Advances in Agriculture and Biology (2018) 1(1): 23-33
RESEARCH PAPER

Evaluation of cotton genotypes for host plant resistance to sucking insects and bollworms: A study on leaf morphology and insect population dynamics

Talib Ashraf

College of Agriculture Dera Ghazi Khan, Sub Campus University of Agriculture, Faisalabad, Pakistan

*****Corresponding author's email: tahamu736@gmail.com

Received: 17 March 2018
Accepted: 15 July 2018

Key Message: This research explores the host plant resistance of various cotton varieties against sucking insects and bollworms. CIM-2 exhibited resistance attributed to specific morphological features. We have defined economic threshold levels for pests, emphasizing the practical implications of our research findings.

Abstract

This research study investigates host plant resistance in various cotton varieties against sucking insects and bollworms, focusing on leaf morphology and insect population dynamics. The study was conducted at Central Cotton Research Institute (CCRI), Multan to explore the diverse challenges faced by cotton growers ranging from production and protection issues to marketing hurdles. The research assesses promising cotton strains included in the National Coordinated Varietal Trial 2003-2004 for their resistance or susceptibility to insect pests under unsprayed conditions. Varieties CIM-2, CIM-7, CIM-8, CIM-9, and CIM-22 were evaluated through a randomized complete block design (RCBD) with three replications. Morphological characteristics such as leaf thickness, hair length, and hair density were measured for providing valuable insights into the physiological features of each variety. Population dynamics of Jassid (*Amrasca biguttula biguttula*), Whitefly (*Bemisia tabaci*), and Thrips (*Thrips tabaci*) were documented for each variety revealing variations in susceptibility. Additionally, a comprehensive field survey conducted in Multan on July 27, 2004, offered a snapshot of cotton insect pests and crop development status in different areas. Farmers' practices and the prevalence of the Cotton Leaf Curl Virus were documented in pest management strategies. Varietal impact on cotton insect pests and crop parameters were analyzed and highlighted notable variations among varieties. Economic threshold levels for whiteflies, jassids, thrips, and bollworms were established. The findings emphasized the resistance conferred by specific morphological traits. For instance, CIM-2's hair density, length, and leaf thickness contributed to resistance against pests. In conclusion, this research provides a comprehensive understanding of host plant resistance in cotton varieties offering practical insights for growers and researchers to optimize crop management strategies. The findings contribute valuable information to address the complex challenges faced by cotton growers and enhance sustainable cotton production practices.

Keywords: Bollworms, Cotton varieties, Host plant resistance, Pest management strategies, Sucking insects

Citation: Ashraf, T. (2018). Evaluation of cotton genotypes for host plant resistance to sucking insects and bollworms: A study on leaf morphology and insect population dynamics. *Advances in Agriculture and Biology, 1*(1), 23-33.

Introduction

Cotton (Gossypium spp.) is widely recognized as a prominent natural fiber and is cultivated in over 111 countries globally (Anonymous, 2005). Serving as a primary cash crop, every component of the cotton plant proves beneficial to farmers in various ways (Shivanna et al., 2009; Ali et al., 2012; Zia et al., 2015). Its semi-woody stem supports a small bush ranging from 1.0 to 1.5 meters in height, with two types of branches: symbodial (fruiting) and monopodial (vegetative). The flowers exhibit cream to yellow petals, while the green fruit splits open when ripe revealing white fluffy seed cotton that hangs from the open bolls until harvest (Anjum et al., 2002). Economically significant, cotton's raw materials are crucial in ginning factories, with seeds providing oil and fibers used in fabric manufacturing. Seed cake serves as nutritious protein for cattle (Zia et al., 2018a, 2018b). Pakistan holds the fourth position in global cotton production contributing significantly to the nation's economy (Tausif et al., 2019).

Cotton thrives across diverse soil types, from nearly pure sand to heavy clay. However, sticky clay can pose challenges in wet weather, making tractor operations difficult. The crop tolerates a broad range of soil acidity and alkalinity but achieves optimal growth at pH 6.0 or higher (Somani, 1996). Cotton's growth is influenced by temperatures between 14 °C and 38 °C with higher temperatures accelerating growth (Zafar et al., 2018). Wind especially in hot climates can impact the crop, leading to lodging and reduced accessibility for spraying and picking (Chaudhary & Guitchounts, 2003). Light is crucial for photosynthesis, while direct sunlight is not necessary, periods of cloudy weather in sunny climates may affect bud and boll shedding. The interaction between sunlight and temperature complicates their individual effects in the field (Chaudhary & Guitchounts, 2003).

Cotton faces a spectrum of challenges encompassing production, protection, and marketing issues. In terms of production, concerns include a low plant population per area, improper fertilizer use, and the cultivation of low-yielding potential varieties (CARITAS, 2004). Protection issues involve the complexity of insect pests, the presence of the Cotton Leaf Curl Virus, inadequate weed control, resistance to insecticides, and the improper use of pesticides. In case of insect pests, cotton confronts a dichotomy: the sucking complex and the chewing complex (CARITAS, 2004). The former includes Jassid, Whitefly, Thrips, Aphid, and Mites, all equipped with sucking mouthparts that damage cotton plants by extracting cell sap, leading to discoloration and plant weakening (Ashfaq et al., 2011). Insects pose a significant threat to cotton crops, causing damage up to 39.50% (Naqvi, 1975; Chaudhry, 1976). *Bemisia tabaci* has emerged as a major sucking pest affecting industrial and food crops worldwide, including cotton, sunflower, melon, tomato, and brinjal (Greathead, 1986). Severe infestations can lead to reduced plant vigor, chlorosis, uneven ripening of bolls, and shedding of immature fruiting parts. The direct feeding of *Bemisia tabaci* induces physiological disorders, resulting in the shedding of immature fruiting parts. Additionally, its nymphs produce honeydew, fostering the growth of black sooty mold, which diminishes the photosynthetic capabilities of plants. This situation leads to stunted plant growth and lint contamination. Moreover, *Bemisia tabaci* serves as the primary vector for over 100 plant viruses, causing diseases in various commercial crops worldwide (Jones, 2003). It is also implicated in transmitting cotton leaf curl virus disease, posing a significant threat to cotton production in Pakistan. *Thrips tabaci* poses a threat by damaging immature cotton seedlings, flowers, and stems. Early in the season, the attack is more severe due to low relative humidity. The aftermath of the attack includes wrinkled and distorted leaves of seedlings, delaying the vegetative phase and resulting in a late harvest, causing substantial losses to both farmers and the country's economy. To combat these pests, a considerable quantity of broad-spectrum insecticides is employed. However, this practice not only raises health and environmental concerns but also contributes to the development of insecticidal resistance among key cotton pests (Mohyuddin et al., 1997).

Effective control strategies involve a holistic approach incorporating cultural practices, biological controls such as the introduction of predators like *Chrysoperla carnea*, Geocoris bug and Lady Bird Beetle, and judicious chemical applications at the economic injury level. Therefore, this research study was aimed to assess the level of resistance or susceptibility in the promising strains of cotton included in the National Coordinated Varietal Trial 2003-2004 against insect pests under unsprayed conditions.

Materials and Methods

Experimental design

The study was conducted at the Central Cotton Research Institute (CCRI), Multan, to evaluate host plant resistance in various cotton varieties against sucking insects and bollworms. The selected cotton varieties (CIM-2, CIM-7, CIM-8, CIM-9, and CIM-22) were part of the National Coordinated Varietal Trial 2003-2004. The experimental design employed a randomized complete block design (RCBD) with three replications.

Varieties and replications

The experimental design encompassed the evaluation of five distinct cotton varieties, each identified by a specific code: V1 = CIM-2, V2 = CIM-7, V3 = CIM-8, V4 = CIM-9 and V5 = CIM-22. This diverse set of cotton varieties was subjected to the study to assess their responses to sucking insects and bollworms. To ensure the reliability and validity of the findings, the experiment was replicated three times, contributing to the robustness of the data and enhancing the statistical significance of the observed trends and variations among the different cotton varieties.

Plot size and layout

The experimental setting featured a plot size of 6×8.84 meters, providing the spatial dimensions for the comprehensive evaluation of cotton varieties. The design employed in this study was a Randomized Complete Block Design (RCBD), a systematic approach that enhances the reliability and accuracy of the experimental results. The specified plot size, coupled with the RCBD layout, allowed for an organized and controlled examination of the selected cotton varieties, facilitating the assessment of their responses to sucking insects and bollworms:

Layout

Set I			Set II			Set III		
V5	V2	V4	V5	V2	V4	V5	V2	V4
V4	V1	V3	V4	V1	V3	V4	V1	V3
V3	V4	V2	V3	V4	V2	V3	V4	V2
V2	V5	V1	V2	V5	V1	V2	V5	V1
V1	V3	V5	V1	V3	V5	V1	V3	V5

Natural field cultivation of genotypes and sucking complex population

The genotypes were grown under natural field conditions with recommended agronomic practices and no control method was used for the insect pests during the whole season even when the population of the pests reached at economic threshold level. The population of sucking complex i.e., jassid, thrips, and whitefly were recorded from three leaves (one each from upper, middle and lower) selected randomly from three plants per plot and then converted into per leaf basis (Ahmad et al., 2011).

Morphological measurements

Morphological characteristics, including leaf thickness, hair length, and hair density were measured for each variety.

Insect population dynamics

The population dynamics of Jassid, Whitefly, and Thrips were documented for each variety. These measurements were conducted in three replications. Population of Jassid, Whitefly and thrips recorded from uper, middle and lower leaves. 15 plants were seletected to record the data as per treatment. However for Bollworms 100 bolls were collected from the treatment then damaged bolls were counted and % damage was calculated.

Field survey

A comprehensive field survey was conducted in Multan on July 27, 2004, to assess cotton insect pests and crop development. Ten farmers/villages were surveyed, documenting pest damage, incidence levels, and protective measures.

Statistical analysis

Morphological data (leaf thickness, hair length, and hair density) were analyzed to understand the physiological features of each cotton variety. Insect population dynamics data were statistically analyzed to assess variations in susceptibility among the cotton varieties. Economic threshold levels for whiteflies, jassids, thrips, and bollworms were established based on the collected data. Statistical analyses were conducted to determine the significance of variations in morphological traits and insect population dynamics among the cotton varieties.

Results

Leaf thickness

In Table 1, leaf thickness measurements for different strains of cotton varieties (CIM-2, CIM-7, CIM-8, CIM-9, and CIM-22) are presented. The leaf thickness was measured three times (R1, R2, R3), and the mean thickness for each variety is calculated. For CIM-2, the leaf thickness ranges from 0.36 to 0.52 mm, with an average thickness of 0.42 mm. CIM-7 exhibits a thickness variation of 0.41 to 0.57 mm, with a mean thickness of 0.48 mm. Similarly, CIM-8 has a range of 0.44 to 0.52 mm, with a mean thickness of 0.48 mm. For CIM-9, the leaf thickness varies between 0.46 and 0.57 mm, with a mean thickness of 0.51 mm. The variety CIM-22 shows the highest leaf thickness among the strains, ranging from 0.59 to 0.72 mm, with a mean thickness of 0.65 mm. These results provide insights into the leaf thickness variations across different cotton strains, which can be valuable for understanding the physiological characteristics of these varieties.

Leaf hair length

Table 2 provides data on leaf hair length for various strains of cotton, including CIM-2, CIM-7, CIM-8, CIM-9, and CIM-22. Measurements were conducted three times (R1, R2, R3), and the mean hair length for each strain is reported. For CIM-2, leaf hair lengths range from 1.8 to 2.3 mm, resulting in an average length of 2.0 mm. CIM-7 exhibits shorter hair lengths, varying from 1.3 to 1.7 mm, with a mean length of 1.5 mm. Similarly, CIM-8 and CIM-22 both have consistent leaf hair lengths across measurements, with mean lengths of 1.4 mm and 1.5 mm, respectively. CIM-9 stands out with the longest leaf hair lengths, ranging from 2.0 to 2.1 mm, and an average length of 2.1 mm. These findings offer insights into the variability in leaf hair lengths among different cotton varieties, providing valuable information for researchers and growers interested in the morphological characteristics of these strains.

Table 1 Leaf thickness of different strains of cotton

Varieties	Leaf thickness (mm)			
	R1	R2	R3	Mean
CIM-2	0.36	0.39	0.52	0.42
CIM-7	0.41	0.46	0.57	0.48
CIM-8	0.44	0.49	0.52	0.48
CIM-9	0.46	0.49	0.57	0.51
CIM-22	0.59	0.65	0.72	0.65

Table 2 Leaf hair length of different strains of cotton

Varieties	Leaf hair length (mm)			
	R1	R2	R3	Mean
CIM-2	1.8	2.3	1.4	2.0
CIM-7	1.3	1.7	1.4	1.5
CIM-8	1.3	1.4	1.5	1.4
CIM-9	2.0	2.1	2.0	2.1
CIM-22	1.6	1.7	1.2	1.5

Leaf hair density

Table 3 presents data on leaf hair density in various strains of cotton, specifically CIM-2, CIM-7, CIM-8, CIM-9, and CIM-22. The number of hairs per square centimeter is reported as a range and the mean value. For CIM-2, the leaf hair density ranges from 357 to 450 hairs/cm^2, with a mean density of 399 hairs/cm^2 based on a sample size (n) of 16. CIM-7 exhibits a broader range, with a density varying from 188 to 368 hairs cm^{-2} and a mean density of 257 hairs/cm^2. CIM-8 displays a range of 246 to 449 hairs/cm^2 and a mean density of 335 hairs/cm^2. CIM-9 shows a range of 257 to 351 hairs/cm^2, with a mean density of 301 hairs/cm^2. CIM-22 has the widest range, from 134 to 391 hairs/cm^2, and a mean density of 265 hairs/cm^2. These results provide valuable information about the leaf hair density variability across different cotton strains, aiding researchers and agricultural scientists in understanding the morphological characteristics of these varieties.

Table 3 Leaf hair density in different strains of cotton

Variety	Number of hairs/cm^2	
	Range	Mean
CIM-2	357-450	399 (n = 16)
CIM-7	188-368	257 (n = 16)
CIM-8	246-449	335 (n = 16)
CIM-9	257-351	301 (n = 16)
CIM-22	134-391	265 (n = 16)

Population of Jassid

Table 4 outlines the population of Jassid per leaf for different strains of cotton, including CIM-2, CIM-7, CIM-8, CIM-9, and CIM-22. The population was recorded in three replicates (R1, R2, R3), and the mean population per leaf is reported. CIM-2 exhibits a relatively consistent population, ranging from 1.08 to 1.2, with a mean population of 1.14. CIM-7 demonstrates a higher Jassid population, with values ranging from 1.82 to 2.26 and a mean population of 2.04. CIM-8 and CIM-9 both show varying populations, with mean values of 1.49 and 1.24, respectively. CIM-22 displays fluctuating populations, ranging from 0.67 to 1.85, and a mean population of 1.23. These findings offer insights into the susceptibility of different cotton varieties to Jassid infestation, which is crucial information for pest management strategies in agricultural practices.

Table 4 Population of Jassid on different strains of cotton

Varieties	Population of Jassid per leaf			
	R1	R2	R3	Mean
CIM-2	1.2	1.08	1.15	1.14
CIM-7	1.82	2.26	2.06	2.04
CIM-8	1.5	1.6	1.37	1.49
CIM-9	1.08	0.98	1.67	1.24
CIM-22	1.85	1.17	0.67	1.23

Population of Whitefly

Table 5 provides data on the population of Whitefly per leaf for different strains of cotton, namely CIM-2, CIM-7, CIM-8, CIM-9, and CIM-22. The population was recorded in three replicates (R1, R2, R3), and the mean population per leaf is reported. CIM-2 exhibits a variable Whitefly population, ranging from 0.53 to 0.97, with a mean population of 0.8. CIM-7 shows a consistent population, varying from 0.36 to 0.57, and a mean population of 0.58. CIM-8 demonstrates fluctuating populations, ranging from 0.65 to 1.31, with a mean population of 0.89. CIM-9 displays a variable population, ranging from 0.12 to 1.01, and a mean population of 0.67. CIM-22 exhibits a range of 0.8 to 1.03, with a mean population of 0.92. These results offer insights into the variability in Whitefly populations across different cotton varieties, providing valuable information for researchers and practitioners engaged in pest management strategies in cotton cultivation.

Table 5 Population of Whitefly on different strains of cotton

Varieties	Population of Whitefly per leaf			
	R1	R2	R3	Mean
CIM-2	0.53	0.97	0.92	0.8
CIM-7	0.41	0.57	0.36	0.58
CIM-8	0.65	0.7	1.31	0.89
CIM-9	0.12	0.87	1.01	0.67
CIM-22	0.8	0.93	1.03	0.92

Population of Thrips

Table 6 presents the population of Thrips per leaf for different strains of cotton, including CIM-2, CIM-7, CIM-8, CIM-9, and CIM-22. The population counts were recorded in three replicates (R1, R2, R3), and the mean population per leaf is reported. CIM-2 displays a varying population of Thrips, ranging from 0.04 to 0.80, with a mean population of 0.32. CIM-7 shows a consistently low Thrips population, fluctuating between 0.10 and 0.12, with a mean population of 0.11. CIM-8 and CIM-22 both exhibit low and consistent Thrips populations, with mean values of 0.10 and 0.10, respectively. CIM-9 displays a slightly higher variability, ranging from 0.20 to 0.32, with a mean population of 0.27. These findings provide insights into the Thrips population dynamics across different cotton varieties, aiding researchers and agricultural practitioners in understanding the susceptibility of these strains to Thrips infestation for effective pest management strategies.

Table 6 Population of Thrips on different strains of cotton

Varieties	Population of Thrips per leaf			
	R1	R2	R3	Mean
CIM-2	0.12	0.04	0.80	0.32
CIM-7	0.10	0.12	0.12	0.11
CIM-8	0.06	0.10	0.14	0.10
CIM-9	0.28	0.20	0.32	0.27
CIM-22	0.18	0.06	0.06	0.10

Field survey of cotton insect pests and crop development

The field survey conducted on July 27, 2004, in the areas of Makhdum Rashid, 9-Kasi, Lar, Qasba Maral, Khokran, District Multan, provided valuable insights into the status of cotton insect pests and crop development. Ten farmers/villages were assessed, revealing varying degrees of pest damage and incidence. Notably, Shoukat Aman from Moza Jandi wala reported 12% damage in insusceptible bolls, with 2 eggs and 3.2 larvae of *Helicoverpa armigera* per 25 plants. The survey indicated a range of predator populations, with an average of 1.1 predators (000/acre). Cotton leaf curl virus (CLCV) incidence levels were recorded, with an average of 14.3%, categorized as mild to medium losses. Plant protection measures varied among farmers, with some opting for chemical insecticides like Cypermethrin or a combination of Triazophos and Deltamethrin, while others relied on non-chemical methods. The average CLCV incidence and pest damage suggested a moderate level of infestation, prompting farmers to employ diverse protective strategies. This comprehensive survey provides a snapshot of the pest scenario and crop health, contributing valuable information for tailored pest management strategies in the studied areas.

Field survey of variety impact on cotton insect pests and crop parameters

The results from Table 8, assessing the variety impact on cotton insect pests and crop parameters in Makhdum Rashid, 9-Kasi, Lar, Qasba Maral, Khokran, Multan on July 27, 2004, provide valuable insights into the performance of different cotton varieties. Notable variations are observed among the farmers, with CIM-526, CIM-505, and IR-901 displaying diverse characteristics. Shoukat Aman's CIM-526 exhibits a relatively low number of sucking insect pests per leaf (1.2) and moderate bollworm damage (1.3%). In contrast, Kausar Hashmi's CIM-505 faces a higher percentage of bollworm damage (1.6%) but has a lower incidence of jassids and thrips. Additionally, Dr. Khalid's CIM-473 shows a significant susceptibility to bollworms (5.6%) and a high number of sucking insect pests per leaf (3.4). The average values across all varieties indicate a moderate insect pest load, with an average of 1.14 sucking insect pests per leaf and 4.9% bollworm damage. The economic threshold levels for whiteflies, jassids, thrips, and bollworms are established, with the asterisk (*) denoting instances where values exceed the economic threshold level. These findings contribute valuable information for farmers and researchers seeking to optimize cotton crop management strategies in the region.

Discussion

Cotton crop sowing typically commences from May to mid-June in the main cotton-growing regions of the Punjab province. The introduction of early maturing varieties accelerates fruit formation, which starts approximately 40-45 days after sowing. Sucking pests such as thrips, jassid, and whitefly begin to manifest shortly after the emergence of the cotton plants. Under normal weather conditions, these pests do not pose significant problems due to the presence of natural enemies. However, during early monsoon rains, when the weather becomes hot and humid, the population of jassid can surge, causing considerable damage to cotton plants. Conversely, in the absence of early monsoon and in dry, hot weather conditions, the populations of thrips and whitefly start to increase. Following the devastating outbreak of the cotton leaf curl virus in the mid-nineties, farmers have become more vigilant about whitefly infestations and the associated disease. In both scenarios, farmers proactively initiate spraying to safeguard their crops from these pests. Unfortunately, early spraying not only results in an increased number of sprays throughout the season but also adversely affects natural enemies. In the absence of natural enemies, the whitefly population can rapidly escalate, exacerbating the problem, as reported in Sudan (Eveleens, 1983); America (Miller, 1986); Turkey (Sengonca, 1975).

Leaf hair density and distribution are considered important components of jassid resistance in cotton. Some research has shown that hairiness is negatively correlated with jassid population but has no relationship with whitefly (Ali & Ahmad, 1982) but other studies found that it contributes to jassid resistance but susceptibility to whitefly (Ahmed, 1980). Greater hair density on the mid rib and leaf lamina was found to be associated with resistance to jassid (Singh et al., 1972; Hussain, 1984; Agarwal et al., 1987). When associated with a greater number of gossypol glands on mid rib, it contributes to whitefly and thrip resistance (Ahmed et al., 1987). All the varieties showing resistance were hairy. During this study, the cotton variety CIM-2 exhibited a hair density of 399/cm^2, a hair length of 2.05 mm, and a leaf thickness of 0.49 mm. These three characteristics act as a defense against pest attacks, as the presence of hair serves as a physical hindrance to both oviposition and feeding. Two crucial factors, hair density and length contribute to resistance against Jassid. Varieties with greater hairiness exhibited lower rates of nymph development for jassid and lower survival rates to the adult stage.

Similar results regarding whitefly population but on different tested genotypes are in conformity with those of Raza & Afzal (2000); Bashir et al. (2001). However, observations regarding period of abundance differed to the findings of these workers. A comparison of these findings with those already completed by Kim (1985), Malik & Nandal (1986); Sharipova (1987); Dhawan et al. (1990); Rao et al. (1991); Ali & Ali (1993); Tomar & Rana (1994); Arif et al. (2004); Aheer et al. (2006); Ali & Aheer (2007) on the comparative resistance of some cotton varieties to the sucking insect-pests was not possible in precise terms, because of the differences in the varietal/pest combinations tried by them. As such, the present efforts were definitely a new addition to the previous fund of knowledge. Mound (1965); Chu et al. (2000) reported the absence of adult whiteflies or their eggs on the initial two upper leaves of certain notably hairy cotton plants. In contrast, existing literature consistently reveals that cotton cultivars with a higher degree of hairiness exhibit increased Bemisia densities when compared to smoother-leaved varieties (Norman & Sparks, 1977; Sippell et al., 1983; Chu et al., 1999). A study conducted by Van Lenteren & Noldus (1990) concluded that habitats with moderate trichome density were more favorable for whitefly colonization compared to those with heavy trichome density. Stanton et al. (1992) assessed 43 accessions for thrips resistance over the period 1988 to 1990 at Cotton Experiment Station, Mariana, Arkansas, USA. Their findings indicated that *G. arboreum* accessions experienced comparatively lower damage from thrips. This observation aligns with the results of the current study, as reported by Arif et al. (2006) who also identified resistance in okra leaf-type cotton. The diminished thrips population on Gumbo Okra may be attributed to its reduced leaf surface area. The reduced surface area of okra leaf cotton facilitates better light penetration to the lower parts of the plant, exposing thrips' hiding places. In the present study, the highest number of thrips was observed on normal leaf cotton S-12 and FH-1000. These genotypes are characterized by large and wide leaves.

Bhatnagar and Sharma (1991) conducted an investigation into the varietal resistance of cotton genotypes against sucking insect pests and documented a lower number of jassid on okra genotypes. Similarly, Chu et al. (2000) explored host plant resistance in normal and okra leaf genotypes against jassid, revealing that okra leaf cotton exhibited resistance in comparison to normal leaf cotton. In a separate study, Ahmad et al. (2005) assessed ten upland genotypes for plant resistance against jassid and identified the okra leaf genotype (Okra-170) as the most resistant.

Table 7 Field survey report on cotton insect pests and crop development in the areas of Makhdum Rashid, 9-Kasi, Lar, Qasba Maral, Khokran, District Multan on July 27, 2004

Sr. No.	Name of farmer /village	% PBW damage insusceptible bolls	*H. armigera*/25 plants		Predators (000/acre)	% CLCV incidence			Plant protection measures		
			Eggs	Larvae		A	B	C	Spray No.	Insecticide used	Dose/acre (ml/g)
1.	Shoukat Aman, Moza Jandi wala	12	2	3.2	27	4	4	3	-		
2.	Kausar Hashmi, Makhdum Rashid	8	4	0.00	29	18	16	9	-		
3.	Safdar A. Bukhari, Chak 5/MR	0	3	0.00	22	3	3	2	-		
4.	Inayat Ali, Chowk Hasina	0	0	0.00	26	3	2	2	1	Cypermethrin	330 ml/acre
5.	Rao Nazir Ahmad, Moza Rid	0	0	0.00	0	2	2	1	1	Sprayed	
6.	Sheikh Khalil, Moza Lar	0	3	3	0	1	2	1	1	Triazophos + Deltamethrin	500 ml + 250 ml/acre
7.	Tasdaq Hussain, Ghok Gamun	0	0	0	0	3	2	1	-		
8.	Ghulam Abbas, Qasba Maral	0	2	2	22	3	4	2	-		
9.	Dr. Khalid, Moza Khokran	0	0	0	3	8	7	4	-		
10.	Zia ul Haq Hashmi, Tara Gahar	0	0	0	14	8	9	5	-		
	Average	**2.0**	**1.4**	**1.1**	**14.3**	**5.3**	**5.1**	**3.0**			

CLCV incidence levels: A = Mild or losses up to 20%; B = Medium or losses up to 40%; C = Severe or losses up to 80%

Table 8 Variety impact on cotton insect pests and crop parameters (Makhdum Rashid, 9-Kasi, Lar, Qasba Maral, Khokran, Multan - July 27, 2004)

Sr. No.	Name of farmer /village	Variety	No. of plants (000/acre)	Plant height (cm)	Sucking insect pests per leaf			No. of fruiting parts (000/acre)		% bollworms damage in fruits	SBW larvae (in 25 plants)
					Whitefly	Jassid	Thrips	Immature FP	Mature bolls	Immature	
1.	Shoukat Aman, Moza Jandi wala	CIM-526	16	58	1.2	0.4	1.3	345	14	3.5	1.6
2.	Kausar Hashmi, Makhdum Rashid	CIM-505	19	60	1.8	0.4	1.6	177	100	0.0	0.0
3.	Safdar A. Bukhari, Chak 5/MR	IR-901	16	63	1.0	0.6	1.1	222	20	0.9	0.0
4.	Inayat Ali, Chowk Hasina	CIM-446	17	58	0.2	0.0	0.5	305	18	1.6	3.0
5.	Rao Nazir Ahmad, Moza Rid	BH-160	22	52	0.6	0.0	0.4	230	15	2.2	0.0
6.	Sheikh Khalil, Moza Lar	CIM-506	19	69	0.8	0.2	0.2	297	22	7.4	0.0
7.	Tasdaq Hussain, Ghok Gamun	CIM-496	19	85	1.2	0.2	0.4	415	13	4.1	1.3
8.	Ghulam Abbas, Qasba Maral	NIAB-111	19	59	0.9	1.7*	0.6	284	12	8.1	3.9
9.	Dr. Khalid, Moza Khokran	CIM-473	18	75	3.4	1.4*	0.6	382	15	5.6	5.6
10.	Zia ul Haq Hashmi, Tara Gahar	CIM-511	16	48	0.3	2.0*	1.7	112	0	13.4	0.0
	Average		**18.1**	**62.7**	**1.14**	**0.7**	**0.6**	**277**	**23**	**4.9**	**1.54**

Economic threshold level: White = 5/leaf; Jassid = 1/leaf; Thrips = 8-10/leaf; Bollworms = 15%; * = above the economic threshold level

Conclusion

The findings indicated prominent variations among the evaluated cotton varieties in terms of leaf morphology and susceptibility to insect pests. CIM-2 demonstrated resistance to pests attributed to specific morphological traits such as hair density, length, and leaf thickness. The economic threshold levels for whiteflies, jassids, thrips, and bollworms were established providing practical benchmarks for pest management strategies. The field survey offered a practical perspective on pest damage, incidence levels, and protective measures adopted by farmers. Variability in the impact of different cotton varieties on insect pests and crop parameters was evident, emphasizing the need for management strategies based on varietal characteristics. Overall, this research contributes valuable insights for cotton growers and researchers, providing a comprehensive understanding of host plant resistance in cotton varieties. The findings offer practical guidance for optimizing crop management strategies, addressing the complex challenges faced by cotton growers, and enhancing sustainable cotton production practices.

References

Agarwal, R. A., Banerjee, S. K., & Katiyar, K. N. (1987). Resistance to insects in cotton-1. To Amrasca devastans. *Coton et Fiber Tropicales, 33*(4), 409-414.

Aheer, G. M., Ali, A., & Hussain, S. (2006). Varietal resistance against jassid, Amrasca devastans Dist. in cotton and role of abiotic factors in population fluctuation. *Journal of Agricultural Research*, *44*, 299-305.

Ahmad, G., Arif, M. J., Ramzan, M., & Sanpal, Z. (2005). Population fluctuation of jassid, Amrasca devastans (Dist.) in cotton through morphological plant traits. *Caderno de Pesquisa Serie. Biologia, 17*, 71-79.

Ahmad, N., Khan, M., Tofique, M., & Rauf, I. (2011). Insect pests management of Bt cotton through the manipulation of different eco-friendly techniques. *The Nucleus, 48*(3), 249-254.

Ahmed, M., Khan, M. R., & Saeed, M. (1987). Studies on factors contributing resistance in five new cultivars of cotton against insect pests. *Pakistan Entomologist*, *9*(1-2), 75-83.

Ahmed, N. (1980). Some studies on the resistance in cotton against sucking insect pests. M.Sc. Thesis, University of Agriculture, Faisalabad.

Ali, A., & Aheer, G. M. (2007). Varietal resistance against sucking insect-pests of cotton under Bahawalpur ecological conditions. *Journal of Agricultural Research*, *45*, 1-5.

Ali, A., & Ahmad, M. (1982). Biophysical resistance in different varieties of cotton against insect pests. *Pakistan Entomologist, 4*(1-2), 27-32.

Ali, M. I., & Ali, M. R. (1993). Okra leaf cotton: a potential source of resistance against the cotton jassid, Amrasca devastans (Dist.) in Bangladesh. *Bangladesh Journal of Zoology, 21*, 45-49.

Ali, S., Shah, S. H., Ali, G. M., Iqbal, A., Asad Ullah, M., & Zafar, Y. (2012). Bt cry toxin expression profile in selected Pakistani cotton genotypes. *Current Science*, *102*(10), 1632-1636.

Anjum, A., Soomro, A., Bano, S., Chang, M., & Leghari, A. (2002). Fruiting position impact on seedcotton yield in American cotton. *Asian Journal of Plant Sciences, 1*, 153-155.

Anonymous. (2005). Training manual on DVS test in cotton with resistance to PPV and FR legislation 2001. All India Coordinated Cotton Improvement Project CICR, Coimbatore, Tamil Nadu, 134-135.

Arif, M. J., Gogi, M. D., & Ahmad, G. (2006). Role of morpho-physical plant factors imparting resistance in cotton against Thrips, Thrips tabasi Lind (Thripidae thysanoptera). *Arabian Journal of Plant Protection, 24*, 57-60.

Arif, M. J., Sial, I. A., Saifullah, Gogi, M. D., & Sial, M. A. (2004). Some morphological plant factors affecting resistance in cotton against thrips (*Thrips tabaci* L.). *International Journal of Agriculture and Biology, 6*, 544-546.

Ashfaq, S., Khan, I. A., Saeed, M., Saljoqi, A. R., Manzoor, F., Sohail, K., Habib, K., & Sadozai, A. (2011). Population dynamics of insect pests of cotton and their natural enemies. *Sarhad Journal of Agriculture*, *27*, 251-253.

Bashir, M. H., Afzal, M., Sabri, M. A., & Raza, A. M. (2001). Relationship between sucking insect pests and physio-morphic plant characters towards resistance/susceptibility in some new cotton genotypes of cotton. *Pakistan Entomologist*, *23*, 75-78.

Bhatnagar, P., & Sharma, P. D. (1991). Comparative incidence of sucking insect pests on different isogenic lines of cotton variety. *Journal of Insect Science*, *4*, 170-171.

CARITAS. (2004). Unfair Trade and Cotton: Global Challenges, Local Challenges; CARITAS-CISDE: Geneva, Switzerland.

Chaudhary, M. R., & Guitchounts, A. (2003). Cotton Facts (Technical Paper No. 25 of the Common Fund for Commodities). International Cotton Advisory Committee.

Chaudhry, G. Q. (1976). Pest Control in Cotton Production. Proceedings of Cotton Production Seminar, Ess o Fertilizer Company Ltd., Pakistan, 114-118.

Chu, C. C., Cohen, A. C., Natwick, E. T., Simmons, G. S., & Henneberry, T. J. (1999). Bemisia tabaci (Homoptera: Aleyrodidae) biotype B colonization and leaf morphology relationships in upland cotton cultivars. *Australian Journal of Entomology*, *38*(2), 127-131.

Chu, C. C., Natwick, E. T., & Henneberry, T. J. (2000). Susceptibility of normal-leaf and okra-leaf shape cottons to silverleaf whiteflies and relationships to trichome densities. In: Proceedings of the Beltwide Cotton Production Research Conference, San Antonio, TX, 4-8 Jan. 2000. Natl. Cotton Counc. Am., Memphis, TN, pp. 1157-1158.

Dhawan, A. K., Simwat, G. S., & Sidhu, A. S. (1990). Field reaction of different varieties of upland cotton to insect-pests in Punjab. *Journal of Research, Punjab Agricultural University*, *27*, 263-266.

Eveleens, K. G. (1983). Cotton-insect control in the Sudan Gezira: Analysis of a crisis. *Crop Protection*, *2*(3), 273-287.

Greathead, A. H. (1986). Host plants. In: Cock (Ed.), Bemisia Tabaci, A Literature Survey on the Cotton Whitefly with an Annotated Bibliography. CAB International, UK. pp. 17-26.

Hussain, T. (1984). Studies on development of Multi-adversity-resistant cotton lines in Pakistan. Second Annual Progress Report (PL-480 Project), Central Cotton Research Institute, Multan.

Jones, D. R. (2003). Plant viruses transmitted by whiteflies. *European Journal of Plant Pathology*, *109*(2), 195-219.

Kim, Ch. N. (1985). Evaluation of the resistance of cotton varieties to aphids. *Zaschita Rastenii*, *7*, 28-29.

Malik, V. S., & Nandal, A. S. (1986). Screening of cotton varieties/germplasm for resistance against cotton jassid, Amrasca biguttula biguttula and pink bollworm, *Pectinophora gossypiella*. *Haryana Agricultural University Journal of Research*, *16*, 290-293.

Miller, T. A. (1986). Status of resistance in the cotton insect complex. In: Proceedings of the Beltwide Cotton Production Conference (eds. J. M. Brown and T. C. Nelson). National Cotton Council, Memphis, TN, pp. 162-165.

Mohyuddin, A. I., Jillani, G., Khan, A. G., Hamza, A., Ahmad, I., & Mahmood, Z. (1997). Integrated pest management of major cotton pests by conservation, redistribution and augmentation of natural enemies. *Pakistan Journal of Zoology*, *29*(4), 293-298.

Mound, L. A. (1965). Effect of leaf hair on cotton whitefly populations in the Sudan Gezira. *Empire Cotton Growers Review*, *42*, 33-40.

Naqvi, K. M. (1975). Crop Protection to Boost up Cotton Production. Cotton Seminar, April 13-14, 1975, Layllpur.

Norman, J. W., & Sparks, Jr. A. N. (1977). Cotton leaf hairs and silverleaf whiteflies in the lower Rio Grande Valley of Texas three year research summary. In P. Dugger & D. Richter (Eds.), Proceedings of the Beltwide Cotton Production Research Conference (pp. 1063-1064). National Cotton Council of America, Memphis, TN.

Rao, N. V., Reddy, A. S., & Rao, K. T. (1991). Reaction of a few cotton cultivars to whitefly, *Bemisia tabaci* Genn. *Madras Agricultural Journal*, *78*(1), 72-73.

Raza, A. M., & Afzal, M. (2000). Physio-morphic plant characters in relation to resistance against sucking insect pests in some new cotton genotypes. *Pakistan Entomologist*, *22*(1), 73-78.

Sengonca, C. (1975). Beitrag zum epidemischen Auftreten der Tabakmottenschildlaus, Bemisia tabaci Genn. Am Baumwollpflanzen in Suedantolien (Homoptera: Aleyrodidae). Anzeiger für Schädlingskunde, Pflanzenschutz, Umweltschutz, 48(9), 140-142.

Sharipova, G. F. (1987). Resistance of cotton to cotton aphid. Zaschita Rastenii, Moscow, 6(26-27).

Shivanna, B. K., Nagaraja, D. N., Manjunatha, M., & Naik, M. I. (2009). Seasonal incidence of sucking pests on transgenic Bt cotton and correlation with weather factors. *Karnataka Journal of Agricultural Sciences*, *22*, 666-667.

Singh, T. H., Singh, G., & Sharma, K. P. (1972). Resistance of cotton to cotton jassid, *Amrasca devastans*. *Indian Journal of Agricultural Sciences*, *42*(5), 421-425.

Sippell, D. W., Bindra, O. S., & Khalifa, H. (1983). Resistance to whitefly (Bemisia tabaci) in cotton. Gezira Agricultural Research Station Working Paper, No. 10.

Somani, L. L. (1996). Crop production in acid soils. Agrotech Publishing Academy, New Delhi.

Stanton, M. A., Stewart, J. McD., & Tugwell, N. P. (1992). Evaluation of Gossypium aroboreum L. germplasm for resistance to thrips. *Genetic Resources and Crop Evolution*, *39*(2), 89-95.

Tausif, M., Jabbar, A., Naeem, M. S., Abdul Basit, Faheem Ahmad, & Thomas Cassidy. (2019). Cotton in the new millennium: advances, economics, perceptions and problems. *Textile Progress*, *50*(1), 1-66.

Tomar, S. K., & Rana, O. S. (1994). Incidence of jassid in relation to variety and time of sowing in cotton (Gossypium spp.). *Indian Journal of Agricultural Sciences*, *64*, 70-71.

Van Lenteren, J. C., & Noldus, L. P. J. J. (1990). Whitefly-plant relationship: Behavioral and ecological aspects. In D. Gerling (Ed.), Whiteflies: Their Bionomics, Pest Status and Management (pp. 47-89). Intercept, Andover, UK.

Zafar, S. A., Noor, M. A., Waqas, M. A., Wang, X., Shaheen, T., Raza, M., & Rahman, M.-U. (2018). Temperature Extremes in Cotton Production and Mitigation Strategies. In M.-U.-R. Rahman & Y. Zafar (Eds.), Past, Present and Future *Trends in Cotton Breeding*. doi:10.5772/intechopen.74648.

Zia, M. A., Jan, S. A., Shinwari, Z. K., Shah, S. H., & Khalil, A. T. (2015). Impact of Bt cotton on animal health: A review. *Global Veterinaria, 14*(3), 377-381.

Zia, M. A., Shinwari, Z. K., Ali, S., Shah, S. H., Anwar, M., & Ali, G. M. (2018a). Comparison among different cotton (*Gossypium hirsutum* L.) genotypes with respect to morphological, fibre quality attributes and expression analysis of *Cry1Ac* gene. *Journal of Animal and Plant Sciences, 28*(3), 819-829.

Zia, M. A., Shinwari, Z. K., Ali, S., Shah, S. H., Anwar, M., & Ali, G. M. (2018b). Comparison among different cotton (*Gossypium hirsutum* L.) genotypes with respect to morphological, fibre quality attributes and expression analysis of *Cry1Ac* gene. *Journal of Animal and Plant Sciences, 28*(3), 819-829.