KZ-323 | 0.0 | 3.5 | 2.4 |
| SS-32 | 0.3 | 5.8 | 2.9 | SS-32 | 0.1 | 3.9 | 2.9 |
| NIAB-868 | 0.1 | 4.2 | 2.2 | MNH-Sup | 0.3 | 4.1 | 3.3 |
| Sahara-500 | 0.0 | 3.3 | 3.4 | NIBGE-PF | 0.4 | 4.2 | 4.2 |
| SAS-3 | 0.1 | 3.4 | 3.3 | Sahara-Kle | 0.2 | 2.5 | 4.5 |
| SS-102 | 0.0 | 3.8 | 4.1 | Silver-Que | 0.1 | 3.3 | 1.4 |
| Tara-337 | 0.0 | 3.1 | 6.1 | SS-102 | 0.0 | 4.3 | 2.2 |
| VH-447 | 0.2 | 4.1 | 2.2 | Super Sulta | 0.0 | 2.2 | 3.9 |
| YBG-2626 | 0.3 | 3.2 | 2.8 | Tara-340 | 0.5 | 1.9 | 3.5 |
| Bahar-GT | 0.4 | 2.4 | 2.9 | VH-461 | 0.3 | 2.0 | 3.1 |
| SLH-94 | 0.2 | 2.5 | 3.3 | YBG-2929 | 0.6 | 2.2 | 3.2 |

**Table 4.6 Seasonal population of sucking insects in Set-1 & Set-2 during September**

| Breeding (Field No. 3/10) | | | | Cyto (Field No. 3/9) | | | |
|---|---|---|---|---|---|---|---|
| **Family No.** | **Jassid** | **Whitefly** | **Thrips** | **Family No.** | **Jassid** | **Whitefly** | **Thrips** |
| BH-227 | 0.1 | 6.6 | 3.4 | AS-85 | 0.1 | 7.2 | 2.3 |
| Capatin-20 | 0.1 | 6.7 | 3.3 | BH-228 | 0.2 | 6.6 | 2.2 |
| CEMB-Te | 0.2 | 9.8 | 3.1 | Captain-30 | 0.2 | 7.9 | 2.4 |
| CRIS-697 | 0.2 | 7.8 | 2.5 | Certus-30 | 0.0 | 8.4 | 2.9 |
| CIM-600 | 0.3 | 9.7 | 2.9 | CIM-600 | 0.0 | 8.7 | 3.7 |
| Cyto-545 | 0.1 | 6.5 | 6.4 | CRIS-700 | 0.2 | 7.6 | 3.3 |
| FBG-Platin | 0.0 | 6.6 | 5.1 | Cyto-547 | 0.4 | 9.5 | 3.0 |
| FH-1133 | 0.2 | 7.8 | 2.5 | FBS-Shshe | 0.3 | 7.9 | 3.1 |
| Inqalab-10 | 0.0 | 8.9 | 6.4 | FH-1214 | 0.1 | 6.8 | 2.5 |
| CKC-3 | 0.0 | 7.9 | 4.0 | CKC-3 | 0.6 | 7.9 | 5.0 |
| IUB-23 | 0.1 | 8.8 | 2.1 | Inqalab-99 | 0.1 | 8.9 | 1.4 |
| JSQ-White | 0.5 | 9.0 | 3.0 | IUB-313 | 0.0 | 8.8 | 1.9 |
| KZ-181 | 0.3 | 8.7 | 3.8 | JSQ-71 | 0.1 | 7.9 | 2.4 |
| MNH-Sult | 0.0 | 7.0 | 3.7 | KZ-323 | 0.2 | 7.6 | 2.2 |
| SS-32 | 0.0 | 6.0 | 3.4 | SS-32 | 0.0 | 6.4 | 2.4 |
| NIAB-868 | 0.0 | 6.9 | 6.4 | MNH-Sup | 0.0 | 7.4 | 2.6 |
| Sahara-500 | 0.4 | 6.7 | 4.6 | NIBGE-PF | 0.4 | 8.7 | 2.7 |
| SAS-3 | 0.2 | 5.5 | 4.4 | Sahara-Kle | 0.3 | 9.4 | 3.1 |
| SS-102 | 0.3 | 5.9 | 4.3 | Silver-Que | 0.5 | 8.4 | 2.4 |
| Tara-337 | 0.1 | 5.6 | 5.5 | SS-102 | 0.2 | 7.5 | 3.6 |
| VH-447 | 0.2 | 7.7 | 1.1 | Super Sulta | 0.6 | 8.9 | 6.6 |
| YBG-2626 | 0.2 | 9.9 | 2.5 | Tara-340 | 0.3 | 6.6 | 5.4 |
| Bahar-GT | 0.0 | 8.4 | 2.3 | VH-461 | 0.1 | 7.4 | 2.4 |
| SLH-94 | 0.0 | 9.4 | 4.1 | YBG-2929 | 0.2 | 9.3 | 5.4 |

## 4.7 Screening of new and commercially available insecticides

### 4.7.1 Jassid (*Amrasca devastans*)

Ten insecticides of different groups were evaluated against jassid at CCRI, Multan field keeping untreated check for comparisons. Different insecticides gave more than 75% pest mortality after 72 hours and up to one week of spray application. Some insecticides have lost their efficacy including fipronil 80%WG, clothianidin 20%SC, imidacloprid 20SL and dinotefuron 30SP (Table 4.7).

**Table 4.7 Efficacy of different insecticides against Jassid**

| Common Name | Formulation (% age) | Dose (ml/g) | Mortality % | |
|---|---|---|---|---|
| | | | 72 hour | Week |
| Fipronil | 80% WG | 30 | 66.5 | 71.2 |
| Chlorfenapyr 30% + Dinotefuran 13% | 43%WDG | 150 | 80.4 | 83.6 |
| Flonicamid | 50% WDG | 60 | 75.8 | 81.0 |
| Abamectin 36 G + Thiamethoxam 72g/l | 108sc | 300 | 77.2 | 80.7 |
| Clothianidin | 20% SC | 150 | 60.3 | 65.1 |
| Flonicamid | 60% WDG | 120 | 81.9 | 89.3 |
| Imidacloprid | 20 SL | 250 | 62.3 | 57.9 |
| Nitenpyram | 24 SP | 50 | 76.8 | 74.1 |
| Flonicamid | 50% DF | 60 | 87.6 | 92.8 |
| Dinotefuran | 30 SP | 100 | 65.7 | 71.8 |
| **CD 5%** | | - | **11.33** | **7.24** |

Pre-treatment data 2.54 per leaf

### 4.7.2 Whitefly *(Bemisia tabaci)*

The efficacy of 13 insecticides from different groups and their mixtures were screened against whitefly and an untreated check plot was kept for comparison. In tested insecticides, pyriproxfen 40% WDG, pyriproxfen 40% WDG, acetamiprid 20SL, spirotetramat 240SC and flonicamid 50%WG gave below 75% mortality one week after application as compared to other tested insecticides (Table 4.8).

**Table 4.8 Efficacy of different insecticides against Whitefly**

| Common Name | Formulation (% age) | Dose (ml/g) | Mortality % | |
|---|---|---|---|---|
| | | | 72 hour | Week |
| Matrin 0.5% + Acetamiprid 5% | 5.5% AS | 500 | 80.6 | 83.2 |
| Spinosad 13% + Flonicamid 40% | 53% WDG | 125 | 80.5 | 82.6 |
| Dinotefuron + Spirotetramat | 50% WDG | 150 | 80.1 | 84.4 |
| Pyriproxfen | 40% WDG | 500 | 75.0 | 72.5 |
| Flonicamid | 50% DF | 80 | 83.4 | 87.2 |
| Flonicamid 20% + Acetamiprid | 35% WDG | 125 | 79.9 | 85.0 |
| Pyriproxfen 21.6% + Acetamiprid | 41.6% EC | 80 | 79.6 | 80.5 |
| Flonicamid + Pyriproxfen | 10% WP | 150 | 75.2 | 78.8 |
| Afidopyropen | 5% DC | 80 | 73.2 | 79.7 |
| Pyriproxfen | 10.8 EC | 500 | 61.6 | 70.1 |
| Acetamiprid | 20 SL | 150 | 59.7 | 69.8 |
| Spirotetramat | 240 SC | 125 | 57.5 | 63.4 |
| Flonicamid | 50% WG | 80 | 56.8 | 71.3 |
| **CD 5%** | | 200 | **7.03** | **11.11** |

Pre-treatment data 8.35 per leaf

### 4.7.3 Thrips *(Thrips tabaci)*

The efficacy of 11 insecticides of different groups were tested against thrips at CCRI, Multan farm. Knapsack sprayer was used for spray application and for comparison an untreated check was kept. After 72 hours of spray, products gave almost 75% pest mortality except for flonicamid 50%DF, fipronil 80%WG, chlorfenapyr 70WDG and acephate 75SP. Moreover, insecticides fipronil 80%WG, acephate 75SP, spintoram 20WDG and chlorfenapyr 70WDG lost efficacy after one week of application (Table 4.9).

**Table 4.9 Efficacy of different insecticides against thrips**

| Common Name | Formulation (%age) | Dose (ml/g) | Mortality % | |
|---|---|---|---|---|
| | | | 72 hour | Week |
| Chloprfenapyr + Abamectin | 17% SC | 300 | 79.5 | 85.4 |
| Spinosad 13% + Flonicamid 40% | 53% WDG | 75 | 83.1 | 84.2 |
| Spinosad + Abamectin | 8.4% SE | 100 | 78.7 | 82.3 |
| Flonicamid | 50% DF | 80 | 64.9 | 73.5 |
| Chlorfenapyr + Abamectin | 17% SC | 200 | 77.6 | 80.7 |
| Abamectin 36 G + Thiamethixam 72g/l | 108 SC | 300 | 75.6 | 79.3 |
| Fipronil | 80% WG | 250 | 71.7 | 65.3 |
| Acephat | 75 SP | 350 | 78.5 | 67.0 |
| Spinetoram | 20 WDG | 60 | 82.7 | 70.2 |
| Chlorfenapyr | 70WDG | 125 | 63.8 | 68.0 |
| Abamectin + Thiamethixam | 108 SC | 300 | 83.6 | 87.9 |
| **CD 5%** | | | **7.33** | **10.47** |

Pre-treatment data 17.50 per leaf

## 4.8 Studying the effect of methyl jasmonate (plant volatile) applications against sucking insect pest of cotton and their predators

Methyl jasmonate (MEJA), a volatile organic compound, can induce plant defenses, thereby contributing to repelling insect pests and attracting their natural enemies. For this purpose, the experiment was laid out in a Randomized Complete Block Design in the farm area of the CCRI, Multan. Five cotton varieties Cyto-537, CIM-990, Cyto-545, CIM-678 (BT) and one non- BT CIM 717 were sown on 22 May, 2023. The net plot size for each treatment was 30x20 feet and was replicated three times Fertilizers were applied at recommended doses. There were four treatments including a control. Three doses of MEJA were diluted in distilled water (D1 = 0.88 mM, D2 = 1.76 mM, and D3 = 3.55 mM) followed by adding 0.1 ml l-of an aqueous surfactant. The treatments were applied using a backpack sprayer. During treatments, all plants were covered as evenly as possible with the required amount of spray volume. The control treatment was distilled water with the same surfactant concentration. Three time-treatments were performed at early plant growth stages. The treatments were applied at the plant growth stages 6–8 true leaves-early square bud. Climatic conditions were seasonally normal throughout the experiments. However, to mitigate possible negative effects of high temperatures and intense sunlight during midday and possible wind flow in the evening hours, MEJA treatments were performed at 6am-7am in the morning.

Overall, thrips population in MEJA-treated cotton plots was lower than in control plots. The lowest phytophagous thrips density was recorded in plots treated with the highest MEJA concentration (D3) (Table-4.10).

D3 (highest MEJA concentration), proved more effective. Moreover, whitefly population observed in MEJA-treated cotton plots was lower than the control (Table-4.11).
Similarly, jassid population in MEJA-treated cotton plots was lower than in control plots. The lowest phytophagous jassid density was recorded in plots treated with the highest MEJA concentration (D3) (Table-4.12).

Predators population recorded were more than the control. Spiders and *Chrysoperla carnea* population were more in plots treated MEJA concentration (Fig. 4.9 & 4.10). Similarly D3 treatment was proved more effective for spiders' population.

**Table-4.10 Methyl jasmonate affects Thrips Population:**

| Doses | Plant population per leaf | | | | | |
|---|---|---|---|---|---|---|
| | Before treatment | After treatment | | | | |
| | 17/7 | 18/7 | 19/7 | 20/7 | 24/7 | 31/7 |
| D1 | 17.9 | 14.1 | 13.1 | 13.0 | 14.3 | 15.1 |
| D2 | 20.2 | 13.2 | 13.1 | 13.0 | 13.4 | 14.3 |
| D3 | 19.3 | 11.3 | 10.1 | 10.0 | 12.5 | 13.3 |
| Control | 21.4 | 21.3 | 20.1 | 21.2 | 18.2 | 17.2 |

**Table-4.11 Methyl jasmonate affects Whitefly Population:**

| Doses | Plant population per leaf | | | | | |
|---|---|---|---|---|---|---|
| | Before treatment | After treatment | | | | |
| | 17/7 | 18/7 | 19/7 | 20/7 | 24/7 | 31/7 |
| D1 | 0.9 | 0.8 | 0.7 | 0.8 | 0.9 | 0.9 |
| D2 | 1.4 | 1.0 | 0.9 | 0.8 | 0.7 | 0.8 |
| D3 | 1.2 | 0.8 | 0.6 | 0.6 | 0.7 | 0.8 |
| Control | 1.1 | 1.2 | 1.1 | 1.0 | 1.3 | 1.0 |

**Table-4.12 Methyl jasmonate affects Jassid Population**

| Doses | Plant population per leaf | | | | | |
|---|---|---|---|---|---|---|
| | Before treatment | After treatment | | | | |
| | 17/7 | 18/7 | 19/7 | 20/7 | 24/7 | 31/7 |
| D1 | 1.8 | 1.3 | 1.2 | 1.2 | 1.3 | 1.6 |
| D2 | 1.7 | 1.2 | 1.0 | 0.9 | 1.3 | 1.4 |
| D3 | 2.0 | 0.8 | 0.6 | 0.5 | 1.0 | 1.0 |
| Control | 2.2 | 2.0 | 2.1 | 1.9 | 2.0 | 1.9 |

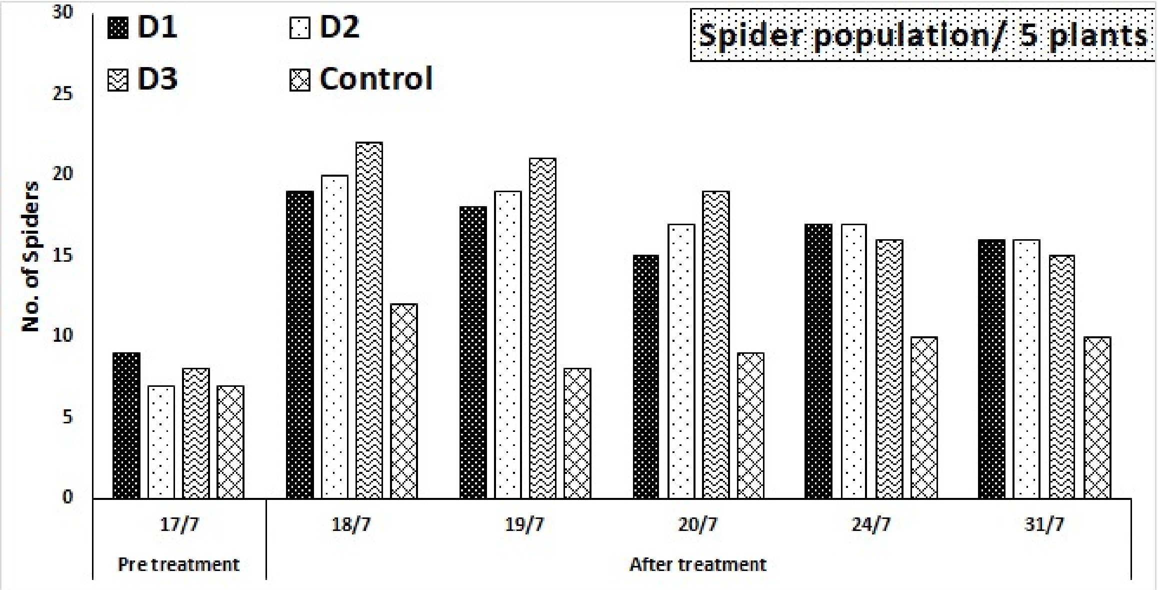


**Fig. 4.9** **Effect of Methyl Jasmonate on spider population.**

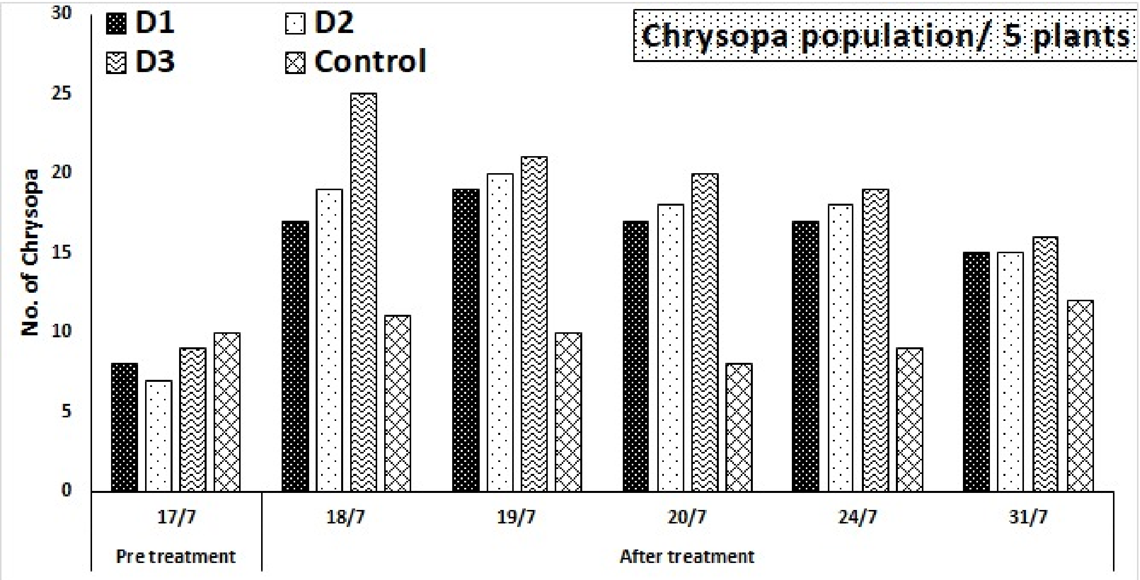


**Fig. 4.10 Effect of Methyl Jasmonate on population of *Chrysoperla carnea*.**

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## 5. PLANT PATHOLOGY SECTION

Main mandate of Plant Pathology Section of the Central Cotton Research, Multan is to conduct research on plant diseases caused by Fungi, Bacteria and Viruses. Management of plant diseases achieved by evaluation of crops germplasm to find out resistance sources against diseases and development of integrated management strategies for cotton diseases.

Experiments conducted under greenhouse and field conditions. The promising strains in National Coordinated Varietal Trial (NCVT) and Punjab Government Trial i.e. Provincial Cotton Coordinated Trial (PCCT), for Bt. and non-Bt. Varieties screened for their reaction to various diseases.

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

### 5.1 Survey of cotton diseases

According to the survey conducted on cotton crops, it was observed that in May, there was a very low incidence of CLCuV (Cotton Leaf Curl Virus) in the Khanewal, Kabirwala, and Multan areas for early sown cotton crops. The maximum incidence of CLCuD (Cotton Leaf Curl Disease) was recorded in August. The average severity level of the disease remained at a medium level, with a rating scale of 2.0, across all surveyed areas. The incidence of boll rot ranged from 0.0 – 2.0 percent. The occurrence of stunting phenomenon was very low. The occurrence of wilting disease was highest in August. However, upon physical and microscopic examination, no fungi, bacteria, or similar pathogens were found to be involved in the wilting symptoms observed. It was noted that this wilting occurred rapidly within a matter of hours and did not follow a specific spatial pattern. Furthermore, blackening was observed to be 90-95% in all varieties during July and August.

**Table 5.1 Survey 26/5/2023**

| Sr. No. | Farmer Name | Variety | Sowing date | Location | CLCuV | Wilt | Blight | Fungicides |
|---|---|---|---|---|---|---|---|---|
| 1 | Imran | FH-333 | 12/3/23 | Mianchanu | 0 | 0 | 0 | Bio pesticides |
| 2 | Attiq-ul Rehman | CS-200 | 22/2/23 | Mianchanu | 0 | wilt | 0 | Thiophenate |
| 3 | M.Saif-ul Rehman | CS-200 | 15/2/23 | Mianchanu-133/16 | 0 | wilt | 0 | Copper Oxychloride |
| 4 | Abdul Aziz | G-4 | 12/11/22 | HayatPur | 0 | 0 | 0 | Intercropping |
| | | | | | | | | |
| 5 | M.hussain | 333 | 20/4/23 | Khanewal | 1% | 0 | Bacterial Blight in traces | |
| 6 | Zahoor Ahmad | C-200 and 111 | 18/13/23 | Khanewal | Jassid | 0 | 0 | |
| 7 | Maqsood-ulhassan | FH-333 | 25/02/23 | Khanewal | Thrips | 0 | 0 | |
| 8 | Shafat Ahmad | K-111 | 5/3/23 | Perowal | Thrips | Jassid | 0 | |

### 5.2 Screening of Breeding Material against CLCuD

The advanced strains/genotypes of this Institute included in varietal, micro varietal trials and various national coordinated varietal trials were screened for their reaction to CLCuD under field conditions. Ninety-eight families were screened during the year. Data shown in Table 5.1 revealed that ninety-six families of breeding material, showed symptoms of the CLCuD under field conditions and two families showed resistance against CLCuD in all breeding material.

**Table 5.2 CLCuD status in Breeding Material under field condition**

| Experiment | No. of Families Screened | No. of Families showing Res. to CLCuD | Disease index Range | Name of strain Resistance or Tolerance |
|---|---|---|---|---|
| VT-1 | 10 | 0 | 26.38~ 100 | |
| VT-3 | 10 | 0 | 6.54~ 100 | * |
| MVT-1 | 10 | 0 | 19.92~100 | |
| MVT-3 | 8 | 2 | 0.00 ~ 100 | MV16& MV17 |
| NCVT-A | 24 | 0 | 59.26~100 | |
| NCVT-B | 21 | 0 | 67.00~100 | |
| SVT-I | 7 | 0 | 91.67~100 | |
| SVT-II | 8 | 0 | 96.21~100 | |
| Total | 98 | 2 | | |

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

## 5.3 Evaluation of National Coordinated Varietal Trial against Different Diseases

National Coordinated Varietal Trial were planted in two sets i.e. Set-A and Set-B. Each set consisted of twenty-four strains that tested under field conditions for their resistance against blackening of cotton leaves, boll rot, and Cotton Leaf Curl Disease.

**NCVT Set-A**

In Set-A of the National Coordinated Varietal Trial, it was found that all the strains tested were highly susceptible to Cotton Leaf Curl Disease. Among the strains, the minimum CLCuD incidence of 56.22% recorded in strain Cyto-547. Additionally, the minimum CLCuD severity of 2.22 and disease index of 32.87 recorded in strain VH-461. Some strains showed traces of boll rot incidence, while the remaining strains were free from boll rot incidence according to Table 5.2. Furthermore, blackening of cotton leaves was observed in all the strains in Set-A.

**NCVT Set-B**

In Set-B of the National Coordinated Varietal Trial, it was observed that all the NCVT strains were highly susceptible to Cotton Leaf Curl Disease. The strain VH-447 showed the minimum disease incidence (48.08%), disease severity (2.80), and disease index (33.72) among the tested strains. Some strains exhibited traces of boll rot incidence, while the remaining strains were free from boll rot incidence, as indicated in Table-5.3. Additionally, blackening of cotton leaves observed in all strains of Set-A and set-B.

## 5.4 Epidemiological Studies on CLCuD

### 5.4 (a) Incidence of Cotton Leaf Curl Disease (CLCuD) in Sowing Date Trial

In the study, five *Bt* strains (CIM-990, CIM-762, CIM-663, Cyto-545, and Cyto-547) were tested at three different sowing dates: April 15th, May 1st, and June 1st to observe their response to Cotton Leaf Curl Disease (CLCuD). The experimental design used was a split-plot design, with sowing time as the main plot and genotype as the sub-plot. Data on CLCuD incidence recorded fortnightly, starting from day 30 after each planting date throughout the season.

Across different cultivars, the initial infection level on day 45 after planting was 0.00. However, as the crop aged, the infection rate gradually increased to 3.8% by day 90. Crop planted on April 15$^{th}$, the incidence of infection reached its highest point at 14.3% after day 135. In the case of the crop planted on May 1st, the infection level started at 0.2% after day 60 and steadily increased, reaching its peak at 51.5% after day 120. On the other hand, Crop sown on June 1st, the incidence of CLCuD was 11.8% after day 45 and reached its maximum level of 76.4% after day 90.

It was observed that the April sowing has a lower incidence of CLCuD compared to the other planting dates. However, In May sowing, there was a higher incidence of CLCuD at 120 days after sowing. Additionally, it was noted that the incidence of CLCuD increased as the sowing was delayed.

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

| NCVT Set A Strain | Cotton Leaf Curl Disease | | | Boll Rot (%) |
|---|---|---|---|---|
| | Disease % age | Disease Severity | Disease Index | |
| AS-85 | 100.00 | 2.90 | 72.41 | 0.00 |
| BH-228 | 100.00 | 3.06 | 76.46 | 0.00 |
| Captain-300 | 100.00 | 2.97 | 74.26 | 0.00 |
| Cestus-33 | 100.00 | 2.94 | 73.45 | 0.00 |
| BH-227 | 100.00 | 3.12 | 77.90 | 1.21 |
| YBG-2636 | 100.00 | 3.06 | 76.58 | 0.50 |
| Cyto-547 | 56.22 | 2.56 | 37.20 | 1.15 |
| FBs-shaheen | 100.00 | 2.93 | 73.18 | 0.00 |
| FH-1214 | 100.00 | 2.94 | 73.49 | 0.50 |
| CKC-3 (Bt. Standard I) | 100.00 | 2.99 | 74.80 | 0.00 |
| Inqalab-99 | 100.00 | 3.00 | 75.07 | 0.00 |
| IUB-04 | 100.00 | 2.98 | 74.45 | 0.00 |
| JSQ-71 | 100.00 | 2.92 | 72.96 | 0.00 |
| KZ-323 | 100.00 | 2.92 | 73.11 | 1.27 |
| SS-32 | 100.00 | 2.99 | 74.83 | 0.00 |
| MNH-SuperGold-22 | 100.00 | 3.02 | 75.46 | 0.00 |
| NIBGE-PF-1 | 100.00 | 3.11 | 77.80 | 0.48 |
| Sahara-Klean-10 | 100.00 | 3.00 | 74.97 | 0.00 |
| Silver Queen-33 | 100.00 | 3.09 | 77.17 | 0.00 |
| SS-102 | 100.00 | 3.02 | 75.51 | 0.53 |
| Super Sultan-22 | 100.00 | 3.09 | 77.26 | 0.00 |
| Tara-333 | 64.11 | 3.11 | 77.80 | 0.00 |
| VH-461 | 59.26 | 2.22 | 32.87 | 1.78 |
| YBG-2929 | 100.00 | 2.91 | 72.74 | 0.94 |

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

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

| NCVT Set-B Strain | Cotton Leaf Curl Disease | | | Boll Rot (%) |
|---|---|---|---|---|
| | Disease % age | Disease Severity | Disease Index | |
| BH-227 | 100.00 | 3.17 | 79.16 | 0.00 |
| Captain-200 | 100.00 | 3.03 | 75.84 | 0.00 |
| CEMB-Tech-Pak | 100.00 | 3.08 | 76.99 | 0.00 |
| CRIS-697 | 100.00 | 3.14 | 78.54 | 1.36 |
| CIM-600 (Bt. Standard) | 100.00 | 3.21 | 80.15 | 0.35 |
| Cyto-545 | 100.00 | 3.15 | 78.71 | 0.00 |
| FBG-Platinum | 100.00 | 3.09 | 77.15 | 0.44 |
| FH-1133 | 100.00 | 3.14 | 78.40 | 0.00 |
| Inqalab-101 | 100.00 | 3.05 | 76.16 | 0.00 |
| CKC-3 (Bt. Standard) | 100.00 | 3.09 | 77.18 | 0.00 |
| IUB-23 | 100.00 | 3.03 | 75.80 | 0.00 |
| JSQ-White-Gold | 95.01 | 3.05 | 72.38 | 0.44 |
| KZ-181 | 68.58 | 2.63 | 44.70 | 0.40 |
| MNH-Sultan | 100.00 | 3.13 | 78.24 | 0.91 |
| SS-32 | 100.00 | 3.11 | 77.76 | 0.00 |
| NIAB-868 | 100.00 | 3.10 | 77.50 | 0.00 |
| Sahara-500 | 100.00 | 3.11 | 77.85 | 0.50 |
| SAS-3 | 100.00 | 3.32 | 83.05 | 1.19 |
| SS-102 | 100.00 | 3.03 | 75.64 | 0.00 |
| Tara-340 | 100.00 | 3.08 | 76.95 | 0.00 |
| VH-447 | 48.08 | 2.80 | 33.72 | 0.68 |
| YBG-2626 | 100.00 | 3.02 | 75.48 | 0.00 |
| Bahar-GTG-155 | 100.00 | 2.98 | 74.50 | 0.00 |
| JSQ-70 | 100.00 | 3.07 | 76.75 | 0.00 |

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

Furthermore, it is evident that the intensity of the disease varied among different varieties of crops, as shown in Fig 5.2. When considering all planting dates, there were significant differences in the performance of different varieties. Specifically, CIM-990, Cyto-547, and Cyto-545 demonstrated high tolerance and performed better when sown in April, as indicated in Fig 5.2.

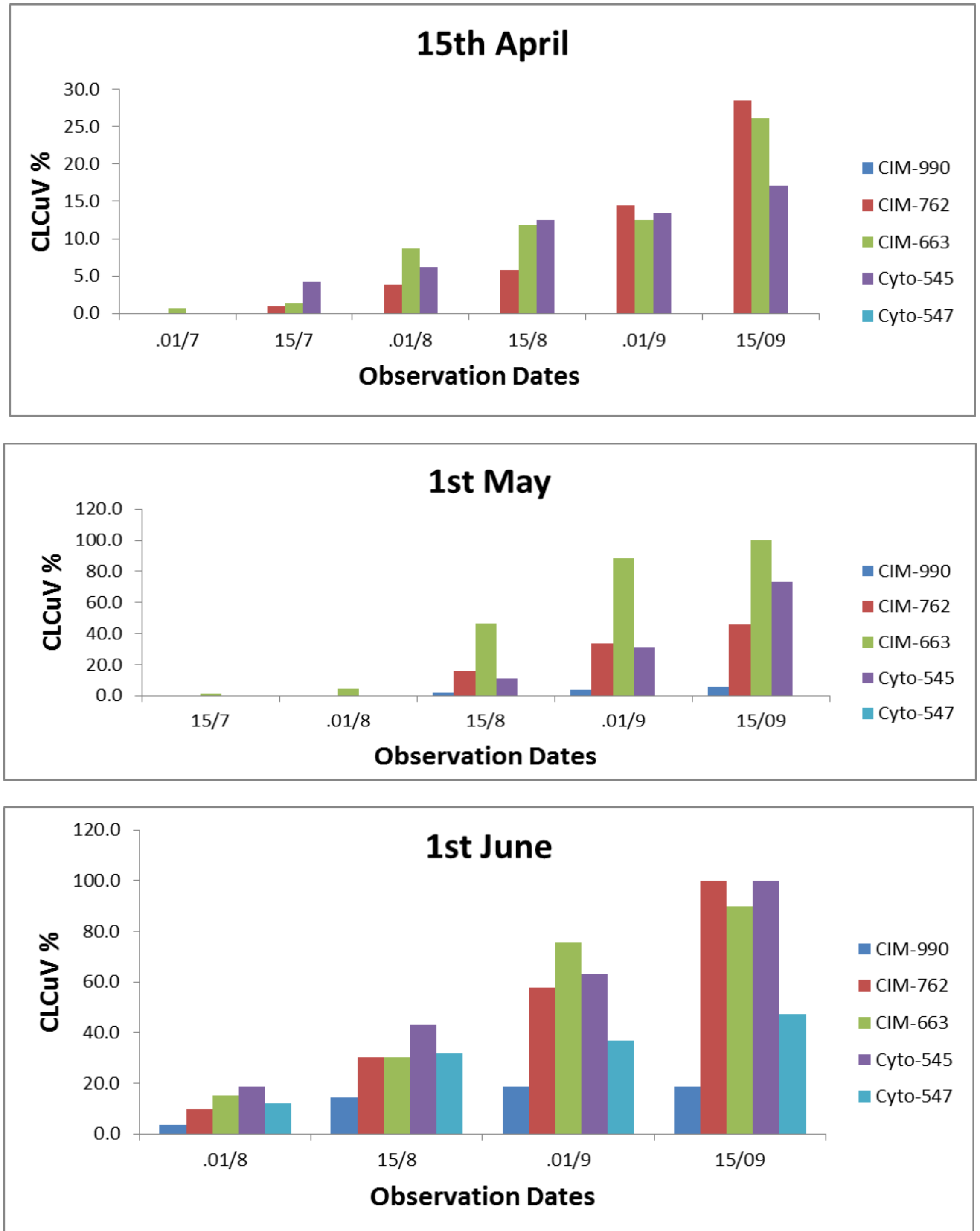


**Fig 5.1 Incidence of CLCuD as influenced by planting dates and strain on *Bt*. cotton**

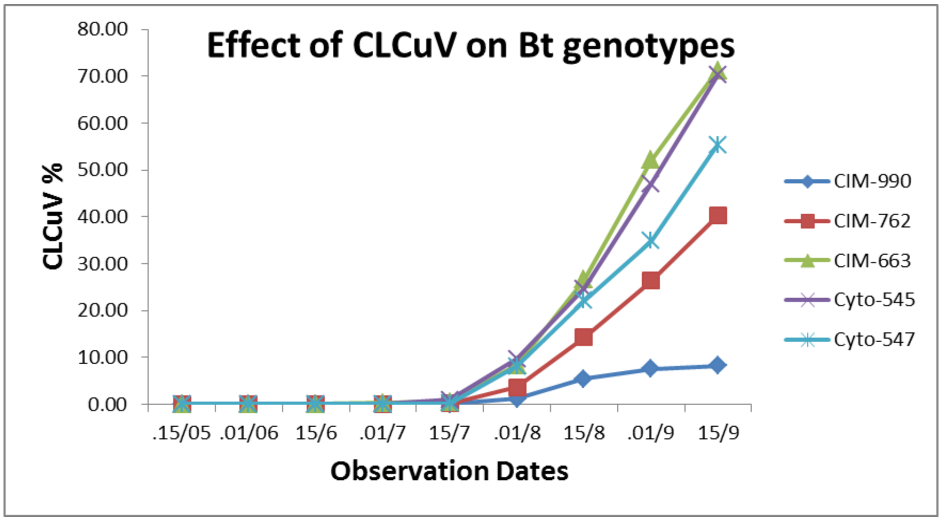


**Fig 5.2 Effect of CLCuD Incidence as influenced by planting dates and *Bt* strain**

It was observed that on average, there was a maximum fortnightly increase in disease in both Bt and Non Bt strains during mid-September. Among the environmental parameters, the maximum temperature range was recorded as 37.4~39.5°C, while the minimum temperature range was 27.4~29.8°C. The relative humidity during this period was 76.6~78%. It has been noted that there is an inverse relationship between the difference in maximum and minimum temperatures and the incidence of cotton leaf curl disease. In other words, when the temperature difference is smaller, the incidence of the disease is higher, and vice versa. Additionally, rainfall also plays a significant role in disease epidemiology. It was observed that early-sown crops were less affected by CLCuD (Cotton Leaf Curl Disease) compared to late-sown crops, primarily due to the attainment of early plant vigor, as indicated in Table 5.5.

**Table 5.5: Disease Index of Cotton Leaf Curl on cultivars planted at different times**

| | **01/4** | **1/5** | **1/6** | **Average** |
|---|---|---|---|---|
| **CIM-990** | 0.00 | 4.33 | 15.23 | 6.52 |
| **CIM-762** | 33.17 | 79.79 | 81.51 | 64.83 |
| **CIM--663** | 75.22 | 77.02 | 80.11 | 77.45 |
| **Cyto-545** | 37.77 | 78.24 | 81.07 | 65.69 |
| **Cyto-547** | 18.22 | 24.40 | 32.93 | 25.18 |
| **Average** | **32.88** | 52.76 | 58.17 | |

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

**Table 5.6 Relationships between Fortnightly Increase in CLCuD and Temperature and Humidity on *Bt*. Cotton**

| **Sowing date** | **16-30/4** | **1-15/5** | **16-31/5** | **1-15/6** | **16-30/6** | **1-15/7** | **16-31/7** | **1-15/8** | **16-31/8** | **1-15/9** |
|---|---|---|---|---|---|---|---|---|---|---|
| **15th April** | | 0.0 | 0.0 | 0.0 | 0.1 | 1.2 | 2.4 | 2.3 | 2.1 | 6.3 |
| **1st May** | | | 0.0 | 0.0 | 0.0 | 0.2 | 0.7 | 14.2 | 16.3 | 13.5 |
| **1st June** | | | | | 0 | 0.0 | 0.0 | 11.8 | 18.0 | 20.5 |
| **Average** | | | | | | 0.05 | 0.47 | 4.97 | 11.50 | 12.96 |
| **Temp Max C** | 28.2 | 32.9 | 38.2 | 34.7 | 37.7 | 37.4 | 37.4 | 39.1 | 37.3 | 38.5 |
| **Temp Min C** | 16.7 | 18.9 | 21.6 | 20.4 | 25.1 | 22.7 | 27.0 | 29.8 | 27.4 | 29.4 |
| **Difference** | 11.5 | 14.0 | 16.6 | 14.3 | 12.6 | 14.7 | 10.4 | 9.3 | 9.9 | 9.1 |
| **RH %age 8pm** | 82.1 | 80.8 | 79.1 | 81.4 | 79.4 | 76.1 | 76.6 | 77.4 | 78.0 | 77.7 |
| **5:00 PM** | 56.9 | 58.3 | 45.5 | 54.3 | 48.4 | 46.0 | 46.3 | 46.0 | 61.1 | 62.0 |
| **Difference** | 25.2 | 22.6 | 33.6 | 27.1 | 31.0 | 30.1 | 30.4 | 31.5 | 16.9 | 15.7 |
| **Rainfall** | 9.2 | 6.0 | 0.0 | 10.0 | 29.5 | 0.0 | 14.0 | 8.6 | 11.3 | 0.0 |

**(B) Non *Bt***

The experiment aimed to observe the response to Cotton Leaf Curl Disease (CLCuD) in three different sowing dates using two elite cotton genotypes (Cyto-231 and Cyto-232) and one standard variety (CIM-610). The sowing dates ranged from 15th April to 1st June, and the experiment design followed a split-plot, with sowing time as the main plot and genotypes as subplots. The incidence of CLCuD was recorded fortnightly at day 30 from each sowing date throughout the season. The results showed that the appearance and progression of CLCuD varied significantly with the sowing dates. In the 15th April planting, the minimum infestation of CLCuD was observed in mid-July at a level of 1.84%. However, as the plants matured, the infestation level gradually increased and reached 8.22% in mid-September. In the 1st May planting, there was a gradual increase in CLCuD incidence. The disease started in early August with a minimum incidence level of 15.37%, which moderately increased to 52.47% in mid-September. In the 1st June planting, the disease started in early August data showed 11.98% incidence and reached 39.11% at day 90. By mid-September, the incidence level had risen to 82.31%.

The results indicate that the timing of sowing has a significant impact on the appearance and progression of CLCuD (Cotton Leaf Curl Disease). Generally, earlier sowing dates tend to show lower initial infestation levels compared to later sowing dates. When comparing different genotypes, Cyto-231 exhibited less CLCuD incidence in the 15th April and 1st May planting dates compared to CIM-610 and Cyto-232. On average across the planting period, there was a significant varietal difference in early planting, but in the late planting, all varieties showed maximum CLCuD infestation (Fig 5.4).

On an average basis of sowing dates, a maximum fortnightly increase in disease recorded in Non Bt strains during mid-September. Among the environmental parameters, the maximum temperature range was 37.4~39.5°C, while the minimum temperature range was 27.4~29.8°C. The relative humidity during this period was 76.6~78%. It has been observed that there is an inverse relationship between the difference in maximum and minimum temperatures and the incidence of cotton leaf curl disease. In other words, when the temperature difference is smaller, the incidence of the disease is higher, and vice versa. Additionally, rainfall also plays an important role in disease epidemiology. It was noted that early-sown crops were less affected by CLCuD compared to late-sown crops due to attainment of early plant vigor, as indicated in Table 5.7.

**Table 5.7 Disease index of Cotton Leaf Curl on Non *Bt* cultivars planted at different time**

| Varieties | 1st April | 1st May | 1st June | Ave |
|---|---|---|---|---|
| CIM-610 | 14.13 | 59.29 | 77.60 | 50.34 |
| Cyto-232 | 30.11 | 79.38 | 82.64 | 64.04 |
| Cyto-231 | 15.00 | 75.61 | 75.00 | 55.20 |
| AVR. | 19.75 | 71.42 | 78.41 | |

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

**Table 5.8 Relationships between Fortnightly Increase in CLCuD and Temperature and Humidity on Non *Bt*. Cotton**

| Sowing date | 16-30/4 | 1-15/5 | 16-31/5 | 1-15/6 | 16-30/6 | 1-15/7 | 16-31/7 | 1-15/8 | 16-31/8 | 1-15/9 |
|---|---|---|---|---|---|---|---|---|---|---|
| **15th April** | | | 0.0 | 0.0 | 0.0 | 1.8 | 0.0 | 0.0 | 4.1 | 2.3 |
| **1st May** | | | | 0.0 | 0.0 | 0.0 | 15.4 | 5.3 | 27.7 | 4.1 |
| **1st June** | | | | | 0.0 | 0.0 | 12.0 | 19.1 | 8.0 | 43.2 |
| **Average** | | | | | 0.0 | 0.6 | 9.1 | 8.1 | 13.3 | 16.5 |
| **Temp Max C** | 28.2 | 32.9 | 38.2 | 34.7 | 37.7 | 37.4 | 37.4 | 39.1 | 37.3 | 38.5 |
| **Temp Min C** | 16.7 | 18.9 | 21.6 | 20.4 | 25.1 | 22.7 | 27.0 | 29.8 | 27.4 | 29.4 |
| **Difference** | 11.5 | 14.0 | 16.6 | 14.3 | 12.6 | 14.7 | 10.4 | 9.3 | 9.9 | 9.1 |
| **RH %age 8pm** | 82.1 | 80.8 | 79.1 | 81.4 | 79.4 | 76.1 | 76.6 | 77.4 | 78.0 | 77.7 |
| **5:00 PM** | 56.9 | 58.3 | 45.5 | 54.3 | 48.4 | 46.0 | 46.3 | 46.0 | 61.1 | 62.0 |
| **Difference** | 25.2 | 22.6 | 33.6 | 27.1 | 31.0 | 30.1 | 30.4 | 31.5 | 16.9 | 15.7 |
| **Rainfall** | 9.2 | 6.0 | 0.0 | 10.0 | 29.5 | 0.0 | 14.0 | 8.6 | 11.3 | 0.0 |

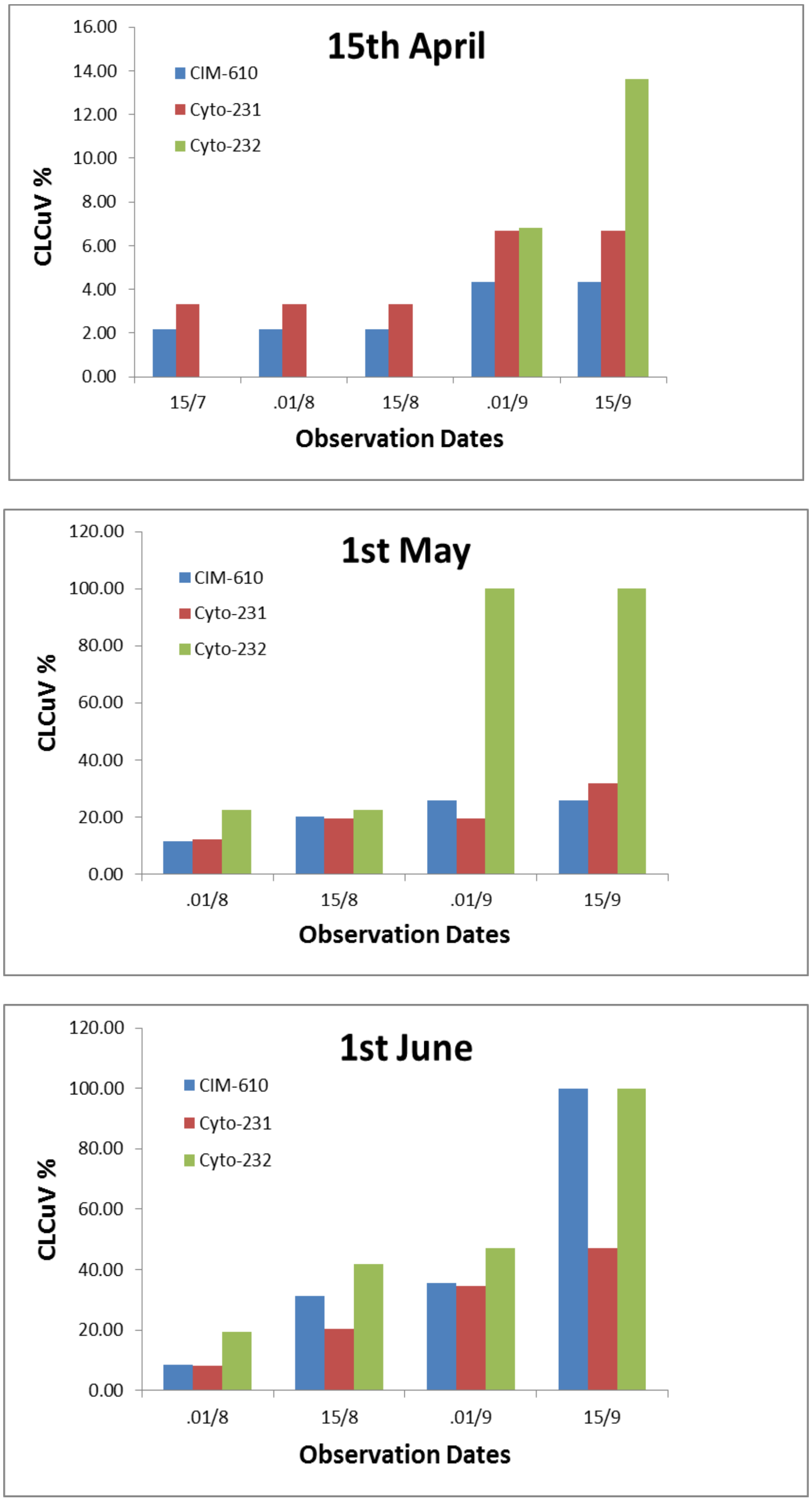


**Fig 5.3 Incidence of CLCuD as influenced by planting dates and strain on Non-*Bt.* cotton**

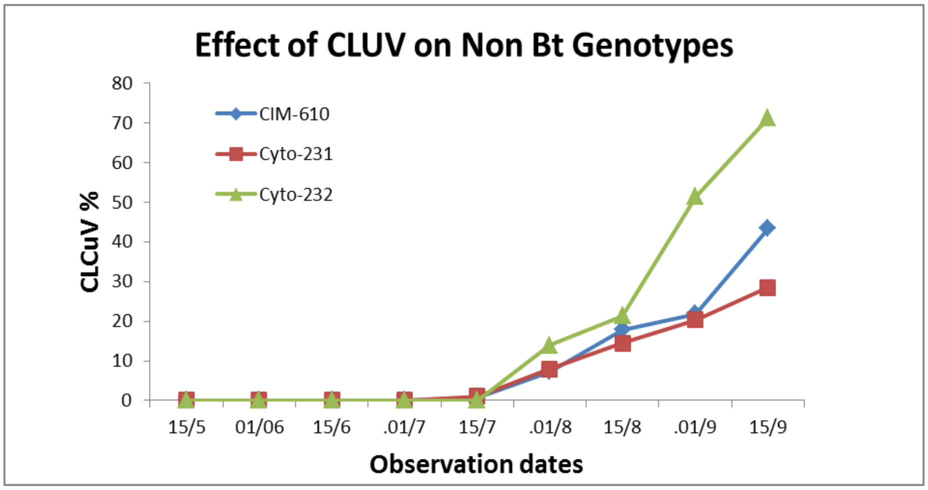

**Fig 5.4** **Effect of CLCuD Incidence as influenced by planting dates and strain**

## 5.5 Boll Rot of Cotton

### (a) Effect on *Bt*-Strains

An experiment was conducted to quantify the occurrence of boll rot disease in different Bt-strains planted on three different dates from 15tht April to 1st June. The results are given in Table 5.8)

Averaged across the strains, the crop planted on 15th April was more affected by boll rot as compared to other planting times. Similarly averaged across sowing dates, Cyto-454 was free from boll rot of cotton and other remaining strains showed less than 1 % boll rot incidence. The boll rot disease ranged from 0.00 to 0.87 % in all sowing dates on an average basis of varieties (Table 5.8).

**Table 5.9: Boll Rot Disease (%) on *Bt* cotton Cultivars planted at different times**

| Strains | 15th April | 1st May | 1st June | Average |
|---|---|---|---|---|
| CIM-990 | 0.97 | 0.00 | 0.00 | 0.32 |
| CIM-762 | 0.88 | 0.00 | 0.00 | 0.29 |
| CIM--663 | 2.25 | 0.00 | 0.00 | 0.75 |
| Cyto-545 | 0.00 | 0.00 | 0.00 | 0.00 |
| Cyto-547 | 1.52 | 1.10 | 0.00 | 0.87 |
| **Average** | 1.12 | 0.22 | 0.00 | |

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

Another experiment (non-Bt varieties) was conducted to quantify the boll rot disease in different strains planted from 15th April to 1st June. The boll rot disease was recorded and results are given in Table 5.9.

Averaged across sowing dates, boll rot was recorded in CIM-231 as compared to other strains. Averaged across the strains, Boll rot incidence appeared in traces on the crop planted on 15th April and 1st June as compared to May planting times. On an average basis, boll rot disease ranged from 0.00 to 0.53 % on different sowing dates (Table 5.9).

**Table-5.10 Boll Rot Disease (%) on Non-*Bt* Cotton Cultivars planted at different times**

| Strains | 15th April | 1st May | 1st June | Average |
|---|---|---|---|---|
| **CIM-231** | 0.85 | 0.00 | 1.59 | 0.81 |
| **CIM-232** | 0.00 | 0.00 | 0.00 | 0.00 |
| **CIM-610** | 0.00 | 0.00 | 0.00 | 0.00 |
| **Average** | 0.28 | 0.00 | 0.53 | |

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# 6. PLANT PHYSIOLOGY /CHEMISTRY SECTION

Soil health being the backbone of crop production cannot be ignored as deteriorated soil may limit agricultural productivity at a level much higher than the other factors. Introducing stress tolerance by the use of conventional plant based products and specific biochemicals are gaining attention to overcome yield losses due to variable stresses faced by the cotton plant during its growth period.

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

## 6.1 Genotype-Environment Relationship

### 6.1.1 Adaptability of genotypes to high temperature stress

Cotton is the most important cash crop with the largest value chain from raw cotton production to final clothing. This value chain employs more than 50% of the total industrial labor and accounts for more than 60% of total exports. Cotton crop is more sensitive to temperature change and availability of water during flowering and boll formation stages and thus its production is negatively affected by higher temperatures at the above critical growth stages. The cotton plant has a very good resilience to high temperature and drought-type situations due to its vertical taproot. Cotton plant is a perennial shrub that requires warmer days and nights for optimum growth and development. Recent research has indicated that a higher temperature is an important abiotic factor adversely affecting cotton yields. High temperatures (> 35$^{o}$C) are common throughout the cotton growing season in many regions of the world which adversely affect growth and development of the crop and ultimately limiting the plant performance. The future cotton production is likely to face an increasing intensity of multiple abiotic stresses, including extreme and prolonged high temperatures. In Pakistan, cotton is generally cultivated in warm areas and average temperature during the cotton season ranges between 40 and 45°C, which sometimes exceeds 50°C. The genotypes recommended for general cultivation in cotton growing areas face very high temperature of more than 45°C during May, June and July, which is almost 15 to 20°C higher than the optimum temperature required for its normal growth.The existing and future increases in temperature during cotton crop urge to take initiatives for the evolution of germplasm with better tolerance to heat stress. The optimum temperature for the photosynthetic carbon fixation in cotton is about 32$^{o}$C and photosynthesis decreases significantly at temperatures of 36$^{o}$C and above. The high temperature environments (35-40$^{o}$C) are frequently associated with infertility and cotton-boll retention problem and number of productive bolls.

Due to prevailing temperature stress during cropping season, the present studies were conducted to screen the advanced cotton germplasm and to identify the potential genotypes, which possess better tolerance to temperature and could produce appropriate yields in heat prone areas of the region.In the study reported, screening of sixteen cotton genotypes was carried out by planting the crop on May, 19, 2023, due to delayed planting the crop partially faces the hottest period during the fruiting phase. The experiment was conducted under field conditions in the research area of CCRI, Multan.

Plant structure and development parameters in different genotypes were recorded at maturity. Genotypes showed unequal behavior in terms of plant structure development under the prevailing high temperature conditions (Table 6.1). The genotype Cyto-547 and CIM-909 excelled in main stem height (147 cm, 127 cm) as compared to other genotypes. The changing behavior of respective genotypes regarding vegetative parameters showed their tolerance to heat stress environment

**Table 6.1 Plant growth and development of different genotypes at maturity**

| Genotypes | Height (cm) | Node | IND (cm) |
|---|---|---|---|
| Cyto-547 | 147 | 52 | 2.83 |
| CIM-909 | 127 | 45 | 2.82 |
| N-696 | 120 | 43 | 2.79 |
| N-585 | 118 | 41 | 2.88 |
| N-992 | 115 | 39 | 2.95 |
| CIM-789 | 115 | 41 | 2.80 |
| CIM-990 | 114 | 42 | 2.71 |
| Cyto-537 | 100 | 38 | 2.63 |
| MNH-1050 | 99 | 41 | 2.41 |
| SLH-93 | 97 | 39 | 2.49 |
| Ayub-3 | 97 | 37 | 2.62 |
| Ayub-2 | 96 | 36 | 2.67 |
| CIM-762 | 92 | 39 | 2.36 |
| Cyto-545 | 89 | 38 | 2.34 |
| SLH-115 | 83 | 36 | 2.77 |
| Ayub-1 | 79 | 35 | 2.26 |
| LSD | 9.18* | 6.8* | $2.07^{ns}$ |

Genotypes differed greatly in their overall yield performance. The genotype Cyto-547 produced the highest seed cotton yield, with more number of bolls/plant than the other genotypes tested. Seed cotton yield of different genotypes ranged from 538 to 1315 kg $ha^{-1}$ (Table 6.2).

**Table 6.2 Seed cotton yield and yield attributing parameters in different genotypes**

| **Genotypes** | **Number of bolls per plant** | **Boll weight** (g) | **Seed cotton yield** (kg $ha^{-1}$) |
|---|---|---|---|
| Cyto-547 | 34 | 2.33 | 1315 |
| Cyto-537 | 29 | 2.57 | 1195 |
| CIM-909 | 22 | 1.99 | 1136 |
| NIAB-992 | 28 | 2.06 | 956 |
| Cyt0-545 | 17 | 2.71 | 897 |
| MNH-1050 | 16 | 2.43 | 837 |
| CIM-990 | 28 | 2.64 | 837 |
| NIAB-696 | 28 | 2.42 | 837 |
| CIM-789 | 15 | 2.45 | 837 |
| AYUB-2 | 29 | 1.88 | 777 |
| AYUB_3 | 27 | 2.48 | 777 |
| NIAB-585 | 28 | 1.95 | 717 |
| CIM-762 | 17 | 2.56 | 717 |
| AYUB-1 | 15 | 2.47 | 658 |
| SLH-93 | 19 | 2.35 | 598 |
| SLH-115 | 17 | 2.33 | 538 |
| **LSD** | 3.98* | $2.12^{ns}$ | 28.7* |

*significant at $p<0.05$

### 6.1.2 Effect of Nitrogen dose and application time on cotton fibre characteristics

Cotton (*Gossypium hirsutum* L.) is known as “White Gold” and it is the cash crop of Pakistan and considered the backbone of the country’s economy. Cotton shares 0.6% in the gross domestic production of Pakistan, 3.1% value addition in agriculture, around 2.079 million hectares area under cultivation with 7.064 million bales production during 2020–2021. The area under cultivation and overall production was lower than in previous years due to low water availability, unfavorable climatic conditions, and loss of grower interest as compared to other major crops, in particular sugarcane. Cotton exhibits an indeterminate growth habit and is mostly grown for fiber production. Pakistan shifted from 4th position to 5$^{th}$ position in cotton producing countries due to several factors.Crop management factors, such as nutrient, water, seed bed preparation, and weed control, are crucial for sustainable cotton production after climatic factors. The uninterrupted supply of plant essential nutrients to the crop is very important for successful cotton production. Several studies on different doses of fertilizer were carried out to optimize the nutrient requirement for sustainable cotton production in various cotton producing zones. N is an essential nutrient required in a large quantity for increasing and optimizing cotton production. Nitrogen application in proper dose and proper time not only increases the number of leaves, leaf area, light interception, photosynthetic activity, fiber quality, lint yield, but increasedbiotic and abiotic stresses in cotton.

An experiment was designed with three different doses of N fertilizer (100, 150 and 200 kg N/ha) applied at two different time (at squaring and flowering stage), but due to unavailability of resources and manpower during the current cotton growing season of PCCC this experiment is not executed. Therefore, the experiment is planned to be conducted in upcoming cotton season.

### 6.1.3 Characterization of cotton germplasm for heat tolerance

Cotton is an international agricultural product of which quality and quantity are subject to various whims of nature. It occupies an important position in global status of commercial crops with annual impact of >US$50 billion in the economy of the world. The lint quality in general, while the quantities of produce, i.e., the seed cotton yield (SCY) particularly is highly sensitive to climatic conditions. In Pakistan,cotton was grown across 2.3 million hectares during 2021-22 with an average per hectare yield of approximately 707 kg/ha compared with 2,320 and 1,765 kg/ha for Australia and China, respectively. The quality of lint produced is also inferior, having a short fiber length, coarse fiber fineness, and lower uniformity, resulting in a higher import of longer fiber and lower price of locally produced cotton lint. The cotton belt of Pakistan is mainly located in the high-temperature zone where mean maximum temperature often exceeded 48°C during the cotton-growing season. The optimum temperature for a successful cotton production is about 35°C. However, temperatures above this threshold level badly affect the peak time of cotton flowers and boll setting, resulting in excessive evapo-transpiration and abscission/no boll set at lower half of the plant. There is also observed a strong negative correlation between high temperature and the lint yield, resulting in a yield decrease of about 110 kg/ha for each unit increase in maximum temperature. Identification of genotypes that have a greater ability to withstand the peaks of heat stress coupled with their limited water use is important to enhance the cotton productivity. However, suitable selection standards are required for measuring resilience of cotton germplasm against heat stress. Plant phenological traits especially flowering and boll retention capacity in high temperature environments are effective in repeatable heat stress screening environments. But genotypes that have better genotype × environment interaction in the field often best perform under heat stress. Therefore, screening of cotton genotypes can be exploited by targeting those traits that are closely associated with plant adaptation to high-temperature environment. Cell membrane thermostability (CMT) has been reported as the most relevant and suitable selection criteria for measuring heat tolerance. Therefore, the present study was carried out to screen cotton germplasm for its heat tolerance characteristics, under field conditions, in collaboration with Plant Breeding and Genetics Section of the Institute. Due to unavailability of proper resources and man power during the current cotton growing season of PCCC this experiment is not executed. Therefore, the experiment will be conducted in coming cotton growing season.

## 6.2 Soil Health and Plant Nutrition

### 6.2.1 Regenerative Agriculture: Practices for Improving Soil health and Long-term sustainability in cotton production

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

Soil tillage refers to physical, chemical or biological soil manipulation to optimize conditions for germination, seedling establishment and crop growth. Tillage is a labor-intensive activity in low-resource agriculture practiced by small landholders, and a capital and energy-intensive activity in large-scale mechanized farming. Continual soil inversion can in some situations result in degradation of soil structure, ultimately, leading to a compacted soil composed of fine dispersed particles with low levels of Soil Organic Matter (SOM). Such soils are more prone to soil loss through water and wind erosion eventually resulting in desertification. This process can directly and indirectly cause a wide range of environmental problems. Conventional soil management practices result in losses of soil, water and nutrients in the field, and degrade the soil by lowering organic matter content and a fragile physical structure, which in turn leads to low crop yields and lower water and fertilizer use efficiencies apart from the increased fuel and labor costs. Therefore, scientists and policy makers are emphasizing to revisit the prevailing cultivation practices and turning to regenerative agriculture practices. Compared to conventional tillage, there are several benefits of regenerative agriculture such as economic benefits of labor costs and time saving, erosion protection, soil and water conservation, and ultimate increases of soil fertility. Therefore, an experiment was conducted to evaluate the effect of regenerative agriculture practices on soil health and crop productivity as well as to lower the cost of production.Cotton genotype Cyto-545 was selected to evaluate the impact of regenerative agriculture practices on productivity. Sowing was done on June 15, 2023. Pre-plant soil samples were collected to determine the soil variability across the experimental field. Physio-chemical analyses of the samples revealed that the soil is silt loam in texture and alkaline in reaction. Soil pH in normal tillage plot was 8.47 while in reduced tillage plot it was 8.41. Electrical conductivity remained at 2.37 mS $cm^{-1}$ in normal tillage and 2.38 mS $cm^{-1}$ in reduced tillage plots, organic matter content remained at 0.72 % in normal tillage plot and 0.88 % in reduced tillage plot, extractable phosphorus at 19.9 mg $kg^{-1}$ soil in normal tillage while 22.5 mg $kg^{-1}$ soilin reduced tillage plots, extractable potassium at 124 mg $kg^{-1}$ and 141 mg $kg^{-1}$ in normal and reduced tillage plots, respectively. Post-harvest soil sample analyses revealed that there was no change in soil texture while pH in normal tillage plot was 8.34 while in reduced tillage plot it was 8.23. Electrical conductivity remained at 2.23mS $cm^{-1}$ in normal tillage and 2.35mS $cm^{-1}$ in reduced tillage plots, organic matter content remained at 0.78% in normal tillage plot and 0.91% in reduced tillage plot, extractable phosphorus at 23.9 mg $kg^{-1}$ soil in normal tillage while 29.8 mg $kg^{-1}$ soil in reduced tillage plots, extractable potassium at 142 mg $kg^{-1}$ and 152 mg $kg^{-1}$ in normal and reduced tillage plots, respectively.Plant growth and development parameters were recorded from normal tillage and reduced tillage plots at maturity. The plant height was 141 cm and 138 cm, number of nodes 46 and 44, inter nodal length 3.06 and 3.13 cm, number of bolls per plant 15 and 14, boll weight 2.81 and 2.67 g, seed cotton yield 1138 kg $ha^{-1}$ and 1124 kg $ha^{-1}$, seed index 8.1 and 8.9 g in normal tillage and reduced tillage plots, respectively. Data on fiber traits revealed that, staple length was 27.1 and 27.8 mm, uniformity index 81.6 and 83.9%, micronaire 5.0 and 5.1, fiber strength 26.8 and 26.2 g/tex in normal tillage and reduced tillage plots, respectively (Table 6.3).

**Table 6.3 Summary of parameters taken from normal tillage and reduced tillage plots**

| **Plant parameters** | **Height (cm)** | | **Node** | | **Inter node (cm)** | | **Bolls per plant** | | **Boll weight (g)** | | **Yield (kg $ha^{-1}$)** | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | NT | RT | NT | RT | NT | RT | NT | RT | NT | RT | NT | RT |
| | 72 | 68 | 29 | 27 | 2.48 | 2.51 | 10 | 11 | 2.34 | 2.28 | 415 | 399 |

| **Soil parameters** | **pH** | | **EC (mS $cm^{-1}$)** | | **OM (%)** | | **Extractable- P (mg $kg^{-1}$)** | | **Extractable-K (mg $kg^{-1}$)** | |
|---|---|---|---|---|---|---|---|---|---|---|
| | NT | RT | NT | RT | NT | RT | NT | RT | NT | RT |
| Pre-plant | 8.47 | 8.41 | 2.37 | 2.38 | 0.72 | 0.88 | 19.9 | 22.5 | 124 | 141 |
| Post-harvest | 8.34 | 8.23 | 2.23 | 2.35 | 0.78 | 0.91 | 23.9 | 29.8 | 142 | 152 |

NT= Normal Tillage RT= Reduced Tillage

### 6.2.2 Improving resource use efficiency and soil health by integrating rice crop in cotton

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

**Treatments**

| | |
|---|---|
| T1 | Cotton-sole |
| T2 | Cotton on beds (1') + Rice in furrows |
| T3 | Cotton (plant space 1.25') +Rice in furrows |

Pre-plant composite soil samples were collected from the plough layer of the experimental field before imposition of treatments. Physical and chemical characteristics of the soil samples were determined. Results indicated that the soil is silt loam in texture and alkaline in reaction. Soil pH varied from 8.31 to 8.43, electrical conductivity from 2.09 to 2.48 mS cm$^{-1}$, organic matter content from 0.55 to 0.76 %, extractable potassium (K) from 133 to 151 mg kg$^{-1}$ soil and extractable sodium from 364 to 458 mg kg$^{-1}$ soil across the field (Table 6.4).

**Table 6.4 Physical and chemical characteristics of experimental field at pre-planting**

| Sample No. | pH | EC (mS cm$^{-1}$) | OM (%) | Ext. K (mg kg$^{-1}$ soil) | Ext. Na (mg kg$^{-1}$ soil) |
|---|---|---|---|---|---|
| 1 | 8.43 | 2.23 | 0.71 | 151 | 408 |
| 2 | 8.31 | 2.09 | 0.76 | 141 | 364 |
| 3 | 8.37 | 2.35 | 0.55 | 133 | 375 |
| 4 | 8.42 | 2.48 | 0.61 | 149 | 458 |
| **Mean** | **8.38** | **2.29** | **0.66** | **143** | **401** |

Data on plant structure development in different treatments were recorded at maturity. Main stem height, nodes on main stem and inter-nodal length varied among different treatments. Plant height varied from 100 to 117 cm, number of nodes on main stem varied from 41 to 43, and inter-nodal distance from 2.44 to 2.72 cm in different treatments. Maximum plant height was observed in the control treatment (117 cm), while minimum height of 100 cm was observed in cotton(1' PxP)+Rice treatment (Table 6.5).

Seed cotton yield, number of bolls per plant and boll weight varied significantly among various treatments. Number of bolls per plant varied from 25 to 29, boll weight from 2.42 to 2.62 g and seed cotton yield from 1009 to 1121 kg ha$^{-1}$, in different treatments. In Cotton(1' PxP)+Rice treatment maximum seed cotton yield and maximum boll weight was observed, while in Cotton-sole treatmentminimum yield and boll weight was observed. Paddy yield in Cotton(1' PxP)+Riceand

Cotton(1.25' PxP)+Rice treatments obtained 1570 and 1288 kg ha$^{-1}$ respectively. Maximum paddy yield was observed in Cotton(1' PxP)+Rice treatment as compared to Cotton(1.25' PxP)+Rice treatment (Table 6.6).

**Table 6.5 Effect of different treatments on plant structure development**

| Treatment | Height | Node | Inter node |
|---|---|---|---|
| Cotton-sole | 117 | 43 | 2.72 |
| Cotton(1' PxP)+Rice | 100 | 41 | 2.44 |
| Cotton(1.25' PxP)+Rice | 110 | 42 | 2.62 |
| Statistical effect | * | ns | * |

**Table 6.6 Effect of different treatments on yield and yield attributing factors**

| Treatment | Boll per plant | Boll weight (g) | Seed cotton yield (kg ha$^{-1}$) | Paddy Rice yield (kg ha$^{-1}$) |
|---|---|---|---|---|
| Cotton-sole | 29 | 2.42 | 1009 | 0 |
| Cotton(1' PxP)+Rice | 25 | 2.62 | 1121 | 1570 |
| Cotton(1.25' PxP)+Rice | 29 | 2.52 | 1065 | 1288 |
| Statistical effect | * | * | * | * |

Temperature of soil was recorded and soil samples were collected at reproductive stages of cotton and rice. Moreover, soil moisture content and bulk density were measured. Results revealed that soil temperature varied from 37.5 to 39.1$^{0}$C, andsoil moisture content ranged from 13.2 to 16.7 % and from 15.3 to 20.4 % in bed and furrows, respectively, while bulk density ranged from 1.45 to 1.58 (g/cc) and from 1.52 to 1.65 (g/cc) in bed and furrows, respectively, in different treatments (Table 6.7).

**Table 6.7 Effect of different treatments on soil moisture content and bulk density**

| Treatment | Moisture % | | Bulk Density (g/cc) | | Soil Temp ($^{0}$C) |
|---|---|---|---|---|---|
| | Bed | Furrow | Bed | Furrow | |
| Cotton-sole | 13.2 | 15.1 | 1.58 | 1.65 | 39.1 |
| Cotton(1' PxP)+Rice | 16.7 | 20.4 | 1.45 | 1.52 | 37.5 |
| Cotton(1.25' PxP)+Rice | 15.9 | 18.7 | 1.49 | 1.56 | 38.0 |
| Statistical Effect | * | * | ns | * | * |

Land Equivalent Ratio (LER), Area Time Equivalent Ratio (ATER) and Cotton Yield Equivalent Ratio (CYER) were calculated for different treatments. LER indicates the efficient utilization of land and higher value of LER indicatesbetter utilization of land, ATER efficient utilization of land within given time, less value of ATER than LER shows the best utilization within given time and CYER indicate the additional benefits from intercrop in cotton. Inthe treatment Cotton(1' PxP)+ rice in furrows LER, ATER and CYERremainedhigher as compared to other treatments which indicated thatCotton (1' PxP)+ rice in furrows is more suitable and economical system for farmers (Tale 6.8).

**Table 6.8 Effect of different treatments on economic analysis**

| Treatment | LER | ATER= (LERxDc/Dt) | CYER=SCY+(IYxIYP/PSC) |
|---|---|---|---|
| Cotton-sole | -- | N/A | 1009+000=1009 |
| Cotton(1' PxP)+Rice | 1.74 | 0.98 | 1121+785=1906 |
| Cotton(1.25' PxP)+Rice | 1.57 | 0.88 | 1065+644=1709 |

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

### 6.2.4 Enhancing nutrient use efficiency (NUE) by synchronizing application rate and methods

Nutrients supply is essential for growth and development in crop plants. Long term nutrients management is very important for ending hunger of the world. Low fertilizer use efficiency is a worldwide concern that is not limited to developing countries. Until now, many countries of the world have been highly dependent on importing mineral fertilizers for agriculture. Nutrients are important for optimum growth, metabolism and development of crops. Worldwide, nutrients are considered a key factor for increasing yield and productivity. Higher rate of minerals are required for cotton growth and development than other crops like rice and wheat. More than 30–40% of the agricultural lands across the world are deficient in macro-nutrients and micro-nutrients. In such soils, nutrients are regulated through exogenous addition of fertilizers to meet the requirement of cotton crop. Out of the total, only 20% of the applied fertilizers are used by the crops while the remaining 80% are lost via fixation, leaching, or in gaseous forms to the environment, resulting in less fertilizer use efficiency. To overcome this problem, foliar fertilization is a widely used practice that can increase nutrients uptake in plants. Among the different techniques, foliar fertilization has better potential to correct nutritional deficiencies in plants caused by the improper supply of nutrients to roots. This practice is usually more economical and effective under certain conditions and is generally considered efficient to supply nutrients quickly to a target organ. This technique is particularly adapted and important for crops to achieve maximum and best yield when crop nutrient demand is not completely fulfilled during the crop growth period. The foliar nutrients application could augment the soil-applied nutrients that may increase the nutrients use efficiency and reduce the crop dependence on soil nutrients. Resultantly, it will help in reducing the recommended dose of nutrients when applied in conjunction with foliar nutrients application.

A new experiment was designed to synchronize the fertilizers application method and rate on cotton crop under field conditions with the objectives to find out the best fertilizers application method that would enhance fertilizer use efficiency and increase the farm income. Two cotton genotypes viz. Cyto-535 and Cyto-537were used for execution of the experiment. Detail of experiment is given below:

| Tr. | Nutrients |
|---|---|
| T1 | Control (without fertilizer) |
| T2 | Recommended dose of NPK nutrients (RD) |
| T3 | 50% of RD by fertigation |
| T4 | 40% of RD by fertigation + 10% foliar |
| T5 | 35% fertigation+15% Foliar |

Field was divided into five blocks to check indigenous soil nutrient status and variability. For this purpose pre-plant composite soil samples were collected from the plough layer of the experimental field before sowing. Physical and chemical characteristics of the soil samples were determined. Results indicated that the soil is silt loam in texture and alkaline in reaction. Soil pH varied from 8.13 to 8.37, electrical conductivity from 2.16 to 2.53 mS $cm^{-1}$, organic matter content from 0.55 to 0.73%, extractable potassium (K) from 124 to 144 mg $kg^{-1}$ soil and extractable sodium from 368 to 439 mg $kg^{-1}$ soil across the field (Table 6.9).

**Table 6.9 Physical and chemical characteristics of soil at pre-planting**

| Sample No. | pH | EC (mS $cm^{-1}$) | OM (%) | Ext. K (mg $kg^{-1}$ soil) | Ext. Na (mg $kg^{-1}$ soil) |
|---|---|---|---|---|---|
| 1 | 8.31 | 2.27 | 0.73 | 133 | 427 |
| 2 | 8.13 | 2.16 | 0.61 | 144 | 392 |
| 3 | 8.26 | 2.32 | 0.55 | 131 | 368 |
| 4 | 8.25 | 2.53 | 0.68 | 124 | 439 |
| 5 | 8.37 | 2.35 | 0.55 | 133 | 375 |
| **Mean** | **8.27** | **2.33** | **0.62** | **133** | **400** |

Data on plant structure development were recorded at maturity. In treatment T4 received 35% of recommended dose by fertigation+15% by foliar spray of fertilizers, the main stem height, number of nodes on main stem and inter-nodal length remained higher over control as well as over other treatments except T2 received recommended dose of fertilizer in both genotypes. Averaged across genotypes, main stem height varied from 93 to 117 cm, number of nodes on main stem varied from 40 to 47 and intermodal distance from 2.26 to 2.51 cm among different treatments (Table 6.10).

**Table 6.10 Plant structure at maturity in two genotypes under different fertilizer application methods**

| Tr. | Height (cm) | | | Nodes on main stem | | | Inter-nodal length (cm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | CIM-785 | CIM-990 | Av. | CIM-785 | CIM-990 | Av. | CIM-785 | CIM-990 | Av. |
| T1 | 90 | 96 | 93 | 38 | 41 | 40 | 2.35 | 2.32 | 2.34 |
| T2 | 113 | 121 | 117 | 45 | 48 | 47 | 2.50 | 2.52 | 2.51 |
| T3 | 92 | 97 | 95 | 40 | 43 | 42 | 2.27 | 2.25 | 2.26 |
| T4 | 104 | 105 | 105 | 42 | 45 | 44 | 2.48 | 2.34 | 2.41 |
| T5 | 108 | 112 | 110 | 42 | 45 | 44 | 2.55 | 2.46 | 2.51 |
| Genotype | * | | | * | | | ns | | |
| Application method | * | | | ns | | | ns | | |
| Interaction | ns | | | ns | | | ns | | |

The fresh weight of leaves and stalk was determined from harvested plant samples. Data revealed that fresh weight of leaf and stalk was higher in treatment where recommended dose of fertilizer was applied as compared to other treatments. In treatment, where 35% of recommend fertilizers was applied (RD) by fertigation+15% of RD by foliar, the fresh weight of leaf and stalk increased by 7% and 4% in CIM-785, and 5% and 6% in CIM-990,respectively, as compared to those where 50% of recommended fertilizer was applied by fertigation (Table6.11).

**Table 6.11 Fresh weights of leaves and stalk at maturity in two genotypes under different fertilizers application methods**

| Treatments | Leaves weight (g) | | Stalk weight (g) | |
|---|---|---|---|---|
| | CIM-785 | CIM-990 | CIM-785 | CIM-990 |
| T1 | 68.8 | 79.0 | 118.8 | 143.0 |
| T2 | 91.3 | 99.7 | 147.1 | 198.2 |
| T3 | 83.2 | 90.7 | 138.3 | 177.8 |
| T4 | 85.8 | 93.3 | 140.2 | 182.5 |
| T5 | 88.3 | 94.6 | 142.6 | 188.6 |
| Genotype | * | | * | |
| Application method | * | | * | |
| Interaction | ns | | * | |

Seed cotton yield, bolls per plant, and boll weight varied among different treatments and between cotton genotypes. The maximum seed cotton yield was observed in the treatment where recommended dose of fertilizers was applied as compared to other treatments in both cotton genotypes. However, the treatment T5where 35% of recommended dose was applied by fertigation+15% of RD by foliar spray performed better with regards to yield and yield attributing factors as compared to other treatments except T2 (Table 6.12).

**Table 6.12 Seed cotton yield and its components in two genotypes under different fertilizer application methods**

| Tr. | Boll per plant | | Boll weight (g) | | Yield (kg $ha^{-1}$) | |
|---|---|---|---|---|---|---|
| | CIM-785 | CIM-990 | CIM-785 | CIM-990 | CIM-785 | CIM-990 |
| T1 | 15 | 21 | 1.82 | 2.34 | 488 | 600 |
| T2 | 26 | 28 | 2.08 | 2.66 | 788 | 900 |
| T3 | 19 | 23 | 1.90 | 2.44 | 563 | 638 |
| T4 | 21 | 26 | 1.90 | 2.58 | 713 | 750 |
| T5 | 22 | 27 | 1.94 | 2.58 | 750 | 825 |
| Genotype | * | | * | | * | |
| Application method | ns | | ns | | * | |
| Interaction | ns | | ns | | * | |

Agronomic efficiency and benefit/cost ratio varied among different treatments and between cotton genotypes. The maximum agronomic efficiency and benefit/cost ratio was observed in T5 treatment where 35% of recommended fertilizer dose was applied by fertigation+15% by foliar as compared to other treatments in both cotton genotypes. Furthermore, T5 treatment showed the best method of fertilizer application as compared to other methods as indicated by higher values of agronomic efficiency and benefit/cost ratio in both genotypes (Table6.13).

**Table 6.13 Economic analyses in two genotypes under different fertilizer application methods**

| Tr. | Agronomic efficiency of fertilizers | | Benefit/cost ratio | |
|---|---|---|---|---|
| | CIM-785 | CIM-990 | CIM-785 | CIM-990 |
| T1 | 2.82 | 3.47 | 1.71 | 1.99 |
| T2 | 3.19 | 3.64 | 2.15 | 2.35 |
| T3 | 4.55 | 5.16 | 2.07 | 2.26 |
| T4 | 5.77 | 6.07 | 2.31 | 2.39 |
| T5 | 6.07 | 6.68 | 2.39 | 2.53 |
| Genotype | * | | * | |
| Application method | * | | * | |
| Interaction | ns | | * | |

## 6.3 Plant-Water Relationships

### 6.3.1 Adaptability of genotypes to water stress conditions

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

One of the important reasons for undernourishment, malnutrition and hunger is global and regional drought events, which reduce agricultural production. In addition to annual drought-related agricultural losses, long-term technology-increased global grain production, the principal indicator of food security, is currently growing slower than the population increase rate. Future prospects are not encouraging since it will require an increase in food production of nearly 70% to feed 2 billion more people by the mid of the century. This situation is further complicated by climate warming, which is assumed to intensify droughts, increasing their area, strength, duration and leading to a further reduction of agricultural production. In years, when moderate-to-intensive drought covers more than 20% of the world's main agricultural areas, there is less food production than what the world needs for consumption.

The situation already deteriorated in the twenty-first century, when in the first 17 years, world grain production was below the consumption and in almost half of the years grain production was 3–6% below consumption. Moreover, in all of these years, drought was the major cause affecting food security and world's sustainability. Although, drought cannot be prevented, instead, it can be detected early and damages to agriculture could be predicted well in advance of harvest in order to provide on time food assistance to avoid hunger. Therefore, one of the most important tasks for prediction of food insecurity is to detect drought early and estimate agricultural production losses several months ahead of harvest. Drought effect not only decreases plant height, shoot growth rate, and yield but also diminishes root growth. It has been found from the earlier studies that varieties/cultivars in each species vary from one another in their reaction to drought conditions, signifying that drought tolerance in these groups can be improved through breeding. Physiological traits linked with drought tolerance in cotton have strong relationship with yield parameters.

For example, shoot growth rate, root growth rate and photosynthetic rate, which significantly decrease with the imposition of water stress, can be used, effectively, for germplasm screening under drought conditions. Since, the germplasm with genetic variability may exhibit differential response under normal and water deficit conditions, regular screening of emerging germplasm needs to be carried out for better adaptability and sustainable production. The following studies were, therefore, conducted to evaluate advanced cotton genotypes for drought tolerance characteristics under field conditions. Outcome of such studies can help to understand the relationship of different physiological and growth traits of cotton and their direct and indirect effects related to cotton productivity.A field experiment was conducted at the experimental area of Central Cotton Research Institute, Multan during the cotton crop season 2023-24. A total of twelve cotton genotypes viz. CIM-990, CIM-909, CIM-975, Cyto-535, Cyto-537, Cyto-545, NIAB-585, NIAB-696,NIAB-786, Gh-Hamaliya NIAB-992 and VH-327 were evaluated for their performance under two water regimes applied on the basis of leaf water potential (LWP) i.e. -1.6 $\pm$ 0.2 MPa $\Psi_w$ (normal irrigation; NS) and -2.4 $\pm$ 0.2 MPa $\Psi_w$ (water stressed; WS). The treatments were laid out in RCBD with split-plot arrangement (water stress main plots; genotypes: sub-plots). Crop was sown on May 22, 2023. Water stress was imposed at squaring phase i.e. at 40 days after planting that continued till cut off irrigation. 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 2685 $m^3$ in NS plots and 1900 $m^3$ in water stressed plots. The precipitation received was 20mm during the crop growth period.

Data on plant structure and development were recorded at maturity. Main stem height, nodes on main stem and inter-nodal length varied significantly with water regime and among the genotypes. Main stem height ranged from 92 to 137 cm, nodes on main stem from 40 to 51 and inter-nodal length from 2.20 to 2.86 cm in different genotypes under normal irrigation. In water stress conditions, the main stem height ranged from 86 to 130 cm, nodes on main stem from 38 to 46 and inter-nodal length from 2.18 to 2.86 cm in different genotypes. Averaged across water regimes, main stem height varied from 89 to 134 cm, nodes on main stem from 39 to 49 and inter-nodal length from 2.18 to 2.86 cm. Imposition of water stress caused a decrease of 10.40% in main stem height and 2.10% in inter-nodal length, irrespective of genotypes (Table 6.14).

Leaf area (LA) and leaf fresh weight per leaf varied significantly among genotypes and between water regimes. Leaf area ranged from 24.7 to 115.0 $cm^2$ and leaf fresh weight from 1.39 to 4.77 g in different genotypes, irrespective of water regimes. The imposition of water stress decreased LA and leaf fresh weight by 28.7% and 28.3 %, respectively (Table 6.15).Proline content, relative water content (RWC) and chlorophyll SPAD values varied significantly among genotypes and between water regimes. The proline ranged from 8.0 - 14.9 (µg $g^{-1}$ FW), RWC from 80.5 - 96.0%, and chlorophyll content (SPAD) from 46.5 to 58.4 in different genotypes, irrespective of water regimes. The imposition of water stress increased proline content from 9.4 to 13.3 (µg $g^{-1}$ FW), decreased RWC from 92.6 to 84.5%, and also lowered chlorophyll content from 54.0 to 52.3, on overall basis (Table 6.17).

Data revealed that seed cotton yield, number of bolls per plant and boll weight varied significantly among the genotypes and under water regimes. Number of bolls per plant varied from 14 to 27, boll weight from 1.70 to 3.14 g, and seed cotton yield from 704 to 1089 kg $ha^{-1}$, in different genotypes, irrespective of water regimes. With the imposition of water stress, seed cotton yield decreased from 970 to 835 kg $ha^{-1}$, bolls per plant from 22 to 17 and boll weight from 2.46 to 2.35 g irrespective of the genotypes. Water stress decreased the seed cotton yield, number of boll per plant and boll weight by 16.2%, 29.4% and 4.68%, respectively.

The genotypes GH-Hamaliya and NIAB-585 produced the maximum seed cotton yield of 1089 kg $ha^{-1}$ with 22 and 22 bolls per plant and boll weight of 2.32 and 2.33 g in normally irrigated plots, similarly under water stress condition same genotypes maintained highest yield. The positive interactions among water regimes and genotypes for yield parameters reveal that the genetic variability and their differential response to varied conditions can help in varietal selection for better yield performance and use of identified desirable traits in breeding programs (Table 6.19).

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

| Genotype | Height (cm) | | | Node | | | Inter-Node (cm) | | |
|---|---|---|---|---|---|---|---|---|---|
| | NS | WS | Avg | NS | WS | Avg | NS | WS | Avg |
| VH-327 | 137 | 130 | 134 | 51 | 46 | 49 | 2.71 | 2.80 | 2.75 |
| CIM-990 | 134 | 118 | 126 | 47 | 41 | 44 | 2.86 | 2.86 | 2.86 |
| NIAB-585 | 129 | 109 | 119 | 46 | 42 | 44 | 2.80 | 2.60 | 2.70 |
| NIAB-696 | 125 | 116 | 121 | 47 | 41 | 44 | 2.66 | 2.81 | 2.73 |
| NIAB-786 | 124 | 110 | 117 | 45 | 41 | 43 | 2.76 | 2.67 | 2.72 |
| CIM-975 | 118 | 106 | 112 | 46 | 43 | 44 | 2.58 | 2.48 | 2.53 |
| GH-Hamaliya | 117 | 109 | 113 | 45 | 41 | 43 | 2.62 | 2.64 | 2.63 |
| CIM-909 | 107 | 95 | 101 | 42 | 39 | 41 | 2.54 | 2.45 | 2.49 |
| Cyto-537 | 106 | 100 | 103 | 41 | 38 | 40 | 2.56 | 2.64 | 2.60 |
| Cyto-545 | 103 | 87 | 95 | 40 | 38 | 39 | 2.55 | 2.28 | 2.42 |
| NIAB-992 | 102 | 95 | 99 | 40 | 39 | 40 | 2.54 | 2.47 | 2.50 |
| Cyto-535 | 92 | 86 | 89 | 43 | 39 | 41 | 2.16 | 2.20 | 2.18 |
| Mean | 116 | 105 | | 44 | 41 | | 2.61 | 2.57 | |
| WR | | * | | | ns | | | * | |
| G | | * | | | * | | | * | |
| WRxG | | * | | | * | | | * | |

WR= Water Regime G= Genotype

**Table 6.15 Leaf area and leaf fresh weight in different genotypes under two water regimes**

| Genotype | Leaf area ($cm^2$) | | | Leaf fresh weight (g) | | |
|---|---|---|---|---|---|---|
| | NS | WS | Avg | NS | WS | Avg |
| NIAB-786 | 115.0 | 89.0 | 102.0 | 4.77 | 3.67 | 4.22 |
| Cyto-535 | 77.3 | 53.7 | 65.5 | 3.14 | 1.91 | 2.53 |
| Cyto-537 | 77.0 | 66.7 | 71.9 | 3.16 | 1.96 | 2.56 |
| CIM-909 | 71.3 | 45.0 | 58.2 | 2.96 | 1.76 | 2.36 |
| Cyto-545 | 71.0 | 40.3 | 55.7 | 2.79 | 1.90 | 2.35 |
| NIAB-696 | 71.0 | 29.7 | 50.4 | 2.95 | 1.62 | 2.29 |
| CIM-975 | 70.3 | 56.7 | 63.5 | 2.84 | 2.29 | 2.57 |
| GH-Hamaliya | 67.7 | 32.7 | 50.2 | 2.44 | 1.81 | 2.13 |
| CIM-990 | 66.7 | 42.3 | 54.5 | 2.49 | 2.10 | 2.30 |
| VH-327 | 50.3 | 42.3 | 46.3 | 2.86 | 1.76 | 1.81 |
| NIAB-585 | 46.3 | 57.7 | 52.0 | 2.85 | 2.43 | 2.64 |
| NIAB-992 | 30.3 | 24.7 | 27.5 | 2.01 | 1.39 | 1.70 |
| Mean | 67.9 | 48.4 | | 2.86 | 2.05 | |
| WR | * | | | * | | |
| G | ** | | | ** | | |
| WR x G | * | | | ns | | |

**Table 6.17 Proline content, relative water content and chlorophyll content in differentgenotypes under two water regimes**

| Genotypes | RWC (%) | | Proline content (µg $g^{-1}$ FW) | | Chlorophyll content (SPAD values) | |
|---|---|---|---|---|---|---|
| | NS | WS | NS | WS | NS | WS |
| Cyto-545 | 93.7 | 83.1 | 10.6 | 12.6 | 57.1 | 51.5 |
| GH-Hamaliya | 94.6 | 86.4 | 9.9 | 12.7 | 55.4 | 55.4 |
| Cyto-535 | 95.5 | 85.5 | 8.9 | 11.4 | 57.1 | 48.0 |
| Cyto-537 | 90.5 | 84.6 | 8.5 | 13.8 | 56.6 | 52.5 |
| NIAB-786 | 96.0 | 89.7 | 10.0 | 14.9 | 52.4 | 50.0 |
| NIAB-585 | 90.1 | 80.5 | 8.0 | 11.6 | 50.1 | 54.8 |
| CIM-909 | 93.3 | 81.7 | 10.0 | 12.9 | 49.2 | 46.5 |
| NIAB-696 | 93.3 | 88.3 | 8.7 | 14.1 | 50.9 | 54.5 |
| CIM-990 | 91.5 | 82.5 | 9.9 | 14.8 | 58.4 | 53.5 |
| NIAB-992 | 91.0 | 81.8 | 9.0 | 12.1 | 54.8 | 54.2 |
| VH-327 | 90.1 | 86.3 | 9.3 | 14.9 | 49.1 | 55.2 |
| CIM-975 | 92.3 | 84.7 | 10.9 | 14.9 | 57.9 | 52.5 |
| **Mean** | **92.6** | **84.5** | **9.4** | **13.3** | **54.0** | **52.3** |
| G | ** | | ** | | * | |
| WR | * | | * | | ns | |
| GxWR | * | | * | | * | |

WR= Water Regime G= Genotype

**Table 6.19 Seed cotton yield and yield components in different genotypes under two water regimes**

| Genotype | Boll per plant | | | Boll weight (g) | | | Yield (kg ha$^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | NS | WS | Avg | NS | WS | Avg | NS | WS | Avg |
| GH-Hamaliya | 22 | 18 | 20 | 2.32 | 2.28 | 2.30 | 1089 | 961 | 1025 |
| NIAB-585 | 20 | 15 | 18 | 2.33 | 2.10 | 2.12 | 1089 | 961 | 1025 |
| Cyto-535 | 16 | 14 | 15 | 2.94 | 2.80 | 2.87 | 1025 | 897 | 961 |
| NIAB-786 | 20 | 15 | 18 | 3.14 | 2.98 | 3.06 | 1089 | 833 | 961 |
| Cyto-545 | 25 | 18 | 22 | 2.56 | 2.40 | 2.48 | 1089 | 833 | 961 |
| CIM-909 | 27 | 23 | 25 | 2.56 | 2.24 | 2.40 | 961 | 833 | 897 |
| NIAB-696 | 24 | 18 | 21 | 2.40 | 2.30 | 2.35 | 961 | 833 | 897 |
| CIM-990 | 22 | 17 | 20 | 2.30 | 2.28 | 2.29 | 833 | 833 | 833 |
| Cyto-537 | 17 | 15 | 16 | 2.80 | 2.62 | 2.71 | 897 | 794 | 845 |
| NIAB-992 | 19 | 15 | 17 | 1.72 | 1.70 | 1.71 | 961 | 769 | 865 |
| CIM-975 | 23 | 19 | 21 | 2.40 | 2.40 | 2.40 | 858 | 769 | 813 |
| VH-327 | 25 | 21 | 23 | 2.22 | 2.04 | 2.13 | 794 | 704 | 749 |
| Mean | 22 | 17 | | 2.46 | 2.35 | | 970 | 835 | |
| Treatment (Tr) | | * | | | * | | | * | |
| Genotype (G) | | * | | | * | | | ** | |
| TrxG | | * | | | * | | | ** | |

### 6.3.2 Synchronizing nutrient application methods to alleviate water stress(deficiency & flooding) in cotton

Increasing scarcity of irrigation water is a principal threat to sustainable production of cotton. Changing climatic conditions is a major environmental factor restricting more than one third of the arable land for cultivation across the world. Climate change such as drought and rainy season is a common abiotic stress during the cotton-growing season, which causes a series of negative effects on cotton plant growth, yield and fiber quality. Cotton is dreadfully climate sensitive crop and is prone to yield reduction by drought and flooding because water stress is a complex phenomenon that affects the physiology of cotton plant. In addition, cotton is a very susceptible plant to the quantity of irrigation water and therefore, irrigation management is very complicated. The flowering and boll-forming stage is the key yield determinant period that was affected by water stress such as flooding in rainy season and drought in water deficient situation. Flooding or water shortage occurring during the squaring, flowering and boll formation stages are seriously affects cotton development and final productivity. To address the above-mentioned situation an experiment was designed with the following objectives and treatments:

- To quantify the efficacy of nutrient application methods under water stress
- To improve nutrient use efficiencies

Treatments:
Irrigation levels: 3

No stress : [(-1.6 $\pm$ 0.2 MPa LWP ($\psi_w$)]
Water stress :(-2.4 $\pm$ 0.2 MPa LWP $\psi_w$)
Flooding stress: standing water for 10 days

Nutrients application methods: 4

T1: Control
T2: Recommended nutrients (fertigation)
T3: 10% of RD by foliar sprays (FS) + 50% by Fert.
T4: 10% of RD by FS + 40% fert.
(NPK, Mg & B, Zn dose of fertilizers)

Due to unavailability of funds during the year 2023, the planned experiment will be conducted in the upcoming cotton season.

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## 7. TRANSFER OF TECHNOLOGY SECTION

The Transfer of Technology Section is crucial in sharing various research findings and practices from cotton researchers. Its main goal is to help both cotton farmers and stakeholders by providing information through communication technologies and mass media. This includes development of new cotton production and seed technology.

### 7.1 Human Resource Development

**Training Programs**

The following training programs were arranged during 2023:

i) Cotton production technology
ii) Advance agronomic practices for better cotton yield
iii) LEEF (Low Expenditure and Environment Friendly) Tehnology
iv) Advance agronomic practices for better cotton yield
v) Soil health & its improvement
vi) Characteristics of advanced cotton varieties and strategy for revival of cotton production
vii) Integrated insect pest management in organic cotton
viii) Fiber properties and their testing

| Date | Organized/ Coordinated by | Venue | Resource Person | Participants |
|---|---|---|---|---|
| 22.02.2023 | Regional Agriculture Economic Development Centre (RAEDC) | Vehari | Dr.M.Naveed Afzal | **Total=26**<br>**Master Trainees**<br>(Agri Officers) |
| 03.03.2023 | CCRI, Multan & Public/Private Sector | CCRI, Multan | Dr. Zahid Mahmood | **Total=62**<br>**Master Trainees**<br>(Public & Private Sector) |
| 10.03.2023 | CCRI, Multan & ENGRO | CCRI, Multan | i. Dr. M Naveed Afzal<br>ii. Dr. Fiaz Ahmad<br>iii. Mr. Sajid Mahmood | **Total=26**<br>**Master Trainees**<br>(Engro Officers) |
| 05.05.2023 | CCRI, Multan & Agri. Ext. Deptt. | CCRI, Multan | i.Dr.Zahid Mahmood<br>ii.Dr.M.Naveed Afzal<br>iii.Dr.Fiaz Ahmed<br>iv.Mr.Sajid Mahmood | **Total=65**<br>Agri.Ext.DDA=01<br>AO= 04<br>Field Staff=60 |
| 6-6-2023 | BCI (CCRI, Multan) | CCRI, Multan | i.Dr.M.Naveed Afzal<br>ii.Dr.Fiaz Ahmed | **Total=43**<br>BCI Producer Unit Managers |
| 02-11-2023 | CABI | Hotel One, Multan | i. Dr. Rabia Saeed<br>ii. M. Ilyas Sarwar | **Total=27**<br>BCI Producer Unit Managers |

#### 7.1.2 TV Programs/ SOT's

Twenty Seven (27) SOTS' /programs were conducted during the season.

#### 7.1.3 Radio Programs

Six (06) Radio Programs: one (01) group discussion conducted during the season.

#### 7.1.4 Press Coverage/Media Talk

The section arranged eleven (11) press coverage during the season.

#### 7.1.5 Preparation of Video Clips

Seventeen (17) video clips were prepared and uploaded on social media for farmer's advice /information during the season.

### 7.1.6 Urdu/English Articles

Thirty eight (38) Urdu/English articles on “Cotton Production Technology” were sent & published in newspapers during the season.

### 7.1.7 Press Releases

Forty Six (46) press releases throughout the season 2023-24 were sent to the press for time to time for the guidance of cotton farming community.

### 7.1.8 Distribution of Printed Material

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

- Recommendations of Cotton Variety Bt.CIM-785
- Recommendations of Cotton Variety Bt.CIM-678
- Recommendations of Cotton Variety Bt.CIM-632
- Recommendations of Cotton Variety Bt.CIM-663
- Recommendations of Cotton Variety Bt.Cyto-535
- Recommendations of Cotton Variety Cyto-226
- Recommendations of Cotton Variety CIM-496
- Recommendations of Cotton Variety CIM-534
- Recommendations of Cotton Variety CIM-573
- Recommendations of Cotton Variety CIM-608
- Recommendations of Cotton Variety CIM-620
- Recommendations of Cotton Variety Cyto-124
- Recommendations of Cotton Variety Cyto-179
- Recommendations of Cotton Variety Bt.CIM-598
- Recommendations of Cotton Variety Bt.CIM-599
- Recommendations of Cotton Variety CIM-496
- Recommendations of Cotton Variety Bt.CIM-602
- Management of Pink Bollworm
- Recommendations for better seed germination
- Kapsa Ki Kasht Aur Nighehdasht
- LEEF Technology
- Kapas K Beej Ka Ugaaou Aur Behtar Sifarshat
- Kapaas mein Potash ki Ahmiyat
- Kaps Ki Mealy Bug Aur Oos Ka Insdaad
- Kapaas Ki Patta Maror Bemari Sy Bachaou Ki Hikmat-E-Amli
- Kapaas ki Meleybug
- Kapaas Ki gulabi sundi aur os ka insdaad
- Kapaas ki gulabi sundi ka tadaruk bazarya pb-ropes
- PBW Manager for PBW management
- Sifarshaat braey Kapaas ki gulabi sundi ka insdaad
- CCRI Multan an introduction

**Preparation of Leaflets**

The following leaflets in Urdu were prepared and printed during the season:

| Sr # | Leaflet | No. of Copies |
|---|---|---|
| **1** | گلابی سنڈی اور اس کا طریقہ انسداد | **1000** |
| **2** | گلابی سنڈی کا انسداد بذریعہ پی بی روپس | **1000** |
| **3** | سفارشات برائے کپاس کی گلابی سنڈی کا انسداد | **1000** |
| **4** | کپاس کی لیف ٹیکنالوجی | **1000** |

**Agriculture Exhibitions**

The institute organized stalls in agricultural exhibition during the season 2023-24:

| Date | Organized by | Venue | Event | Resource Persons |
|---|---|---|---|---|
| March 17-19, 2023 | District Govt. Multan | Qila Kohna Qasim Bagh | Jashn-e-Baharan | Dr. Khadim Hussain |
| 7th October, 2023 | CCRI Multan | CCRI, Multan | World Cotton Day | i. Dr. Tasawar Hussain Malik<br>ii. Dr. M. Naveed Afzal<br>iii. Dr. Javed Hassan<br>iv. others |

## 7.2 Meetings

### 7.2.1 Agriculture Research Sub-Committee (ARSC)

One day meeting of Agriculture Research Sub-Committee (ARSC) of Pakistan Central Cotton Committee (PCCC) was held at Central Cotton Research Institute (CCRI), Multan on March 20, 2023 under the chairmanship of Dr. Tasawar Hussain Malik, Director Research (PCCC). The agenda of the meeting was the consideration of Annual Summary Progress Report for the year 2022-23 and the approval of Annual Program of Research Work for the year 2023-24. The meeting was attended by all members of the subcommittee PCCC offices, other public stakeholders, private seed sector and progressive farmers.

### 7.2.2 Meeting of Cotton Seed Committee

A significant meeting of cotton seed committee was held at Lahore under the chairmanship of Punjab Governor Muhammad Balighur Rehman on March 17, 2023. The governor emphasized on integrating research on seeds of modern technology with the collaboration of the public and private sectors. Dr. Muhammad Idrees Khan, Head, PBG, CCRI Multan actively participated in the meeting with other participants of seed cotton committee.

### 7.2.3 Punjab Seed Council Meeting

i. 56th meeting of Punjab Seed Council was held on 24th March, 2023 at Lahore chaired by caretaker provincial minister for industrial SM Tanveer for approval of crop varieties. Cotton varieties developed by CCRI, Multan viz Bt.CIM-343 and Bt.Cyto-537 were approved for general cultivation in Punjab. Both of these varieties are high yielding, heat tolerance, big boll, with high lint %age will boost cotton production.

ii. In the 57th meeting of the Punjab Seed Council held on 11th August 2023 at Lahore under the Agriculture Minister, Punjab. Two (02) new BT varieties CIM 775 & Cyto 511 of Central Cotton Research Institute, Multan were approved. These cotton varieties have high fiber properties, good productivity, and good resistance against viruses (CLCuV). The production potential of these varieties is more than 45 quintals per acre. Director of Central Cotton Research Institute Multan Dr. Zahid Mehmood presented a case for approval of new varieties in the meeting. Agricultural scientists and agricultural experts from across Punjab participated in the meeting

### 7.2.4 Review Meeting of Cotton Crop

A review meeting of cotton crops in Multan, Bahawalpur & D.G. Khan Divisions was held at MNSUA, Multan on 3rd June 2023. This meeting was held under the chairmanship of the Secretary of Agriculture, Punjab. Dr. Zahid Mahmood, Cotton Commissioner MNFS&R / Director CCRI Multan attended the meeting with all other stakeholders.

**7.2.5 Advisory Committee Meetings**

Ten (10) meetings of farmers' advisory committee were held at the Institute under Director CCRI Multan during the season 2023-24. Fortnightly recommendations were presented in the meeting for the guidance of all cotton growers community.

**7.2.6 Spot Examination Meeting**

Spot examination under the chairmanship of D.G. Research Punjab Agricultural Research at PSC research farm was convened at Khanewa on 9th August,2023l. Two varieties i.e. Bt.CIM-990 and Bt.Cyto-545 were presented by Dr. Muhammad Idrees Khan, Head, PBG, CCRI Multan. Dr Khezir Hayat, scientific officer, Cytogenetics section, CCRI Multan was also accompanied.

**7.3 Participation in Conference/Workshop**

| Date | Workshop/Conference | Venue | Organized by | Participants |
|---|---|---|---|---|
| 11th to 14th December, 2023 | Workshop on "Using climate information and crop productivity models for climate adaptation strategies and planning in agriculture" | Lahore | FAO | Dr.Muhammad Tariq |
| 18th to 19th December, 2023 | Better Cotton on "P&C Consultation Workshop" | Lahore | BCI | i. Dr. M.Naveed Afzal<br>ii. Dr. Fiaz Ahmad<br>iii. Dr. M. Tariq |

**7.4 a. World Cotton Day**

CCRI Multan celebrated the World Cotton Day today the 7th October 2023. Dr. Tasawar Hussain Malik, Director Research, PCCC was the chief guest of the program. Dr. M. Naveed Afzal, Director CCRI Multan; Dr. Javed Hassan, Cotton Advisor, APTMA, M. Abdullah,country manager and other important dignitaries highlighted the importance of cotton crop in the economy of Pakistan. Cotton production problems were discussed and measures were suggested for its enhancement and revival in the country. More than 150 participants from various stakeholders, NGOs and farmers attended the program.

**b. Cotton Walk**

On the eve of World Cotton Day at the institute, a cotton walk was arranged in commemorating the importance of cotton for the economy of Pakistan. Dr. Tassawar Hussain Malik, Director Research, PCCC & Dr. M. Naveed Afzal, Director of the institute along with other number of participated in the walk.

**7.5 14th August 2023 Ceremony**

Hoisting of National Flag ceremony & Tree Plantation was held on 14th August, 2023. Dr. Zahid Mahmood, Director, CCRI Multan hoisted the national flag. All the staff members and their kids also participated in the ceremony and prayed for the country's prosperity. The national anthem was also sung in the ceremony. Dr. Zahid Mahmood, Director of the institute stated that we must all work with complete dedication and devotion for the country.

**7.6 Visits**

**a. Dignitaries**

| Dignitaries/Delegation | Dated |
|---|---|
| Two member Chinese delegation | 12.04.2023 |
| Additional Deputy Commissioner Malik Sami, Assistant Commissioner Dr. Fiaz Ali Jatala (Shujabad) | 05.05.2023 |
| Additional Chief Secretary South Punjab Capt.(Retd) Saqib Zafar | 09.05.2023 |

| | |
|---|---|
| Chairman PCBA Major (R) Kashif Islam | 30.05.2023 |
| Uzbek diplomat Mr. Bakhrom Yusupov visited CCRI Multan | 13.07.2023 |
| Honorable Secretary of South Punjab, Saqib Ali Ateel | 28.08.2023 |
| Honorable Vice President ,PCCC Mr.Ejaz Ahmad Bajwa, | 23.02.2023 |
| FAO delegation, Mr. Jam Muhammad Khalid, National FFS Specialist/Provincial Coordinator Punjab and Mr. Rauf Ahmad Khan (Agronomist) with GCF Project | 02.03.2023 |
| Six member delegation from Peshawar were involved in honeybee-keeping | 02.11.2023 |

**b. Student Study Tour**

Students visited CCRI Multan during the season:

| Name of University/College | Participants |
|---|---|
| University of Agriculture, Faisalabad | 164 |
| B.Z.U. Multan | 55 |
| Ghazi University, DG Khan | 179 |
| Agricultural Training Institute Karor Layyah | 56 |

## 7.7 Social Media Activities

**a. Face book Page CCRI, Multan**

A page on Face book www.facebook.com/CCRI.MTN is being regularly updated by the Section to disseminate regular cotton R&D activities of the Institution social media.

**b. Twitter/YouTube**

An account on Twitter https://twitter.com/CCRI_Multan & YouTube Channel https://youtube.com/@CCRICottonNews9200 are updated on regular basis by the Section to disseminate regular cotton R&D activities of the Institution for the guidance of cotton growers.

**c. Multimedia Presentations**

During the month, the scientists of the Institute prepared almost 2037 multimedia slides for various activities.

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# 8 FIBRE TECHNOLOGY SECTION

The core objective of Fibre Technology section is to provide technical support to Plant Breeding & Cytogenetics sections in testing of fibre characteristics and spinning potential of newly developed cotton varieties. The section also extended the facilities to the cotton breeders working in Central Cotton Research Institute, Sakrand, Cotton Research Stations at Ghotki, Sibbi, Sahiwal, Lasbella, and other relevant public and private parties. Research activities were focused on studying the enhancing nutrient use efficiency by synchronizing application rate & methods and their impact on fibre properties, and the effect of different intercrops in cotton on fibre characteristics. 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 and government research stations were tested for different fibre characteristics. The detail of the samples tested is given in Table 8.1.

**Table 8.1 Number of Samples Tested for Various Fibre Characteristics**

| Source | Fibre Length (mm) | Fibre Strength (g tex$^{-1}$) | Micro-naire | Color Grade | Total |
|---|---|---|---|---|---|
| Breeding & Genetics Section, CCRI, Multan | 6804 | 6804 | 6804 | - | 20412 |
| Cyto-genetics Section, CCRI, Multan | 4023 | 4023 | 4023 | - | 12069 |
| Fibre Technology Section, CCRI, Multan | 40 | 40 | 40 | 40 | 160 |
| Plant Physiology/Chemistry Section, CCRI, Multan | 24 | 24 | 24 | - | 72 |
| Research Material Director CCRI, Multan | 6066 | 6066 | 6066 | - | 18198 |
| Central Cotton Research Institute, Sakrand | 456 | 456 | 456 | - | 1368 |
| Cotton Research Station, Sibbi | 95 | 95 | 95 | - | 285 |
| Cotton Research Station, Ghotki | 302 | 302 | 302 | - | 906 |
| Cotton Research Station, Sahiwal | 539 | 539 | 539 | - | 1617 |
| Federal Seed Certification, Lasbella | 8 | 8 | 8 | - | 24 |
| Spot Examination | 28 | 28 | 28 | - | 84 |
| **Total** | **18385** | **18385** | **18385** | **40** | **55195** |

## 8.2 Testing of Commercial Samples

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

**Table 8.2 Number of Samples Tested for Various Fibre Characteristics**

| Source | Fibre Length (mm) | Micro-naire | Fibre Strength (g tex$^{-1}$) | Color Grade | Trash (%) | Total |
|---|---|---|---|---|---|---|
| Private Sector | 103 | 103 | 103 | 66 | 30 | **405** |

## 8.3 Enhancing Fertilizer Use Efficiency by Synchronizing Application Rate and Methods

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

**Table 8.3 Fibre characteristics of genotypes CIM-990 and CIM-785 as altered by fertilizer**

### 8.3.1 Genotypic Variation in Fibre Characteristics

| Genotype | Fibre length (mm) | Uni. Index | MIC | Strength (g/tex) | Lint (%) | Rd | +b |
|---|---|---|---|---|---|---|---|
| **CIM-990** | 27.6 | 81.5 | 4.1 | 28.7 | 37.6 | 71.9 | 8.68 |
| **CIM-785** | 25.9 | 79.2 | 4.1 | 26.7 | 42.9 | 72.3 | 7.86 |

### 8.3.2 Nutrients Effect on Fiber Characteristics

| Fertilizer (NPK) | Fibre length (mm) | Uni. Index | MIC | Str. (g/tex) | Lint (%) | Rd | +b |
|---|---|---|---|---|---|---|---|
| Control | 24.8 | 79.6 | 4.3 | 25.5 | 44.9 | 72.20 | 8.40 |
| Recommended dose of fertilizer | 27.0 | 80.4 | 4.1 | 28.2 | 40.6 | 72.20 | 8.55 |
| 1/2 of the recommended dose | 26.8 | 79.9 | 4.1 | 27.6 | 39.2 | 72.35 | 8.00 |
| 10% foliar + 40% fertigation | 26.8 | 80.4 | 4.0 | 27.5 | 40.5 | 72.00 | 8.10 |
| 15% foliar + 35% fertigation | 27.1 | 80.7 | 4.1 | 28.2 | 39.9 | 71.95 | 8.15 |

The whole data of the experiment are presented in Table 8.3. Table 8.3.1 represents the genotypic variation in fibre characteristics which showed that genotype CIM-990 had better fibre characteristics. Table 8.3.2 represents the NPK effect on fibre characteristics which showed that 15% foliar + 35% fertigation improved fibre characteristics than other treatments and control (Figs, 8.3.1, 8.3.2, 8.3.3 & 8.3.4).

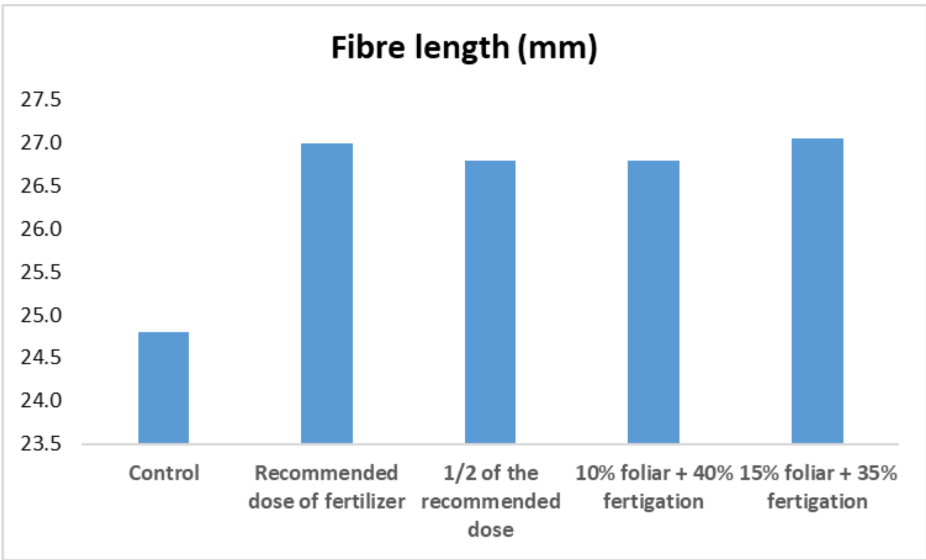


**Fig. 8.3.1 Effect of fertilizer on fibre length**

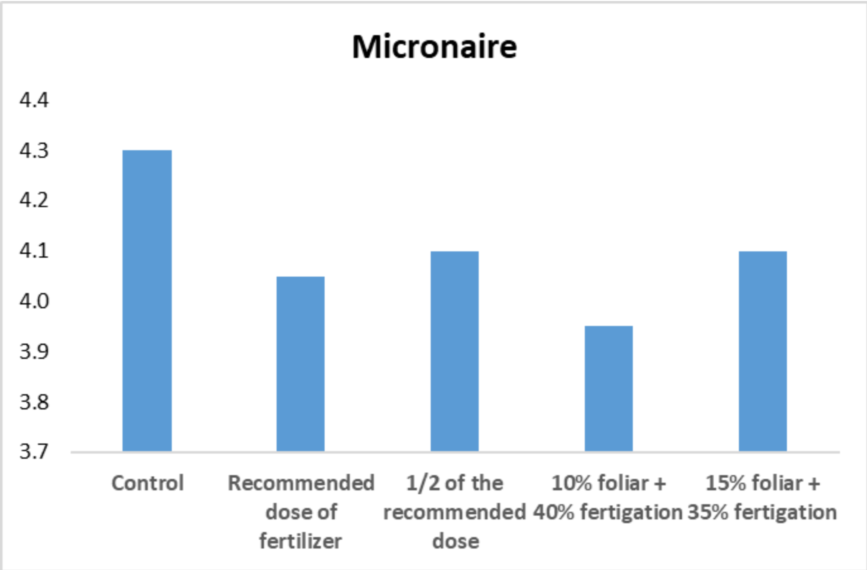


**Fig. 8.3.2 Effect of fertilizer on MIC**

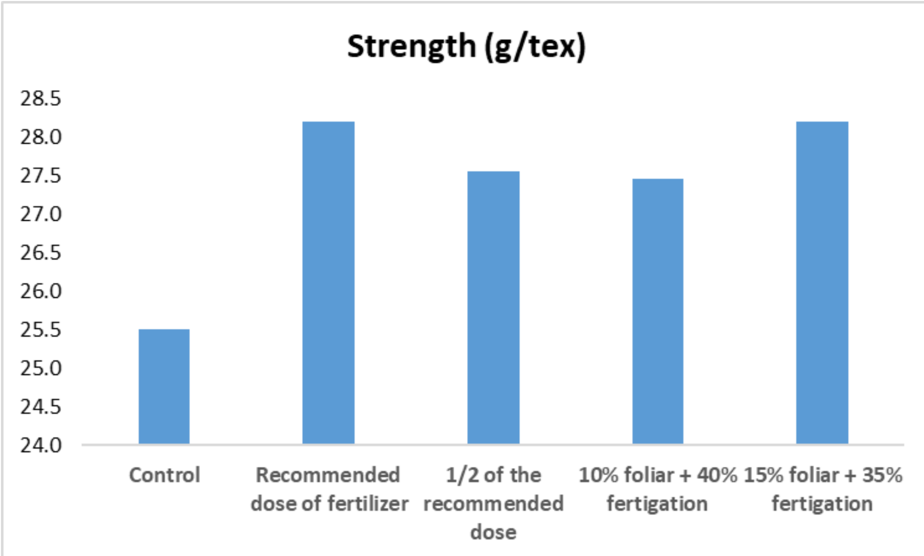


**Fig. 8.3.3 Effect of nutrients use efficiency on fibre strength**

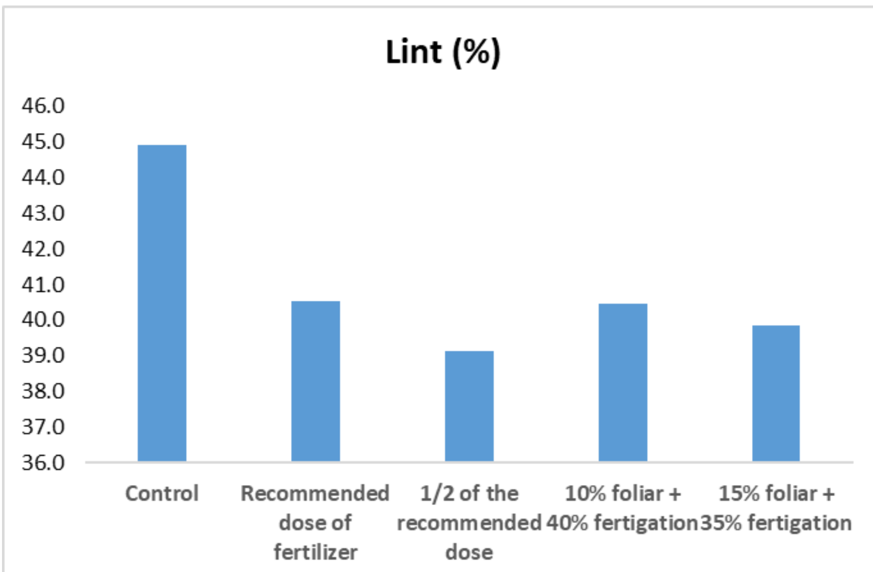


**Fig. 8.3.4 Effect of nutrients use efficiency on lint percentage**

## 8.4 Effect of Different Intercrops in Cotton on Fibre Characteristics

The objective of the experiment was to evaluate the impact of different intercrops in cotton on fibre quality characteristics. This study was conducted with the collaboration of Agronomy section of the institute. Sowing was done on 25$^{th}$ May 2023 and *Bt.*Cyto-535 was selected and sown with two different crops i.e., mung bean and sesame. Plants tagging was done and cotton bolls were picked. The seed cotton was ginned. The lint samples were tested for various fibre characteristics. The results are presented in Table 8.4.1.

### 8.4.1 Effect of Intercrops on Fibre Characteristics

| Intercrops | Fibre length (mm) | Uni. Index | MIC | Strength (g/tex) | Lint (%) | Rd | +b |
|---|---|---|---|---|---|---|---|
| Cotton | 26.4a | 81.0a | 3.5a | 29.6a | 36.0a | 70.9a | 9.0ab |
| Cotton + Sesame | 26.6a | 81.4a | 3.6a | 27.7b | 36.6a | 70.9a | 8.7b |
| Cotton + Mung Bean | 26.4a | 81.6a | 3.6a | 27.3b | 37.1a | 70.3a | 9.2a |

The significant difference exists in fibre strength and degree of yellowness. Cotton crop showed better strength. All other parameters such as fibre length, uniformity index, micronaire, lint percentage and degree of whiteness showed no significant difference.

### 8.5 Quality survey of lint collected from ginning factories

The Quality Survey of Ginning industry for the crop year 2023 was not conducted due to financial constraints. The purpose of this study is to conduct the comprehensive survey of the core cotton areas of the Punjab region and generate the cotton fibre quality report "Quality Survey of Punjab Cotton" will be useful for all actors in the cotton supply chain, i.e., farmers, ginners, spinners, traders, and researchers. This report depicts the fibre traits of commercially grown cotton varieties under different climatic conditions.

### 8.6 ICA-Bremen cotton round test program

The Fibre Technology Section participated in the ICA-Bremen Cotton Round Test Program with Faser Institute, Germany to keep the fibre testing equipment in calibrated form. Three lint samples were received during the year 2023. The lint samples were tested for different fibre characteristics. The results were submitted to the Faser Institute, Germany and fibre analysis was compared with other testing laboratories approved in the world. The results of the Institute's Laboratory and the average results of the other participating laboratories are presented in Table 8.5.

**Table 8.5 ICA-Bremen Cotton Round Test Program with Faser Institute, Germany**

| Date of Test | Sample No. | Name of Test | Results of CCRI, Multan (1) | Avg. results Of all Labs (2) | Difference (1-2) |
|---|---|---|---|---|---|
| **09.03.2023** | **2023/1** | **Conventional Instruments** | | | |
| | | Micronaire | 5.25 | 5.14 | 0.11 |
| | | Pressley Index (0") | 7.12 | 6.91 | 0.21 |
| | | G/tex (1/8") | 24.0 | 23.62 | 0.10 |
| | | Elongation (%) | 4.5 | 7.64 | -3.14 |
| | | Trash Content (%) | 2.97 | 2.00 | 0.97 |
| | | Lint Content (%) | 97.03 | 96.9 | 0.04 |
| | | **HVI-900A** | | | |
| | | U.H.M.L. (mm) | 28.98 | 28.24 | 0.74 |
| | | Uniformity Index (%) | 85.50 | 83.98 | 1.52 |
| | | Micronaire | 5.14 | 5.19 | -0.05 |
| | | G/tex (1/8") | 28.19 | 29.34 | -1.14 |
| | | Elongation (%) | 6.33 | 7.55 | -1.25 |
| | | Rd (Reflectance) | 75.5 | 77.13 | -1.63 |
| | | +b (Yellowness) | 12.4 | 12.08 | 0.32 |
| **25.07.2023** | **2023/2** | **Conventional Instruments** | | | |
| | | Micronaire | 4.36 | 4.38 | -0.02 |
| | | Pressley Index (0") | 6.80 | 6.90 | -0.10 |
| | | G/tex (1/8") | 22.0 | 21.8 | 0.20 |
| | | Elongation (%) | 5.95 | 5.95 | -- |
| | | Trash Content (%) | 3.65 | 2.75 | 0.90 |
| | | Lint Content (%) | 96.35 | 99.16 | 0.19 |
| | | **HVI-900A** | | | |
| | | U.H.M.L. (mm) | 27.7 | 27.7 | -- |
| | | Uniformity Index (%) | 81.7 | 80.82 | 0.88 |
| | | Micronaire | 4.30 | 4.40 | -0.10 |
| | | G/tex (1/8") | 28.50 | 28.05 | 0.45 |
| | | Elongation (%) | 6.10 | 6.50 | -0.40 |
| | | Rd (Reflectance) | 73.5 | 73.9 | -0.40 |
| | | +b (Yellowness) | 9.75 | 9.60 | 0.15 |

| | | | | | |
|---|---|---|---|---|---|
| **30.10.2023** | **2023/3** | **Conventional Instruments** | | | |
| | | Micronaire | 4.70 | 4.59 | -0.10 |
| | | Pressley Index (0") | 7.18 | 7.29 | 0.10 |
| | | G/tex (1/8") | 23.2 | 24.06 | 0.90 |
| | | Elongation (%) | 6.30 | 6.60 | 0.30 |
| | | Trash Content (%) | 8.70 | 6.91 | -1.80 |
| | | Lint Content (%) | 91.3 | 91.98 | 0.70 |
| | | **HVI-900A** | | | |
| | | U.H.M.L. (mm) | 29.2 | 29.18 | -0.20 |
| | | Uniformity Index (%) | 82.7 | 82.67 | -0.03 |
| | | Micronaire | 4.60 | 4.70 | 0.10 |
| | | G/tex (1/8") | 28.4 | 30.06 | 1.66 |
| | | Elongation (%) | 5.60 | 6.75 | 1.15 |
| | | Rd (Reflectance) | 73.6 | 75.2 | 1.60 |
| | | +b (Yellowness) | 10.2 | 9.45 | -0.70 |

**8.7 Survey of spinning industry of Pakistan**

A. No spinning mill was surveyed due to financial constraints. The objective of the proposed study is to compare the fibre quality of the available cotton, imported cotton and non-cotton fibres.

**Projects Preparation**

B. Development of artificial neural network-based system for intelligent prediction of the potential of high yielding as well as high quality indigenous cotton varieties/genotypes. Project has been submitted to the Planning Commission of Pakistan for funding.

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## 9. STATISTICS

This section is providing substantial support to the institute's scientists in both the development of experimental designs and the subsequent analysis of data. It involves the meticulous documentation of cotton statistics and the daily market rates of cotton commodities.

### 9.1 Experimental Design Layout

This section was responsible for planning the layout of field experiments conducted by various divisions of the Central Cotton Research Institute, Multan. In sixty experiments, a randomized complete block design was implemented, while six experiments utilized a split-plot design and ten experiments employed a split-split plot design.

### 9.2 Statistical Analysis

A total of 76 sets of experimental data were analyzed by Statistics Section during 2022-23 which twenty four data sets of Breeding & Genetics, nine Cytogenetics, sixteen Entomology, twenty seven Fibre Technology sections of the institute and further detail presented in Table 9.1

**Table 9.1 Detail of Statistical Analyses.**

| Sections | RCBD | Split | Split-Split | Total |
|---|---|---|---|---|
| Agronomy | --- | --- | --- | **---** |
| Physiology | --- | --- | --- | **---** |
| Breeding | 24 | --- | --- | **24** |
| Cytogenetics | 9 | --- | --- | **9** |
| Pathology | --- | --- | --- | **---** |
| Entomology | 16 | --- | --- | **16** |
| Fiber | 11 | 6 | 10 | **27** |
| **Total** | **60** | **6** | **10** | **76** |

### 9.3 Prices of Seed Cotton and its Components

Daily Spot Rates of Cotton (lint) were documented. The average weekly price for Base Grade cotton per 40 kg for the three cotton seasons i.e. 2021-22, 2022-23 and 2023-24 exclusive of upcountry charges are shown in Fig. 9.1.

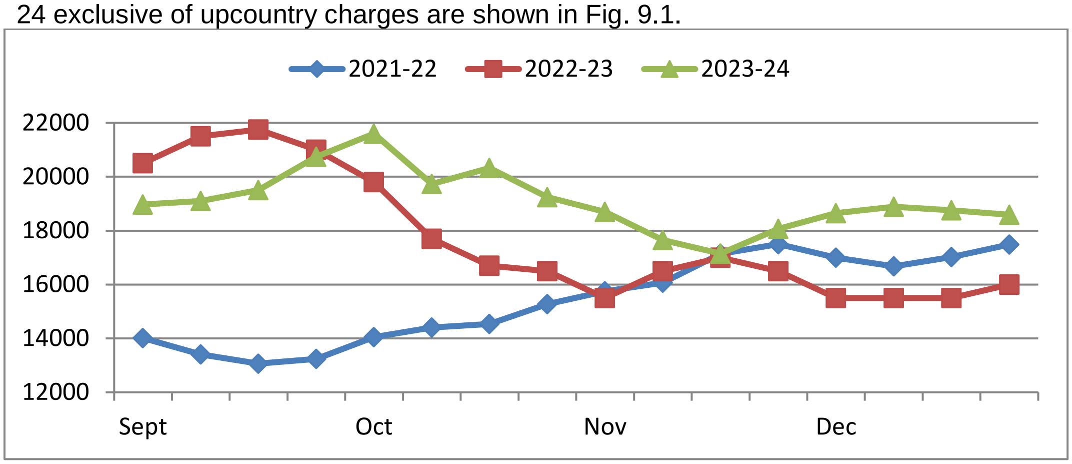


**Figure 9.1: Weekly Average Spot Rates of Lint announced by Karachi Cotton Association during Cotton Seasons 2021-22, 2022-23 and 2023-24.**

The information depicted in Fig 9.1 illustrates the rate fluctuations over the past three years, highlighting that in the 2023-24, rates were notably higher compared to previous years. For the 2022-23 period, the average price stood at Rs.17,716 per 40 kg, reaching a minimum of Rs.15,500 per 40 kg in December,2022 and a maximum of Rs. 21,750 per 40 kg in September,2022. In contrast, during 2023-24, the average price was

Rs.19,104 per 40 kg, with the lowest value recorded at Rs.17,147 per 40 kg in November,2023 and the highest at Rs. 21,599 per 40 kg in October,2023.

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

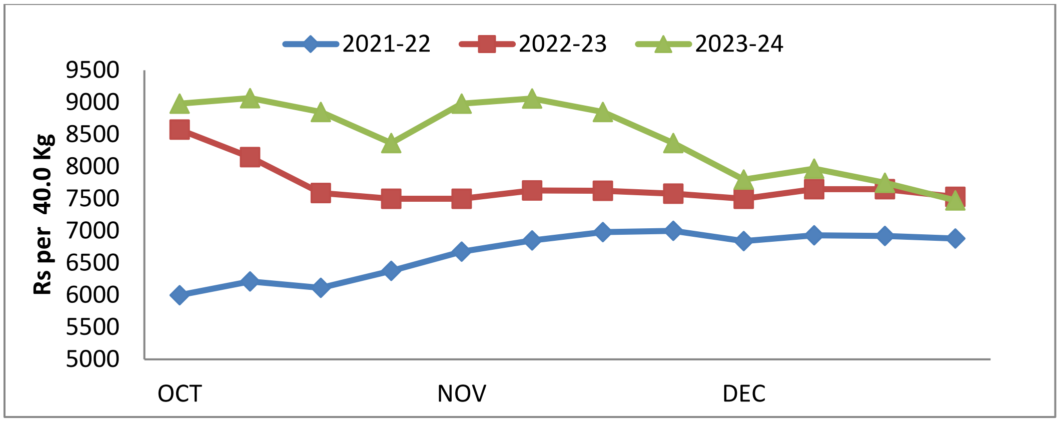


**Figure 9.2:** **Weekly Average Rates of 40 Kg Seed-cotton in Bahawalpur Market during 2021-2022, 2022-23 and 2023-24**

The data illustrated in Figure 9.2 show a significant rise in seed-cotton rates for the 2023-24 period compared to previous years. In 2022-23, the average rate for seed-cotton in the Bahawalpur market was 7,707 per 40 kg, with a range between 7,500 and 8,575 per 40 kg. Conversely, for the 2023-24 season, the average rate increased to Rs. 8,459 per 40 kg, with a maximum of 9,067 and a minimum of Rs. 7,475 per 40 kg. This represents a 9.76% increase in average price compared to 2022-23 and a 27.24% increase compared to 2021-22.

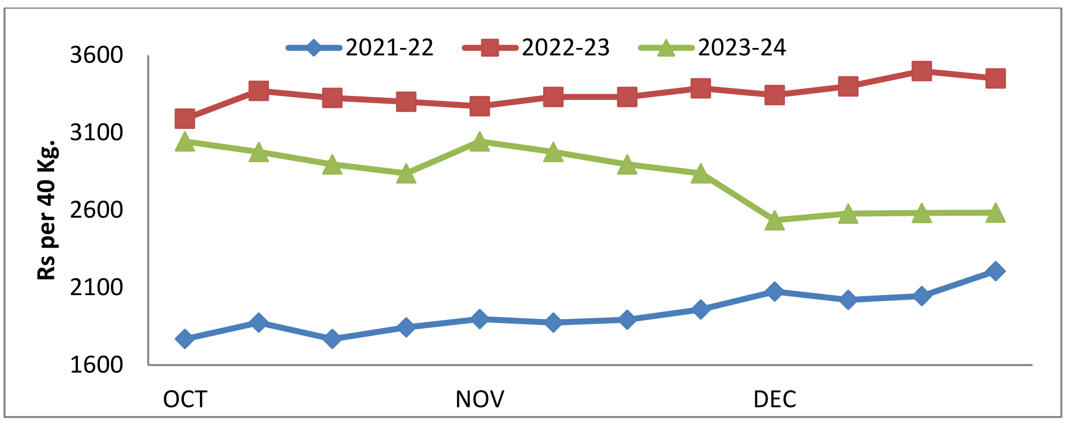


**Figure 9.3:** **Weekly Average Rates of 40 Kg Cottonseed cake in Bahawalpur Market during 2021-22, 2022-23 and 2023-24.**

The rates for cottonseed cake remained lower than those of previous year, with the highest value of Rs. 3,043 observed in October, 2023 and the lowest price of Rs. 2,535 recorded in December, 2023. The average price for the 2023-24 was 2,754 per 40 kg. Comparing this to the previous year, the average price reached Rs. 3,349 per 40 kg in 2022-23, with a minimum of Rs. 3190 per 40 kg and a maximum of Rs. 3,497 per 40 kg in October and December, 2022 respectively. In the 2021-22, the average price was Rs. 1,999 per 40 kg, with the maximum price at Rs. 2,223 per 40 kg and the minimum at 1,768 per 40 kg.

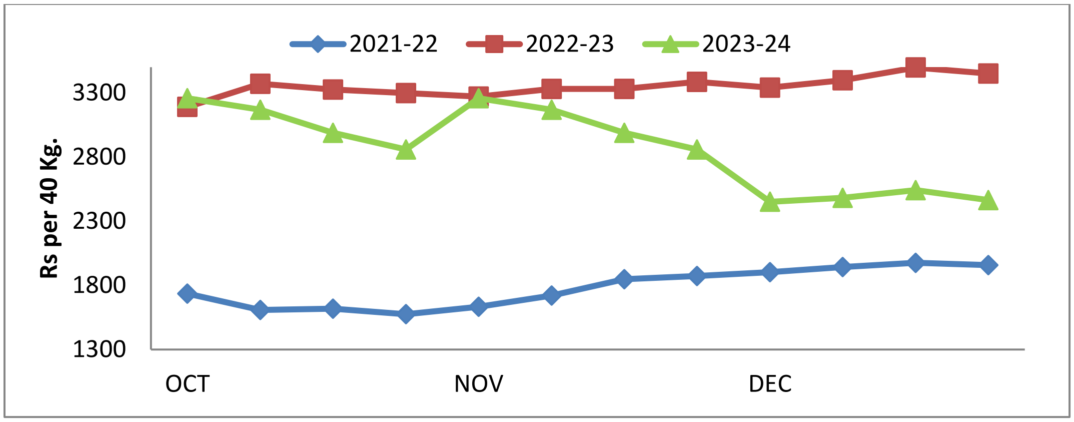


**Fig 9.4** **Weekly Average Rates of 40 Kg Cottonseed in Bahawalpur Market during 2021-22, 2022-23 and 2023-24.**

Cottonseed rates for the year 2023-24 were lower than the year 2022-2023. Average rate for 2023-24 was Rs.2,777 per 40 kg with maximum at Rs. 3,258 per 40 kg and minimum Rs.2,451 per 40 kg while in 2022-23 the average rate was Rs.3,349 per 40 kg with maximum Rs.3,497 per 40 kg and minimum at Rs.3,190 per 40 kg.

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

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

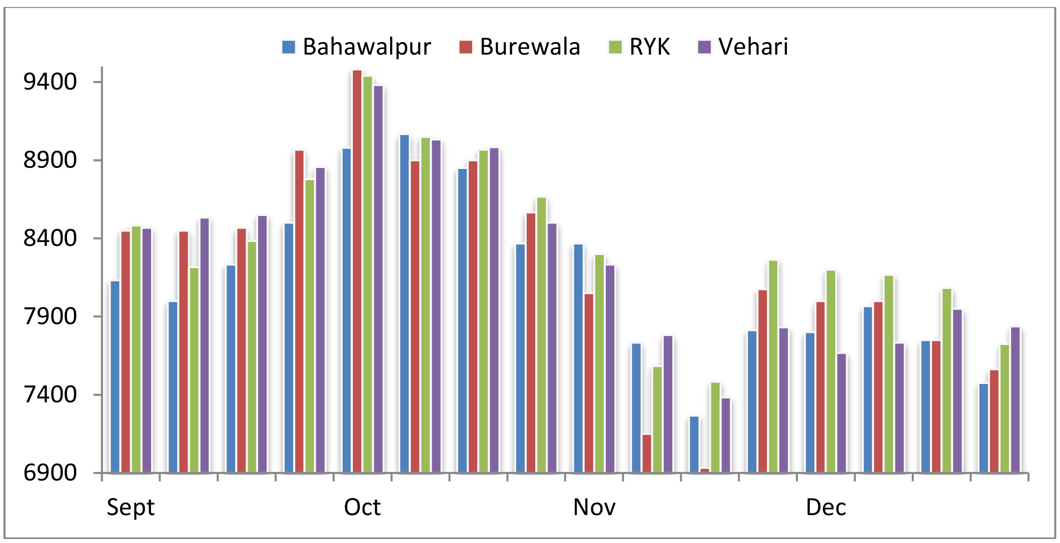


**Fig 9.5 Rates of seed-cotton 2023-24 in Punjab**

Rahim Yar Khan recorded the highest average rate at Rs.8361 per 40 kg, while Vehari reported the lowest average rate at Rs.8295. The peak rate of Rs.9480 per 40 kg occurred in Burewala during the first week of October, whereas the lowest rate of Rs.6933 was observed in Burewala during the third week of November.

### 9.5 Rates of seed-cotton in four different cities of Sind:

Figure 9.6 depicts the comparative rates of seed-cotton in Hyderabad, Mirpurkhas, Sukkur and Khairpur districts.

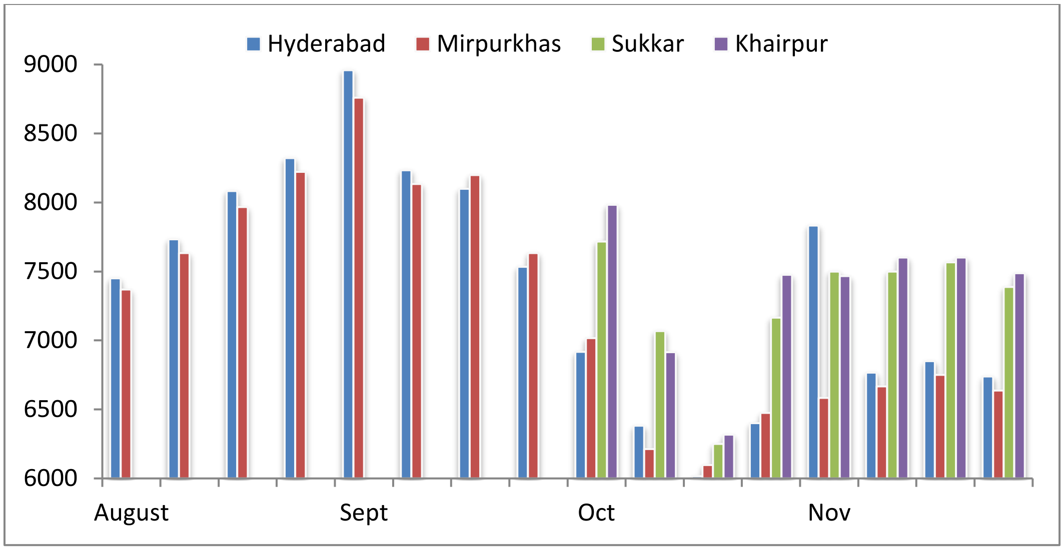


**Fig 9.6 Rates of seed-cotton 2023-24 in Sind**

The highest average rate was Rs.7,395 per 40 Kg in Hyderabad, and the lowest average rate was Rs.7,272 in Mirpurkhas. The maximum rate of Rs.8,960 per 40 Kg was in Hyderabad in the first week of September and lowest rate was Rs.6,017 in Hyderabad in third week of October.

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## VI. RECOMMENDATIONS

Unlike other countries, cotton crop in Pakistan faces a number of challenges such as weather adversaries including higher (day & night) temperatures, irregular rainfall pattern, shortage of canal irrigation water supplies, availability of water at sowing time and peak demand period, non-judicial use of crop inputs (irrigation, fertilizer, pesticide etc.), deteriorating soil health (salts, fertility problems) rising cost of inputs resulting in un-economical crop yields, insect-pest complex (whitefly, jassid, thrips, Bollworms, dusky & red cotton bugs etc), diseases (CLCuV, stem & twig blight) and fluctuating produce prices. In addition, the *Bt* cotton has now become vulnerable to Pink Bollworm infestation which not only increases the cost of production through additional use of pesticides but also limits crop yield. To ensure sustainable crop productivity along with economic returns for the farmers, concerted efforts need to be carried out at all levels involving the cotton sector stakeholders through public and private partnership approach. Based on the research work conducted by the scientists of the Institute, all the way through, following recommendations are made to dilute cotton production problems and getting maximum yield from the available resources.

### SOIL HEALTH IMPROVEMENT AND ITS PREPARATION

- Improvement and maintenance of soil physical condition ensures better soil productivity. Therefore, green manuring/farm yard manure should be incorporated one month before sowing to improve the physical condition of the soil. Among green manure crops, berseem is the best choice. Green manuring crops should be buried into the soil at tender stage 4 weeks ahead of cotton planting for timely decomposition and soil conditioning. For rapid decomposition of buried green matter apply ½ bag urea followed by irrigation.
- After the use of combine harvester, the tradition of burning wheat straw is not beneficial. It must be incorporated into the soil which improves the physical properties and organic matter content of soil. Apply slasher after that disc harrow instead of rotavator followed by irrigation along with ½ bag urea per acre must be used.
- Preserve the farmyard manure properly in pits. Do not keep in heaps in the open.
- Reclamation of saline-sodic soils is accomplished by incorporating the recommended quantity of gypsum into the soil followed by 2-3 heavy irrigations. This should be followed by green manuring to restore soil fertility.
- Where plant growth is restricted and downward penetration of water in the soil is slow, chiseling/ripping or deep ploughing should be done. It breaks down the hard and plough pan to improve root growth and soil health.
- Level the fields properly with laser leveler for uniform and economized application of irrigation water.

### 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 germination. It saves 30% irrigation water over conventional planting (flat cultivation). It also saves the crop from the damages of untimely and heavy rains. Apply second irrigation 3-4 days 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 cotton, therefore, use pre-emergence herbicides to control weeds.
- To sustain the good physical soil conditions, always cultivate the fields in '*wattar*' condition (workable condition / field capacity level) and never cultivate in dry condition.
- Apply ½ bag of urea at the time of land preparation for efficient and accelerated decomposition of previous crop residues because of white-ant problem. It 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 seedbed preparation simultaneously for conventional as well as bed-furrow cotton planting to avoid possible delay in planting as early planting after wheat produces better yields.

**RECOMMENDATION OF COTTON VARIETIES FOR GENERAL CULTIVATION**

- Recommendation of *Bt*. & Non *Bt* cotton varieties for general cultivation in core and non-core cotton areas of the Punjab.

| ***Bt.* Varieties** | **Non-*Bt.* Varieties** |
|---|---|
| *Bt.*CIM-775, *Bt.*Cyto-511, *Bt.*CIM-343, *Bt.*Cyto 537, *Bt*.CIM-678, *Bt*.CIM-785, *Bt*.Cyto-535, *Bt*. CIM-663, *Bt*. CIM-632, *Bt*.CIM-602, *Bt*. Cyto-177, *Bt*. Cyto-178, *Bt*.CIM-600, *Bt*. Cyto-179 | Cyto-226, CIM-610, CIM-620, Cyto-124, CIM-496, CIM-506, CIM-554, CIM-573, |

- Always purchase 10% more cotton seed than required for re-planting in case of any damage or low germination.
- Always sow 10% area with Non-*Bt.* along with *Bt.* varieties, as a refuge crop, to avoid development of resistance in insects.
- Generally use delinted seed. One liter of commercial sulphuric acid is sufficient for delinting 10 kg fuzzy cotton seed. Wash thoroughly and dry the seed under shady and well ventilated area. Always store cotton seed in gunny bags or cotton cloth bags in such a way that air could pass across the bags from bottom to top. Avoid the storage cotton seed in plastic bags.
- In case of sandy soil fuzzy seed should be used for getting good crop stand.
- Check seed germination before planting. Use delinted seed @ 6-8 kg/acre with 75 percent germination for flat planting. Adjust seed rate according to germination percentage.
- Ensure that seed drill is in perfect condition and drop the seed uniformly at appropriate depth for perfect emergence of cotton seedlings.
- Optimum sowing time for core areas in Punjab is from 1st April to 31st May and non-core areas is 1st April to 15th May. The yield decreases drastically in June planting. Planting up to May 15th should be preferred. It gives better yield than late planting.
- Ensure 17,000-23,000 plants per acre for obtaining profitable yield.

**THINNING**

- Thinning should be completed after dry hoeing and before first irrigation in flat planting (conventional) by keeping 9"-12" plant to plant distance with in the rows to obtain 17000-23000 plants per acre. On bed-furrow planting, thinning should be completed within 20-25 days, when plants are 10cm (4") in height. Remove weak or virus affected plants, if any, while thinning.
- A uniform early good crop stand ensures profitable cotton production.

**WEED CONTROL**

- The first 40-70 days after sowing are crucial and growth of weeds is faster than cotton plant, therefore, all possible measures should be adopted to control weeds.
- Use of pre-emergence herbicides saves the crop from early weed infestation when the crop does not permit mechanical hoeing operations.
- Pendimathelin 330 EC can be used as pre-emergence herbicide before sowing in flat planting at seed bed preparation by incorporating into soil at 5 cm depth.
- Pendimathelin 330 EC can be used in bed-furrow planting in dry condition before sowing.
- S-Metolacholor 960 EC should not be incorporated in the soil at sowing time. It causes mortality of cotton seedlings during germination. It is used on bed-furrow planting as surface application within 24 hours of sowing/ irrigation on moist soil.
- Glyphosate 490 G/L @ 4.7 lit $ha^{-1}$ can be used as post-emergence weedicide provided that 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 and *quizalofop* @ 20g per acre as post-emergence without protecting the cotton plants. Haloxifop can be used more than one time at any growth stage of cotton plant. No phyto-toxicity was observed on crop by the spray of said herbicide.
- In flat planting, inter-culturing 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 inter-culturing, weeds which are not killed/eradicated by inter-culturing must be removed manually and the crop should be earthed up during the last inter-culturing 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. In bed-furrow planting, after the application of irrigation for germination subsequent irrigation should be given at 8-10 days interval. Apply such quantity of irrigation water that can easily be absorbed by the soil within 24 hours. Water standing in field even upto 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.
- 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. Soils showing available phosphorus less than 10 ppm, use upto 100 kg $P_2O_5$ per hectare after thinning. Mixing of phosphate fertilizer with farmyard manure in 1:2 ratio improves its efficiency. Use 50 kg $K_2O$ per hectare at planting, to soils showing available potassium less than 125 mg $kg^{-1}$ soil. Cotton-wheat is the major cropping pattern in the cotton area. Farmers should also use recommended levels of phosphorus and potassium fertilizers for wheat crop.
- In normal season planting, 150-200 kg N per hectare should be applied in split doses and fertilizer application should be completed by end of August. Excessive use of nitrogen does not improve the yield and crop turn towards vegetative growth also attracts the pests, delays the crop maturity and adds up cost of production.
- To improve the efficiency of nitrogen, phosphorus and potassium fertilizers, these may be applied in split doses. Band placement or fertigation of phosphorus in splits is more efficient than the broadcast at time of sowing.
- The crop showing deficiency of nitrogen late in the season can be sprayed in morning/evening with 3% urea solution (3 kg urea per 100 litre water) but it should not be mixed with the insecticides.
- Fertigation (fertilizer solution dripping into irrigation water) of nitrogenous fertilizer is also a useful method to apply nitrogen during the cropping season but its efficacy is more in leveled fields.
- The adverse effects of water shortage in cotton crop may be minimized by the combined application of phosphorus and potassium fertilizers.
- Gypsum as a source of sulphur may be added @ 50-100 kg per hectare in light textured and saline-sodic soils to correct sulphur deficiency syndrome. Alternatively use elemental sulfur @ 10 kg $ha^{-1}$.
- Three-four foliar sprays of boron and zinc @ 0.05% solution [(250g zinc sulphate with 21% Zn, 300g boric acid)/ per 100 litre water] should be done to improve fruiting in stress condition after rain.

- Mixing of 2% urea in the spray tank along with B and Zn nutrients enhances the efficacy of foliar spray.
- Potassium application through foliar sprays of 2% $KNO_3$ or $K_2SO_4$ (soluble potash) solution improves yield over non-sprayed crop and minimizes the adverse effects of biotic and abiotic stresses.
- Half of the recommended dose of NPK fertilizers i.e. $75N+25P_2O_5+25K_2O$ kg $ha^{-1}$ is as effective as recommended dose ($150N+50P_2O_5+50K_2O$ kg $ha^{-1}$) when applied in conjunction with poultry broiler litter.
- For early germination and seedling vigor, cotton seed may be primed with Disprin + Salicylic acid (195 mg/L and 100 g) prior to sowing.
- Application of magnesium sulphate both by fertigation and foliar sprays proved benefial in improving seedcotton production. However, foliar application of magnesium @ 6 kg per hectare in three splits was more productive and cost-effective.
- Seed priming Disprin + Salicylic acid @ 0.01 increases cotton health and production. The efficiency of Disprin + Salicylic acid is further increased by addition of B & Zn in foliar sprays.

## FRUIT SHEDDING

- Fruit shedding results either due to natural adversaries like high temperature coupled with high relative humidity, cloudiness, and intermittent rains or due to insufficient nutrition, excessive or shortage of water and pest attack.
- Take care of nutritional deficiency, irrigation, pests and don't worry about natural shedding.

## PLANT PROTECTION

- Keeping in view the losing efficacy of *Bt.* cotton against pink bollworm, farmers are advised to plant cotton not before the 1st April.
- Always use delinted seed to avoid carryover of pink bollworm in double seed.
- Seed treatment with insecticide ensures better crop growth and saves it from sucking pests at early stage.
- The first spray should be delayed as long as crop tolerates pests so that predators and parasites could play their role to suppress the pest population.
- Pyrethroids or their combinations should be avoided at early stage of the crop.
- Pesticides should be applied on the pest scouting basis at the 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 last picking to reduce the number of left over bolls. It is better if the cotton sticks are shredded and incorporated into the soil which will improve the physical condition of the soil. In case the cotton sticks are to be kept for fuel purpose, these should be kept in bundles and top portion should be directed towards sun and should be used by mid-February.
- Removal of leftover bolls after picking with Pink Bollworm Manager (PBWM) machine is an effective strategy that will not only manage or reduce Pink bollworm but also save sticks to be used by the farmers for fuel purpose.
- Spray machines must be in order and properly calibrated. Use hollow cone nozzles with uniform flow rate, fine mist and keep the nozzle at 1.5 to 2 feet height from the plant canopy to ensure better coverage of the crop.
- Use right dose of right insecticide at appropriate time with clean water for better results. Spray in the morning or late in the afternoon. Do not spray when rain is expected. If the rain has affected spray application, it should be repeated. Pest scouting should also be done after 3-4 days of spray to assess efficacy of the pesticide.

**Economic Threshold Levels for Different Insect Pests**

| Name of insects | Economic Threshold Levels |
|---|---|
| Jassid | 1 adults/nymphs per leaf |
| Whitefly | 5 adults/nymphs or both per leaf |
| Thrips | 10 adults/nymphs per leaf |
| Spotted bollworm | 3 larvae/25 plants |
| Pink bollworm | 5 % bolls damage |
| American bollworm | 5 brown eggs or 3 larvae or collectively 5/25 plants |
| Armyworm | On appearance |

## CONTROL OF DISEASES

- The seed should be treated with fungicides for seed rot and seedling diseases during early planting.
- Previous year's cotton stubs should be removed from the fields. The reason being that new sprout from diseased stubs is the source of Cotton Leaf Curl Virus (CLCuD) transmission to the newly planted crop.
- Always plant more than one virus resistant/tolerant variety to create genetic barrier.
- Use healthy and delinted seed.
- Avoid the late planting of cotton to minimize the CLCuD incidence.
- The seed should also be treated with systemic insecticide to protect the crop against whitefly which is the vector of CLCuV.
- Whitefly is vector of CLCuD. It should be managed and controlled at economic threshold level.
- Reduce the whitefly population during mid-June to end-August and other pests to manage CLCuD.
- The diseased and weak seedlings should be removed at thinning stage and buried.
- Weeds in and around cotton fields, water channels and field bunds should be eradicated. Reduce whitefly population during mid-June to end of August and other pests to manage CLCuD.
- Judicious use of fertilizer and irrigation helps in the management of CLCuD.
- Application of fertilizer and irrigation should be given in accordance with recommendations. Excessive use of these inputs increases the incidence of boll rot of cotton.
- Good drainage / proper irrigation helps to grow healthy plants and show more resistance against wilt and boll rot diseases.

## PICKING

- Seed-cotton on the plant is a precious silver fiber. Maintaining its quality during picking, storage and transportation from the field to store or from store to the ginning factories ensures reasonable 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 to restart 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 the 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 get heated up in the stores. This will deteriorate lint as well as cotton seed quality.

## VII. PUBLICATIONS

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Yusuf, M.I., Hussain, S., Aslam, M.Z., Shah, S.W.H., Zubair, M., Ibrar, I. and Akhtar, I. 2023. Evaluation of upland cotton genotypes for morph-metric, photosynthesis-related traits and parameters related to enzymatic and non-enzymatic antioxidant accumulation. *Biol*. & *Clin. Sci. Res. J.* 1: 375-375. Doi: http://doi.org/10.54112/bcsrj v202311.375.

**Book Chapters**

Tariq, M., Khan, M.A., AL-Huqail, A.A. and Ahmad, S. 2024. Agriculture and COVID-19, In, Post-Pandemic Economy, Technology, and Innovation: Global Outlook and Context. Samina Yaqoob, Arwa Abdulkreem AL-Huqail, and Fakhra Aziz (Eds.). Apple Academic Press, Inc. Co-published with CRC Press (Taylor & Francis).

**Participation in Trainings/Workshops**

1. Launching of Organic Cotton Training Curriculum (OCTC) for Pakistan & Pilot Training of Trainer on Organic Cotton. Hosted by CABI & OCA, at Ramada hotel Multan on 13, 14 December, 2023.
2. Dr. Muhammad Naveed Afzal, Head, Agronomy and Mr. Muhammad ilyas Sarwar, Head, Fibre Technology imparted training to the Cotton Classers of the Pakistan Cotton Standards Institute, Multan on 04.08.2023 at CCRI Multan.
3. Mr. Muhammad Ilyas Sarwar, Head, Fibre Technology participated in “The Textile Industry’s Sustainability Forum” organized by GIZ covering the topic, EU Green Deal – Challenges and Opportunities for Pakistan, (ii) EU Strategy on Circular and Sustainable Textile held on 07.12.2023 at Islamabad.
4. Mr. Muhammad Ilyas Sarwar, Head Fibre Technology attended training “Fundamental Principles & Rights at Work in the Cotton Supply Chain – Rise for Cotton Impact” organized by ILO held on 06.01.2024 at Lahore.

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**Annexure-I**

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## Annexure-II

**Comparative Monthly Meteorological Data Recorded at CCRI, Multan during 2022 and 2023**

| Month | Air Temperature (ºC) | | | | Relative Humidity | | | | Average Wind Speed (Km h⁻¹) | | Rainfall (mm) | | Evapo-transpiration (cm day) | | Soil Temperature (ºC) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Minimum | | Maximum | | Minimum | | Maximum | | | | | | | | 0 cm | |
| | 2022 | 2023 | 2022 | 2023 | 2022 | 2023 | 2022 | 2023 | 2022 | 2023 | 2022 | 2023 | 2022 | 2023 | 2022 | 2023 |
| January | 7.2 | 7.9 | 19.6 | 19.9 | 49 | 53 | 81 | 80 | 5.9 | 1.5 | 56.6 | 0.0 | 0.51 | 0.45 | 10.6 | 11.6 |
| February | 10.7 | 11.8 | 23.9 | 26.8 | 48 | 45 | 82 | 81 | 4.9 | 3.2 | 0.0 | 3.0 | 0.78 | 0.31 | 12.8 | 15.2 |
| March | 17.5 | 16.5 | 33.6 | 29.7 | 49 | 56 | 72 | 82 | 4.5 | 6.9 | 0.5 | 27.5 | 0.87 | 0.51 | 24.1 | 20.8 |
| April | 25.1 | 20.3 | 39.9 | 35.7 | 47 | 52 | 72 | 80 | 5.5 | 5.4 | 0.0 | 12.0 | 0.92 | 0.84 | 28.7 | 25.8 |
| May | 28.2 | 23.6 | 42.0 | 37.3 | 47 | 50 | 76 | 80 | 6.2 | 6.2 | 0.0 | 79.0 | 0.91 | 0.85 | 33.3 | 30.0 |
| June | 27.3 | 26.5 | 39.5 | 38.0 | 50 | 45 | 79 | 74 | 6.5 | 6.5 | 110.80 | 31.0 | 0.78 | 0.83 | 33.4 | 32.6 |
| July | 27.3 | 28.5 | 36.7 | 38.2 | 51 | 54 | 78 | 78 | 6.3 | 6.8 | 69.80 | 43.2 | 0.75 | 0.85 | 30.9 | 33.6 |
| August | 27.2 | 29.2 | 35.0 | 38.7 | 49 | 60 | 77 | 76 | 5.1 | 5.4 | 68.40 | 44.0 | 0.56 | 0.90 | 30.8 | 34.2 |
| September | 25.4 | 27.0 | 37.0 | 36.6 | 48 | 57 | 77 | 77 | 4.2 | 4.0 | 0.0 | 0.0 | 0.73 | 0.91 | 31.4 | 33.8 |
| October | 19.5 | 22.5 | 33.6 | 34.5 | 58 | 60 | 78 | 77 | 2.8 | 3.6 | 0.0 | 0.0 | 0.63 | 0.75 | 27.1 | 30.3 |
| November | 13.8 | 15.7 | 28.5 | 27.4 | 57 | 64 | 79 | 81 | 2.5 | 2.0 | 0.0 | 0.0 | 0.63 | 0.61 | 18.1 | 21.0 |
| December | 8.7 | 8.5 | 23.0 | 22.8 | 59 | 65 | 81 | 95 | 2.2 | 2.1 | 1.0 | 0.0 | 0.41 | 0.46 | 12.5 | 13.2 |

# X. COTTON RESEARCH STATION, D.I. KHAN

## 1. INTRODUCTION

Cotton research sub-station D.I.Khan was established in 1962-63 and was subsequently upgraded to a full-fledged Cotton Research Station in 1974-75. The objectives of the station are:

1. To evolve high yielding, short stature, early maturing better quality varieties with resistance to insect pest, CLCuD and suitable for the agro-climatic conditions of D.I.Khan.
2. To develop a package of cotton production technology suitable for the prevailing cropping pattern of D.I.Khan area.

Work at the station comprised of screening of varieties, selection and hybridization programme and evaluation of cotton crop production technology. As a result of breeding work at the station a strain DNH-01 was evolved and approved by the provincial seed council with the commercial name of **Gomal-93** during the year 1993. Another advance strain DNH-105 was included in the non BT NCVT trail during the year 2012-13 seasons and got 2$^{nd}$ position. During the 2013-14, the strain again performed very well and got 1$^{st}$ position. Proposal for the same was submitted to the provincial seed council of KPK and been approved by the technical committee of the province as cotton variety **"Israr Shaheed"**.

Moreover time to time different varieties were recommended for general cultivation in the area on the basis of their performance. Meanwhile a project "Cotton Research and Development in KPK" financed by provincial government was launched in 2004-05. In this project, varieties were screened out and cotton crop was introduced in the new areas of KPK viz., Bannu, Karak, Kohat, Nowshehra and Mardan. The project was terminated in June 2008.

## 2. STAFF POSITION

| | | |
|---|---|---|
| 1. | Officer Incharge | 01 |
| 2. | Computer operator | 01 |
| 3. | Upper division clerk | 01 |
| 4. | Field assistant | 02 |
| 5. | Driver (Tractor + jeep) | 02 |
| 6. | Naib Qasid | 01 |
| 7. | Chowkidar | 02 |
| 8. | Sweeper | 01 |
| 9. | Field worker | 02 |
| | **Total strength** | **13** |

## 3. SEASON CROP

The optimum sowing time in D.I.Khan is from April to May. Sowing of the experiments at the station was completed up to 12$^{th}$ May 2023. The weather at the time of sowing remained favorable and the crop germination was normal. During the season, heavy rain with storm before the second picking, badly affected the opened bolls and the seed cotton yield was severely reduced.

The attack of sucking pest's viz., white fly, jassids, aphids and thrips was observed. The attack of thrips was more severe on the crop. The attack of spotted boll worms was also observed on non BT varieties. Control measures were adopted to check the attack of these insects. Mealy bugs were also observed in patches. The early sown crop escaped from CLCuD but the crop sown after 2$^{nd}$ May was infected.

## 4. WORK CONDUCTED

The work at cotton research station D.I.Khan comprised of four NCVTs (set A, B, C & D). The details are given as under;

## 5. COORDINATED VARIETY TESTING PROGRAMME

### 5.1 NATIONAL COORDINATED VARIETAL TRAIL (Set A)

Twenty four promising strains of different cotton breeders of the country were tested in National coordinated varietal trail (set A) to screen out the most promising and climate adopted variety. The experiment was carried out in randomized complete block (RCB) design having three replications with a net plot size of 30/ × 10/. The sowing was done by dibbling method on 29th April, 2023 Nitrogenous fertilizer @ 150 kg $ha^{-1}$ N was applied in 3 split doses. Standard cultural practices were applied to all the treatments. The data for seed cotton yield (kg $ha^{-1}$), plant population ($ha^{-1}$), number of bolls per plant, are presented in table 1. The data in table 1 shows that highest seed cotton yield of **1901** kg $ha^{-1}$ was recorded for **Captain-300** followed by super sultan-22 **1829** kg $ha^{-1}$ and sahara klean-10 **1801** kg $ha^{-1}$

**Table 1. Performance of Cotton varieties at Cotton Research Station D.I.Khan during 2023-24**

| Variety | Seed Cotton Yield kg / ha | Plant Population $ha^{-1}$ | No. of Ball |
|---|---|---|---|
| AS-85 | 1676 | 38976 | 25 |
| BH-228 | 1671 | 23727 | 24 |
| **Captain-300** | **1901 I** | 34650 | 30 |
| Certus-30 | 1783 | 33181 | 23 |
| CIM-600 | 1532 | 27844 | 26 |
| CRIS-700 | 1769 | 31023 | 23 |
| Cyto-547 | 1462 | 35171 | 24 |
| FBS-Shaheen | 1446 | 28463 | 26 |
| FH-1214 | 1688 | 31233 | 27 |
| CKC-3 | 1665 | 34410 | 19 |
| Inqalab-99 | 1636 | 30089 | 25 |
| IUB-313 | 1621 | 27484 | 23 |
| JSQ-71 | 1645 | 29140 | 23 |
| KZ-323 | 1498 | 30795 | 24 |
| SS-32 | 1729 | 29495 | 23 |
| MNH-Super Gold-22 | 1509 | 32895 | 28 |
| NIBGE-PF-01 | 1783 | 26962 | 19 |
| SAHARA-Klean-10 | 1801 III | 31651 | 24 |
| Silver-Queen-33 | 1407 | 27674 | 23 |
| SS-102 | 1469 | 27339 | 27 |
| Super-Sultan-22 | 1829 II | 33631 | 23 |
| Tara-340 | 1469 | 25719 | 24 |
| VH-461 | 1691 | 29052 | 19 |
| YBG-2929 | 1652 | 29855 | 24 |

## 5.2 NATIONAL COORDINATED VARIETAL TRAIL (Set B)

Twenty four promising strains of different cotton breeders of the country were tested in National coordinated varietal trail (set B) to screen out the most promising and climate adopted variety. The experiment was carried out in randomized complete block (RCB) design having three replications with a net plot size of 30/ × 10/. The sowing was done by dibbling method on 30th April, 2023 Nitrogenous fertilizer @ 150 kg $ha^{-1}$ N was applied in 3 split doses. Standard cultural practices were applied to all the treatments. The data for seed cotton yield (kg $ha^{-1}$), plant population ($ha^{-1}$), number of bolls per plant, are presented in Table 2. Table 2 shows that maximum seed cotton yield of 2148 kg $ha^{-1}$ was recorded in SS-32 followed by YBG-2626with 1738 kg $ha^{-1}$.

**Table 2. Performance of BT varieties at Cotton Research Station D.I.Khan during 2023-24.**

| VAREITY | Seed Cotton Yield kg / ha | Plant Population $ha^{-1}$ | No. of Ball |
|---|---|---|---|
| BH-227 | 1616 | 37635 | 24 |
| Captain-200 | 1542 | 31918 | 24 |
| CEMB-Te | 1333 | 27575 | 23 |
| CRIS-697 | 1274 | 22245 | 24 |
| CIM-600 | 1632 | 27746 | 23 |
| Cyto-545 | 1058 | 26550 | 22 |
| FBG-Platin | 1366 | 30497 | 23 |
| FH-1133 | 1659 III | 33607 | 25 |
| Inqalab-10 | 1449 | 26670 | 23 |

| | | | |
|---|---|---|---|
| CKC-3 | 1326 | 29780 | 25 |
| IUB-23 | 947 | 34563 | 25 |
| JSQ-White | 1150 | 31334 | 26 |
| KZ-181 | 1647 | 18059 | 31 |
| MNH-Sultan | 1305 | 25235 | 23 |
| SS-32 | 2148 I | 24398 | 27 |
| NIAB-868 | 1218 | 29062 | 28 |
| Sahara-500 | 1492 | 33128 | 27 |
| SAS-3 | 1069 | 32052 | 29 |
| SS-102 | 1349 | 37194 | 25 |
| Tara-337 | 1417 | 31454 | 24 |
| VH-447 | 929 | 33009 | 22 |
| YBG-2626 | 1738 II | 31095 | 23 |
| Bahara-GT | 977 | 31454 | 24 |
| SLH-94 | 1126 | 31095 | 26 |

### 5.3 NATIONAL COORDINATED VARIETAL TRAIL (Set C)

Twenty four promising strains of different cotton breeders of the country were tested in National coordinated varietal trail (set C) to screen out the most promising and climate adopted variety. The experiment was carried out in randomized complete block (RCB) design having three replications with a net plot size of 30/ × 10/. The sowing was done by dibbling method on 10th May 2023. Nitrogenous fertilizer @ 150 kg ha$^{-1}$ N was applied in 3 split doses. Standard cultural practices were applied to all the treatments. The data for seed cotton yield (kg ha$^{-1}$), plant population (ha$^{-1}$), number of bolls per plant, are presented in table 3. The data in table 3 shows that highest seed cotton yield of 3411 kg ha$^{-1}$ was recorded for NIAB-585 followed by IUB-4 & KZ-111which produced 3367 and 3344 kg ha$^{-1}$ seed cotton yield respectively.

**Table 3. Performance of non BT varieties at Cotton Research Station D.I.Khan during 2023-24.**

| VAREITY | Seed Cotton Yield kg / ha | Plant Population ha$^{-1}$ | No. of Ball |
|---|---|---|---|
| BS-352 | 2533 | 35444 | 24 |
| CEMB-Ind | 2744 | 35889 | 23 |
| CIM-990 | 2600 | 35667 | 25 |
| CS-424 | 2467 | 33000 | 24 |
| CIM-600 | 2622 | 32333 | 23 |
| FBG-Gold | 1711 | 37000 | 24 |
| FBG-Super | 3244 | 30556 | 30 |
| ICS-388 | 2011 | 27556 | 25 |
| NIBGE-PF | 3311 | 30667 | 26 |
| CKC-3 | 3267 | 26667 | 25 |
| IUB-4 | 3367 II | 28000 | 23 |
| KZ-111 | 3344 III | 30778 | 32 |
| MNH-1095 | 3156 | 30111 | 24 |
| NIAB-585 | 3411 I | 32333 | 26 |
| SS-32 | 3167 | 30000 | 28 |
| RH-Bagh | 1156 | 8000 | 24 |
| SAS-2 | 3222 | 32333 | 23 |
| Silver-Queen | 3267 | 34333 | 24 |
| Tara-224 | 3533 | 35889 | 25 |
| SS-102 | 2103 | 33692 | 24 |
| VH-442 | 2595 | 41338 | 21 |
| YBG-2828 | 2548 | 41099 | 24 |
| Tartaj-Silver | 2270 | 38301 | 24 |
| BAHAR-777 | 2065 | 41338 | 25 |

### 5.4 NATIONAL COORDINATED VARIETAL TRAIL (Set D)

Twenty three promising strains of different cotton breeders of the country were tested in national coordinated varietal trail (set D) to screen out the most promising and climate adopted variety. The experiment was carried out in randomized complete block (RCB) design having three replications with a net plot size of 30/ × 10/. The sowing was done by dibbling method on 2nd May 2023. Nitrogenous fertilizer @ 150 kg $ha^{-1}$ N was applied in 3 split doses. Standard cultural practices were applied to all the treatments. The data for seed cotton yield (kg $ha^{-1}$), number of bolls per plant, are presented in Table 4. Table 4 shows that maximum seed cotton yield of 2595 kg $ha^{-1}$ was recorded in Silver-Queen-44 Followed by the IR-NIBGE (2548).

**Table 4. Performance of BT hybrid varieties at Cotton Research Station D.I.Khan during 2023-24.**

| VAREITY | Seed Cotton Yield kg / ha | Plant Population $ha^{-1}$ | No. of Ball |
|---|---|---|---|
| BS-315 | 1909 | 37446 | 27 |
| CEMB-AA | 2102 | 33597 | 33 |
| CIM-762 | 2061 | 34935 | 25 |
| CS-110 | 1746 | 32214 | 24 |
| CIM-600 | 1915 | 36370 | 29 |
| Diamond S | 2061 | 35748 | 25 |
| FBS-Smart | 1939 | 33836 | 24 |
| FH-Tri | 1934 | 36987 | 23 |
| IR-NIBGE | 2228 | 35962 | 24 |
| CKC-3 | 2084 | 34395 | 25 |
| IUB-325 | 2259 | 38432 | 24 |
| JSQ-70 | 1962 | 36798 | 29 |
| KZ-324 | 1592 | 35603 | 25 |
| NIAB-484 | 1972 | 33214 | 24 |
| SS-32 | 2103 | 33692 | 25 |
| Silver-Queen-44 | 2595 I | 41338 | 24 |
| IR-NIBGE | 2548 II | 41099 | 22 |
| SAS-1 | 2270 III | 38301 | 23 |
| Tahafuz-S | 2065 | 41338 | 24 |
| SS-102 | 2043 | 38043 | 24 |
| TR-500 | 2031 | 36363 | 23 |
| Weltop-32 | 2067 | 35895 | 24 |
| ZAR-24 | 2079 | 33844 | 21 |

**6. NEEDS FOR COTTON RESEARCH AND DEVELOPMENT**

1. Tubewell installation at the station is the primary need to overcome the water shortage for irrigation purposes.
2. There is no storage facility at the station and we are dependent on Provincial Government for storing the produce and other items. Therefore the store facility may kindly be provided.
3. Solar and UPS installation at the station is the basic need of station to overcome the current load shedding at CRS, DI Khan.

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