Research Article

Varietal Response of Cotton (*Gossypium hirsutum* L.) against Different Sucking Insect Pests

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Abstract | Nine cotton (*Gossypium hirsutum* L.) varieties were tested for resistance against whiteflies (*Bemisia tabaci*), jassid (*Amrasca biguttula biguttila*), and thrips (*Thrips tabaci)* at the Cotton Research Institute, Multan. This study investigates the population dynamics of sucking insect pests cross different cotton varieties during the months of July, August, and September. Significant variations in pest populations were observed, with the peak infestations exceeding the Economic Threshold Level (ETL). In September, the highest whitefly population was recorded on FH-1184 (5.20/leaf), while the lowest was noted on MNH-Sultan and CKC-6, at 3.67 and 3.69/leaf, respectively. August also revealed elevated jassid infestations, notably on FH-1184 and MNH-1082 (4.24/leaf). In contrast, thrips populations peaked on CKC-6 (1.17/leaf) while the lowest was recorded on MNH-Shan (0.51/leaf). Results indicate that both July and August were conducive to the growth of whitefly and jassid populations, contrasting with findings by Swidrak *et al*. (2013), which identified a July peak for jassids. The study enhances understanding of pest resistance among cotton varieties, with MNH-789 exhibiting the highest tolerance to jassids, whereas CKC-6 showed notable resistance to thrips and whitefly. These findings contribute valuable insights into host plant resistance against sucking pests, highlighting the importance of genotype selection in pest management strategies.

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Introduction

As an important cash crop and source of fiber, cotton contributes significantly to Pakistan's economy (Tayyib *et al*., 2005). According to the GoP (2022), it accounts for 68% of the nation's foreign exchange profits. Cotton is one of the most economically significant agricultural crops globally, providing raw materials for the textile industry and supporting the livelihoods of millions of farmers.

However, its cultivation faces significant challenges due to the prevalence of various insect pests, notably sucking insects such as whiteflies (*Bemisia tabaci*), jassid (*Amrasca biguttula biguttila*), and thrips (*Thrips tabaci)*. These pests not only cause direct damage to the cotton plants but can also serve as vectors for plant diseases, leading to reduced crop yields and lower quality fiber.

Cotton cultivation requires significant financial investment, especially in pest control measures, with synthetic chemicals being extensively used to protect and enhance growth (Deguine *et al*., 2008). Insect pests pose a significant biotic threat to cotton production, reducing quality and yield, particularly in developing countries where small landholdings limit farmers' access to costly protective measures. Additionally, the excessive use of synthetic chemicals contributes to environmental pollution (Fahad *et al*., 2023). Pathogens and insect pests can cause yield losses of up to 30% in certain regions. Weeds, competing for nutrients and space, negatively impact cotton growth, accounting for 9% of total production losses. Input deficiency contributes to 40% of total production losses, emphasizing the importance of proper resource management.

Cotton farming experiences 29% total losses despite extensive pest control measures, highlighting the need for integrated pest and weed management strategies to minimize environmental harm and enhance production. Pakistan's cotton cultivation heavily relies on synthetic pesticides, causing environmental and health concerns due to the prolonged use of toxic chemicals (Iqbal *et al*., 1997; Tariq *et al*., 2007; Damalas, 2009; Damalas and Eleftherohorinos, 2011).

Pesticides are used to protect crops from pests and boost productivity, but misuse poses significant threats to human health and the environment. Globally, there's a need to educate farmers on sustainable use, raise awareness about integrated pest management, and explore innovative methods to manage pests that impact cotton yields. Pakistan, the fourth-largest cotton-producing country globally, struggles with low cotton yield per acre due to widespread insect pest attacks, with 162 species feeding on cotton at various growth stages, complicating crop management (Kannan *et al*., 2004). To address these challenges, adopting sustainable farming practices, investing in farmer education, and exploring eco-friendly pest control strategies are essential to improve productivity and reduce reliance on harmful chemicals in cotton cultivation.

Cotton pests are classified into sucking and chewing types. Sucking pests like thrips, jassids, and whiteflies extract cell sap from leaves, causing significant yield losses. Chewing pests like pink bollworm, spotted bollworm, and American bollworm feed on cotton bolls, causing 5-10% yield losses under normal conditions and 40-50% during severe infestations (Chaudhary, 1976). Whitefly infestations, which can persist from seedling to maturity, lead to substantial reductions in both yield and quality (Amer *et al*., 1999). Jassid and thrips alone account for a 38% yield loss (Baloch *et al*., 1986), while overall pest attacks caused losses of approximately 3.1 million during 2019-20 (Ahmad and Poswal, 2020). Farmers commonly use insecticides to mitigate these losses, but their overuse has led to significant drawbacks, including environmental pollution, health risks for humans and animals, and the development of resistance in pest populations (Mohyuddin *et al*., 1997).

Resistant cotton cultivars offer an effective alternative, providing protection against pests without compromising yield (Chaudhary and Arshad, 1989). Plant breeders in Pakistan have focused on developing high-yielding varieties with resistance traits to counter both sucking and chewing pests. The need for integrated pest management (IPM) given cotton's economic importance, implementing an integrated pest management (IPM) program is critical. Effective IPM requires understanding key ecological factors, such as plant spacing and weather conditions (temperature, relative humidity, and precipitation), which influence pest multiplication and distribution. However, progress in this field has been slow due to limited research. This study aimed to: Evaluate the population dynamics of sucking insect pests on cotton under various plant spacing conditions. As well as analyze the relationship between pest populations and weather factors to provide insights for effective pest control strategies.

Materials and Methods

This experiment aimed to evaluate the variation in pest population and yield performance among different cotton varieties under natural field conditions. The findings contribute to understanding pest dynamics and their impact on cotton productivity, guiding the development of effective pest management strategies. This study was conducted at the Cotton Research Institute (CRI) in Multan under a Randomized Complete Block Design (RCBD). The experiment involved ten cotton varieties (FH-1199, MNH-Super Gold, CKC-6, FH-1133, MNH-1082, MNH-Sultan, FH-Tri Star, FH-1184, MNH-Shan), with three replications for each genotype. The varieties were sown in June 2023-24 in plots measuring 250 m^2. The plants were cultivated under natural field conditions with standard agronomic practices. No pest control measures were applied. Data were collected from June to August 2023-24. The population of sucking insect pests (jassid, whitefly, and thrips) was recorded from three randomly selected leaves (upper, middle, and lower) of three plants per plot. These observations were converted to a per-leaf basis. Cotton yield for each plot was recorded by harvesting the crop twice during the growing season. The collected data were analyzed using Analysis of Variance (ANOVA) with the software Statistix 8.1. Differences in mean pest populations and yield among varieties were evaluated at a 5% probability level using Duncan's Multiple Range (DMR) test.

Fiber characteristics

Ginning out turn (%): The ginning out turn was calculated using the following formula:

$$\text{GOT \%} = \frac{\text{Lint weight}}{\text{Seed cotton weight}} \times 100$$

Other quality parameters: These include Fiber Length (mm), Fiber Strength (g/tex) and Fiber Fineness (μg/g) were measured using the Fibrograph HVI-900 from the Fiber Technology Lab at the Cotton Research Station, AARI, Faisalabad, Pakistan.

Statistical analysis

Ten plants were sampled per treatment, with insect populations quantified as the number of adults/nymphs per leaf. Data were statistically analyzed using Duncan's Multiple Range (DMR) test at a 5% probability level. Correlations between pest populations and weather factors were also assessed.

Results and Discussion

The results highlight significant differences in the pest populations across the experimental varieties during the different months (Table 1). During the month of September, the infestation exceeded the economic threshold level (ETL), with the highest infestation of whitefly was observed on FH-1184 (5.20/leaf) while the lowest infestation observed on MNH- Sultan and CKC-6 i.e., 3.67 and 3.69/leaf, respectively. Jassid population also exceed due to favorable environmental condition, the maximum population was on FH-1184 and MNH-1082 i.e., 4.24/leaf on both the verities, while minimum was observed on CKC-6 and MNH-Shan i.e., 1.27 and 1.30/leaf, respectively. Conversely, the lowest infestation of thrips was recorded on MNH-Shan (0.51/leaf), while maximum was observed on CKC-6 (1.17/leaf) (Table 1).

During the month of August the highest whitefly populations across all varieties, surpassing the ETL, with FH-1184 (5.24/leaf), FH-Tristar (5.04/leaf), and MNH-1082 (5.00/leaf) showing significant levels of infestation. While the lowest infestation recorded on FH-1133 (3.84/leaf), MNH-Shan (3.34/leaf) and CKC-6 (3.23/leaf), respectively. The results also indicated that during this month the maximum population of jassid was observed on FH-1184, FH-Tri Star, MNH 1082 i.e., 5.60, 5.27 and 5.20/leaf, respectively. While the minimum population infestation was on MNH-Shan and CKC-6 i.e., 1.64 and 1.24/leaf, respectively. The lowers population of thrips was observed on MNH-Shan and CKC-6 i.e., 0.28 and 0.74/leaf, respectively (Table 1).

The lowest infestation of whitefly was recorded on MNH-Shan and CKC-6 i.e., 2.84/leaf during the month of July. While the maximum population was observed on MNH-Sultan and MNH – 1082 i.e., 8.30 and 8.04/leaf, respectively, the maximum Jassid population was observed on FH-1184 and FH-Tri Star i.e., 4.87 and 4.74/leaf, respectively. While minimum was observed on MNH- Shan and CKC-6 i.e., 1.40 and 1.30/leaf, respectively. Thrips population was highest of FH-Tri Star i.e., 7.97/leaf, while lowers of MNH-Shan and CKC-6 i.e., 2.87 and 2.07/leaf, respectively (Table 1).

The results of this study indicate that both July and August were favorable months for the population growth of whitefly and jassid. Additionally, the peak thrips population occurred in July, whereas the highest infestation levels for jassid were observed in August and September, in contrast to July. These findings are in contrast to the study by Swidrak *et al.* (2013), which reported the maximum population of jassid in July. The discrepancy between the findings could be attributed to differences in the varieties studied as well as variations in ecological conditions.

The infestation of sucking insect pests (jassid, whitefly, and thrips) and the resulting yield varied significantly across the experimental varieties. The results clearly show that MNH-789 exhibited the highest tolerance to jassid attacks, while CKC-6 demonstrated the greatest resistance to thrips and whitefly infestations. Several researchers have reported significant findings on host plant resistance against sucking pests and bollworms, including Rehman *et al.* (2001), Khan *et al.* (2003), Syed *et al.* (2003), Chandramani *et al.* (2004), Kulkarni and Sharma (2004), Razaq *et al.* (2004), Memon and Chang (2005), Ali and Aheer (2007), Atta *et al.* (2015), and Bhantnagar and Sharma (1991). These studies measured the resistance of cotton varieties to sucking insect pests such as whitefly, thrips, and jassid, with findings suggesting that glandless cotton varieties were more susceptible to infestations than frego bract and okra leaf varieties. However, the minimum thrips infestation was observed on CKC-6, followed by FH-Tristar, while FH-1133 and MNH-1082 were the most susceptible. Hernandez *et al.* (1999) also studied whitefly infestations on various cotton varieties and found no significant yield differences between them.

The results concerning the correlation between abiotic factors and the populations of jassid, thrips, and whitefly are presented in Table 2. The analysis revealed that rainfall and temperature exhibited a significant positive correlation with the jassid population, whereas relative humidity had no significant effect. Temperature also had a significant and positive impact on both thrips and whitefly populations, while relative humidity and rainfall showed no significant correlation with thrips populations. However, a significant positive correlation was observed between relative humidity and whitefly population, although rainfall did not significantly correlate with whitefly.

These findings are partially consistent with those of Bishnol *et al.* (1996), who reported a significant relationship between mean air temperature, relative humidity, and jassid population. Similarly, EI-Mezayyen *et al.* (1997) found that temperature and relative humidity were critical factors influencing insect pest populations, and Gogoi *et al.* (2000) emphasized the importance of meteorological parameters in the population buildup of the cotton jassid. In the present study, temperature had a significant positive correlation with pest populations, and both temperature and relative humidity were found to contribute significantly to population changes.

These results align with findings by Seif (1980), Majeed *et al.* (1995), and Umar *et al.* (2003), but are partially in agreement with those of Rote and Puri (1991), Murugan and Uthamasany (2001), and Panickar and Patel (2001), who also found that weather factors significantly affected the fluctuation of insect pest populations.

Table 1: *Response of cotton varieties against sucking insect pest of cotton observed during the month of July, August and September.*

Varieties	July			August			September		
	WF	J	TH	WF	J	TH	WF	J	TH
FH-1184	6.17±0.12	4.87±2.03	7.47±1.12	5.24±0.23	5.60±2.43	1.93±1.04	5.20±2.33	4.24±0.25	1.43±1.43
FH-Tristar	7.00±2.23	4.74±4.22	7.97±1.43	5.04±2.41	5.27±1.53	2.52±1.63	4.02±2.44	4.02±0.11	1.72±0.44
FH-1133	6.34±1.21	3.10±0.43	4.04±2.56	4.80±1.03	4.67±2.12	1.91±4.03	4.07±2.03	3.89±0.24	1.76±0.67
FH-1199	5.07±2.22	3.17±0.03	4.40±0.21	3.84±3.34	4.47±2.41	1.43±1.03	3.79±0.22	3.82±0.35	1.61±0.32
MNH-Supesr gold	7.14±0.33	3.37±0.32	6.44±2.11	4.94±0.67	4.40±0.22	1.27±0.42	4.04±0.03	3.89±0.56	1.75±0.87
MNH-Sultan	8.30±2.53	2.94±1.24	6.14±2.11	4.24±1.23	4.47±2.13	1.73±2.13	3.67±2.04	3.70±1.23	1.57±2.03
MNH-Shan	2.84±1.04	1.40±1.03	2.87±1.03	3.34±3.03	1.64±0.03	0.28±1.03	4.09±2.03	1.30±2.03	0.51±1.13
MNH-1082	8.04±2.53	3.27±3.03	4.07±1.03	5.00±3.03	5.20±2.03	2.3±3.03	4.02±1.03	4.24±1.13	1.67±0.03
CKC-6	2.84±0.63	1.30±2.22	2.07±1.01	3.54±1.23	1.24±2.54	0.74±2.03	3.69±1.13	1.27±2.33	1.17±1.03

Means sharing similar letters are not significantly different by Tukey's test at P = 0.05. WF = Whitefly, J = Jassid, TH = Thrips.

Additionally, the results showed that whitefly had a negative correlation with maximum temperature, rainfall, and sunshine, indicating the multifaceted effects of abiotic factors on whitefly population dynamics. The influence of rainfall on whitefly population fluctuations was found to be 8.5% (Table 2). This influence increased to 33.5% when temperature was included, and the combination of rainfall, temperature, and relative humidity explained 66.4% of the variation in whitefly population fluctuations. Furthermore, these factors were positively correlated with minimum temperature and relative humidity. These findings are consistent with those of Seif (1980), Isler and Ozgur (1992), Majeed *et al.* (1995), and Sohi *et al.* (1995).

Table 2: *Correlation regarding effect of abiotic factors on whitefly population.*

	Max	Min	RF	RH	SS
Min	-0.7688 (0.4417)				
RF	0.8434 (0.3611)	-0.3048 (0.8028)			
RH	-0.9998 (0.0128)	0.7815 (0.4289)	-0.8324 (0.3739)		
SS	0.5940 0.5951	-0.9711 (0.1533)	0.0688 (0.9561)	-0.6101 (0.5822)	
Whitefly	-0.6740 (0.5292)	0.9906 (0.0874)	-0.1716 (0.8902)	0.6888 (0.5163)	-0.9946 (0.0659)

Relative humidity (RH), sunshine hours (SS), rain fall (RF), Minimum (Min.) and Maximum (Max.).

The results showed that jassid had a negative correlation with maximum temperature, rainfall, and sunshine, which is consistent with the findings of Butter *et al.* (1992), who also reported higher jassid populations at lower plant spacing. However, the present results differ from Sohi *et al.* (1995), who found that the incidence of jassid was less influenced by different spacing. Additionally, the findings do not align with those of Joginder *et al.* (1998) and Gogoi *et al.* (2000), who observed peak jassid populations at different times compared to the current study. This variation can be attributed to differences in ecological conditions and study periods. However, the present study found a positive correlation between jassid populations and minimum temperature and relative humidity.

The study further reveals the multiple effects of abiotic factors on jassid population fluctuations. Rainfall was found to contribute 32.4% to the fluctuation of jassid populations (Table 3). This effect increased to 48.4% when temperature was added. When relative humidity was also considered, the role of abiotic factors in population fluctuation increased further to 53%. This highlights the complex interplay of environmental factors in influencing jassid population dynamics.

Table 3: *Correlation regarding effect of abiotic factors on jassid population.*

	Max	Min	RF	RH	SS
Min	-0.7688 (0.4417)				
RF	0.8434 (0.3611)	-0.3048 (0.8028)			
RH	-0.9998 (0.0128)	0.7815 (0.4289)	-0.8324 (0.3739)		
SS	0.5940 (0.5951)	-0.9711 (0.1533)	0.0688 (0.9561)	-0.6101 (0.5822)	
Jassid	-0.6722 (0.5307)	0.9903 (0.0890)	-0.1692 (0.8918)	0.6870 (0.5179)	-0.9949 (0.0644)

Relative humidity (RH), sunshine hours (SS), rain fall (RF), Minimum (Mni) and Maximum (Max).

Table 4: *Correlation regarding effect of abiotic factors on thrips population.*

	Max	Min	RF	RH	SS
Min	-0.7688 (0.4417)				
RF	0.8434 0.3611	-0.3048 (0.8028)			
RH	-0.9998 (0.0128)	0.7815 (0.4289)	-0.8324 (0.3739)		
SS	0.5940 (0.5951)	-0.9711 0.1533	0.0688 (0.9561)	-0.6101 (0.5822)	
Thrips	0.9898 (0.0910)	-0.6698 (0.5328)	0.9114 (0.2700)	-0.9867 (0.1039)	0.4733 (0.6861)

Relative humidity (RH), sunshine hours (SS), rain fall (RF), Minimum (Mni) and Maximum (Max).

The results showed that thrips had a positive correlation with maximum temperature, rainfall, and sunshine, indicating that these abiotic factors significantly influence thrips population fluctuations. The study found that these factors contributed 7.7% to the population fluctuations of thrips, with the effect increasing to 36.8% when the influence of temperature was included. However, these findings are not in agreement with Al-Faisal and Kardu (1986), who reported two population peaks for thrips one in early May and another at the end of June or early July.

Table 5: *Data regarding percent got and fiber characteristics of different varieties of cotton.*

Varieties	G.O.T (%)	Fiber characteristics		
		Staple length (mm)	Fiber fineness (µg/inch)	Fiber strength (tppsi)
FH-1184	37±0.33 b	25±0.33 abc	5.4±0.07 b	31.9±0.03 b
FH-TRISTAR	41.1±0.62 ab	25±0.33 abc	4.3±0.09 d	31.4±0.15 b
FH-1133	44.1±0.55 a	25.2±0.24 abc	6.3±0.09 a	30.8±0.67 b
FH-1199	41.3±0.20 ab	24±0.33 bcd	6.0±0.03 ab	33.7±0.15 b
MNH-SHAN	44.9±0.38 a	22±0.33 d	6.40±0.15 a	23.6±0.38 c
MNH-Super Gold	42.1±1.18 ab	23.4±0.17 cd	5.8±0.15 ab	30.8±0.49 b
MNH-Sultan	43.0±0.58 ab	25.3±0.20 abc	5.2±0.06 bc	31.4±0.19 b
MNH-1082	41.7±1.25 ab	27.2±0.24 a	4.4±0.09 cd	38±0.33 a
CKC-6	40.3±0.71 ab	26.2±0.24 ab	5.2±0.06 bc	33.8±0.52 b

Means sharing similar letters are not significantly different by Tukey's Test at P = 0.05.

In contrast, the present study found a negative correlation between thrips populations and minimum temperature and relative humidity (Table 4). This suggests that while certain weather conditions, such as maximum temperature, rainfall, and sunshine, favor thrips population growth, cooler temperatures and higher humidity may inhibit it.

Percent ginning out turn (GOT) of different varieties of cotton

The data reveals significant differences (F=3.00; df=8,26; P<0.0291: Table 3) among different bt varieties of cotton regarding percent GOT. The maximum and statistically similar GOT was recorded in MNH-Shan, FH-1133, MNH-Sultan, MNH-Super Gold, MNH-1082, NIAB.bt-2, FH-Tristar, and CKC-6 i.e., 44.9, 44.1, 43.0, 42.1, 41.7, 41.3, 41.10 and 40.30 percent. The minimum percent GOT was recorded in FH-1184 i.e., 37.0 percent (Table 5).

Staple length (mm) of different varieties of cotton

The data reveals significant differences (F=19.76; df=8,26; P<0.0001: Table 3) among different bt varieties of cotton regarding staple length. The maximum staple length was recorded in MNH-1082 i.e. 27.20 mm statistically similar to CKC-6, MNH-Sultan, FH-1133, FH-1184 and FH-Tristar i.e. 26.20,25.30, 25.20, 25.0 and 25 followed by FH-1199 having 24.0. The MNH-Super Gold 23.23.43. The minimum staple length was recorded in IUB-63 i.e. 22mm (Table 5).

Fiber fineness (µg/inch) of different varieties of cotton

The data reveals significant differences (F=19.76; df=8,26; P<0.0001: Table 3) among different bt varieties of cotton regarding fiber fineness. The maximum fiber fineness was recorded in MNH-Shan and FH-1133 i.e. 6.40 and 6.30 ug/inch statistically similar to FH-1199 and MNH-Super Gold having 6.0 and 5.80 ug/inch followed by FH-1184, MNH-Sultan and CKC-6 having 5.40, 5.20 and 5.20. The varieties MNH-1082 having 4.4. The minimum fiber fineness was recorded in FH-Tristar i.e. 4.30 ug/inch (Table 5).

Fiber strength (G Tex -1) of different varieties of cotton

The data reveals significant differences (F=30.64; df=8,26; P<0.000: Table 3) among different bt varieties of cotton regarding fiber strength. The maximum fiber strength was recorded in MNH-1082 i.e. 38.00 (G Tex $^{-1}$) followed by CKC-6, FH-1199, FH-1184, MNH-Sultan, FH-Tristar, FH-1133 and MNH-Super Gold having 33.8, 33.7, 31.9, 31.4, 31.4, 30.8 and 30.8 *G Tex* $^{-1}$. The genotype IUB-63 having 23.60 *G Tex* $^{-1}$ having minimum fiber *strength (G Tex* $^{-1}$*)* (Table 5).

Conclusions and Recommendations

The varieties CKC-6 and MNH-Shan demonstrated resistance to the sucking pest complex while also producing better seed cotton yield. These varieties show promise for use in future breeding programs aimed at improving resistance to insect pests. Additionally, they can be incorporated into integrated pest management (IPM) strategies to effectively manage these pests and minimize yield losses, contributing to more sustainable cotton production practices. The findings offer critical insights into the interaction between plant spacing, weather factors, and pest populations. These results aim to guide entomologists and farmers in formulating effective IPM strategies for controlling insect pests and ensuring sustainable cotton production in Pakistan.

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Novelty Statement

The study explores the relationship between cotton varieties and pest populations under natural field conditions. It identifies potential pest resistance markers and offers insights for integrated pest management strategies, contributing to crop resilience in the face of increasing agricultural challenges.

Author's Contribution

Muhammad Ihsan Ullah and Muhammad Hasnain: Performed the experiment and collected data.
Zaib-un-Nisa and Saeed Ahmad: Write first manuscript and Managed overall crop.
Javeed Shabbir Dar and Muhammad Akram: Helped in paper write up.
Muhammad Tauseef, Asifa Hameed and Imran Ali: Performed the statistical analysis.
Shamim Akhtar, Abdul Ghaffar and Naeem Arshad Mann: Collected the literature and supervised the study.

Conflict of interest
The authors have declared no conflict of interest.

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