Research Article

Response of Abiotic Factors and Physico-Morphic Characters on Population Fluctuation of Jassid, *Amrasca biguttella biguttela* on Traditional and Transgenic Cultivars of Cotton

Muhammad Afzal[1*], Muhammad Imran[1], Habib Anwar[1], Sohail Alam[3], Khuram Zia[2], Shafqat Saeed[4], Hasan Riaz[4], Muhammad Ishtiaq[4], Muhammad Saleem[5] and Muhammad Qasim[6]

[1]Department of Pest Warning and Quality Control of Pesticides, Lahore, Pakistan; [2]Department of Entomology University of Agriculture Faisalabad, Pakistan; [3]Department of Sales and Marketing, Ali Akbar Enterprises, Lahore, Pakistan; [4]Department of Plant Protection, Muhammad Nawaz Shareef University of Agriculture Multan, Pakistan; [5]Entomological Research Institute, Ayub Agricultural Research Institute, Faisalabad, Pakistan; [6]Key Laboratory of Oasis Agricultural Pest Management and Plant Protection Utilization, College of Agriculture, Shihezi University, Shihezi, 832002, Xinjiang, China.

Abstract | The jassid, *Amrasca devastans* (Dist), is a significant pest causing serious infestations in cotton crops. Various chemical insecticides have been employed for its management; however, these chemicals negatively impact beneficial insects, lead to insecticide resistance, and degrade the environment. In contrast, host plant resistance is considered a highly effective strategy for jassid management. The present research was conducted on the field of farmer in tehsil Raiwind, district Lahore, Punjab, Pakistan from July to November during 2021-2022 to evaluate the resistance and susceptibility of transgenic cotton cultivars (AA-703, AA-802, SITARA-08, FH-113, CRSM-07) and traditional cultivars (CIM-496, FH-1000, FH-941, FH-942, FH-901) against jassid infestations. Data on jassid populations were recorded per leaf across various cultivars, and the mean values from different observation dates were correlated with weather factors such as temperature, relative humidity, and rainfall. The experiment was laid out in a randomized complete block design (RCBD) with three replications of the designated transgenic and traditional cultivars. The results of the comparative mean data indicated that traditional cultivars were more susceptible to jassid infestations compared to transgenic cultivars. A significant positive correlation was observed between temperature and jassid population, while relative humidity and rainfall exhibited negative and non-significant correlations with jassid populations. Furthermore, the correlation between jassid populations and physico-morphic traits of transgenic and traditional cultivars showed that jassid populations had a non-significant negative correlation with the density of hairs, gossypol glands, and hair length, while a significant negative correlation was observed with the leaf lamina thickness of the cultivars. Based on these findings, it is proposed that considering the physico-morphic traits of cotton plants and transitioning from traditional to transgenic cultivars can be an effective strategy for the sustainable management of insect pests.

Received | December 25, 2024; **Accepted** | February 19, 2025; **Published** | June 02, 2025
***Correspondence** | Muhammad Afzal, Department of Pest Warning and Quality Control of Pesticides, Lahore, Pakistan; **Email:** mafzalaopp@gmail.com
Citation | Afzal, M., M. Imran, H. Anwar, S. Alam, K. Zia, S. Saeed, H. Riaz, M. Ishtiaq, M. Saleem and M. Qasim. 2025. Response of abiotic factors and physico-morphic characters on population fluctuation of Jassid, *Amrasca biguttella biguttela* on traditional and transgenic cultivars of cotton. *Sarhad Journal of Agriculture,* 41(2): 807-816.
DOI | https://dx.doi.org/10.17582/journal.sja/2025/41.2.807.816
Keywords | Jassid, Cotton, Transgenic cultivars, Traditional cultivars, Abiotic factors, Physico-morphic characters

Introduction

Cotton is an important cash crop, playing a significant role in Pakistan's economy by contributing approximately 2.9% to the value added in agriculture and around 0.7% to the GDP. The area under cotton cultivation has reached 2.4 million hectares, marking a 13.1% increase compared to the previous year (2.1 million hectares). Cotton production for 2023-24 is estimated at 10.2 million bales, representing an impressive 108.2% increase compared to the 4.9 million bales produced last year (GoP, 2023-24). It accounts for approximately 17.7 % of the country's edible oil production through cottonseed and provides livelihoods for millions of people across the supply chain, from farm to factory (Malik and Ahsan, 2016). However, cotton production has faced severe losses due to various challenges, one of the most significant being the damage caused by sucking insect pests, particularly the Jassid.

The emergence of pests significantly reduces the yield and quality of cotton (Arshad *et al*., 2001). Cotton crops are particularly vulnerable to damage from a variety of factors, including a complex of sucking pests such as whiteflies (*Bemisia tabaci*), jassids (*Amrasca devastans*), mites (*Tetranychus* spp.), and thrips (*Thrips tabaci*), which target the flowers. In Pakistan, approximately 150 species and varieties of insects have been identified as harmful to cotton, leading to reduced yield and quality (Attique and Rashid, 1983). During the crop's full developmental stage without control measures of insect pests, infestations can cause severe losses of up to 40-50% and 70% (Thirasack, 2001; Ali *et al*., 2005).

Among these pests, jassid (*Amrasca devastans*) are particularly polyphagous and destructive pests that feeds on different species of plants including cotton. The jassid causes damage by sucking cell sap, which leads to curling of leaf, stunted growth and eventually reduced yield of crops. The infestation of jassid has been reported in many countries such as the United States, Egypt, China, India and Pakistan (Lopez and Sword, 2015). The jassid responsible for 20% to 50 % yield losses which depends upon cotton cultivars and infestation severity. The cotton plants become more susceptible to the cotton leaf curl disease due to infestation of jassid (Farooq *et al*., 2011).

The jassid is highly destructive; it not only sucks the cell sap but also injects toxic substances into the leaves, causing severe damage to crops (Mawblei *et al*., 2024; Ahmed *et al*., 2005) estimated that total losses due to *Amrasca devastans* up to 40% that caused stunted growth, leaf bend downward resulted in bolls losses. Under favorable environmental conditions, pests can multiply rapidly and cause significant economic damage, as was evident in 1983 and 1984, when a cotton disaster severely impacted the economy by reducing the yield of "white gold" fiber by 40-50%. The emergence and proliferation of jassid pest is influenced by various physiological and environmental factors. Their populations can grow rapidly under favorable conditions and development of resistance against pesticides, resulting in significant damage.

Amjad *et al*. (2022), Aheer *et al*. (2006) demonstrated that temperature and relative humidity play a critical role in the occurrence and severity of pest infestations. (Singh and Matsui, 2002) conducted a field study on the cowpea crop and reported that maximum temperature and relative humidity exhibited a positive correlation with the incidence of jassid, whereas minimum temperature showed a negative correlation. Relative humidity and rainfall during the growing season significantly influence pest emergence and growth. Climatic conditions, particularly temperature, have been shown to positively affect the population fluctuations of insect pests in cotton ecosystems. The relative impact of ecological factors on the population dynamics of mites, thrips, whiteflies, and jassids has been reported by (Aheer *et al*., 1994; Amjad *et al*., 2022).

The agriculture sector in Pakistan is heavily reliant on pesticides to manage crop insect pests, with millions of rupees spent annually on pesticide imports. Nearly 85% of the total pesticide usage in Pakistan is dedicated to controlling cotton insect pests (Gilden *et al*., 2010). The increasing cost of pesticide imports each year highlights the indiscriminate use of pesticides, which not only causes health hazards and environmental pollution but also leads to the development of insecticide resistance in pests (Mohyuddin *et al*., 1997; GoP, 2022-23). Despite the widespread application of pesticides in cotton farming, many pests persist and cause crop losses of up to 45% in certain regions (Abhilash and Singh, 2009).

Given the importance of the cotton crop and the complex challenges posed by cotton insect pests in Pakistan, it is crucial to develop effective management strategies. These strategies should focus on identifying varietal resistance and understanding ecological factors, particularly climatic conditions, which play a critical role in the distribution and proliferation of insects. Greater emphasis must be placed on researching the factors that influence pest incidence and development through various scientific approaches.

Despite ongoing research efforts, the findings remain inadequate and necessitate further comprehensive studies. Due to a lack of sufficient prior information, the present study aims to identify varietal resistance against jassid, determine the relationship between jassid populations and climatic factors, and correlate physico-morphic traits of different cotton cultivars with pest populations. The ultimate goal is to understand the role of these traits in determining resistance or susceptibility, thereby providing entomologists with valuable insights for developing Integrated Pest Management (IPM) approaches to control the notorious insect pests of cotton.

Materials and Methods

The present study was conducted in tehsil Raiwind, district Lahore, Pakistan (31.294966° N, 74.07505° E) to examine the effects of abiotic factors on the jassid population across various transgenic and traditional cotton cultivars and to determine the degree of physio-morphic resistance in these cultivars against jassid. For this purpose, five transgenic cultivars (AA-703, AA-802, SITARA-08, FH-113, CRSM-07) and five traditional cultivars (CIM-496, FH-1000, FH-941, FH-942, FH-901) of cotton were sown on May 28, during 2021-2022 (Ayub Agricultural Research Institute). The experiment was conducted using a Randomized Complete Block Design (RCBD) with 10 treatments, each replicated three times. The plot size for each treatment was 30 m × 5 m, with a plant-to-plant distance of 0.25 m and a row-to-row distance of 0.83 m. Each treatment consisted of seven rows. No plant protection measures were applied during the experiment, although recommended agronomic practices were followed when necessary. The jassid population was recorded weekly during the morning hours when the insects were accessible in the field, and no chemical sprays were applied throughout the experiment. For data collection, fifteen leaves were randomly selected from 15 cotton plants in each plot. The sampling method involved selecting one upper leaf from the first plant, one middle leaf from the second plant, and one lower leaf from the third plant, and so on, throughout the plot. Daily meteorological data, including mean temperature, relative humidity, and rainfall, were obtained from the Pakistan Meteorological Department.

Physio-morphological characters

The number of gossypol glands was determined by selecting three plants at random from each plot. From each plant, one leaf was taken from the upper, middle, and lower sections. The gossypol glands on the midrib, veins, and leaf lamina were counted on the lower side of the leaves using a biological binocular microscope. For this purpose, a 1 cm^2 area of the lamina, as well as a corresponding 1 cm length of the midrib and veins, was examined. An iron-assembled dye of 1 cm^2 was utilized to cut the samples. To determine hair density, three leaves were selected randomly from the upper, middle, and lower sections of three different plants in each plot. The hairs on the midrib, veins, and leaf lamina were counted on the lower side of the leaves using a biological binocular microscope. For this analysis, a 1 cm^2 sample of the leaf lamina and a 1 cm length of the midrib and veins were used. Hair length (mm) was measured by randomly selecting three leaves one each from the upper, middle, and lower sections from three plants per plot. A fine razor was used to peel hair samples, which were mounted on slides. The hair length was measured under a biological binocular microscope with the assistance of an ocular micrometer. A stage micrometer was used to calculate the factor for the ocular micrometer, and the hair length was determined by multiplying the number of divisions observed by this factor. The thickness of leaf lamina (mm) was measured by selecting three plants at random from each cultivar's plot. From each plant, one leaf was collected from the upper, middle, and lower sections. A cross-section of each leaf was carefully cut with a sharp razor. The leaf lamina thickness was measured at three different points on each leaf using an ocular micrometer under a biological binocular microscope. As before, the recorded divisions were multiplied by the ocular micrometer factor calculated using the stage micrometer.

Statistical analysis

Population means data of jassid and weather factors from 15 July to 18 November were recorded in the table and then conducted statistical analysis by using analysis of variance (ANOVA) in MSTAT software version 2.1. The Duncan's Multiple range test was applied to compare the means data at level of significance P<0.05% (Steel and Torrie, 1980), and correlation was carried out between jassid populations and cultivars, as well as weather factors were also estimated. The results are graphically depicted to see the effect of different traditional and transgenic cultivars of cotton under unsprayed conditions. Statistical correlation was carried out between jassid density and cultivar plants' physic-morphic characters.

Results and Discussion

Population of jassid per leaf

The overall mean data for the jassid population on various cotton cultivars, as shown in Table 1, were used to compare population levels. Data from 2021 and 2022 were pooled by calculating the mean of the two years before analyzing the effect of jassid populations per leaf. The analysis of variance for mean data of jassid population on various transgenic and traditional cotton cultivars were highly significant (Table 2). The maximum mean jassid population was 1.58/leaf, recorded on the traditional cultivar CIM-496, while the minimum population of 0.77/leaf was observed on the transgenic cultivar AA-802. An intermediate population of 1.14/leaf was recorded on the traditional cultivar FH-942, whereas the traditional cultivar FH-1000 exhibited a population slightly below the intermediate level. The transgenic cultivars SITARA-08 and CRSM-07, along with the traditional cultivar FH-901, had higher-than-intermediate populations of jassid, with mean values of 1.16, 1.25, and 1.20 per leaf, respectively (Table 3). Meanwhile, the populations on the transgenic cultivar AA-703 and the traditional cultivar FH-941 were nearly identical (Figure 1). In general, the infestation of jassid was higher on traditional cultivars compared to transgenic cultivars (Figure 2). The seasonal trend of the jassid population (Table 1) revealed that traditional cultivars were more susceptible, indicating that they may serve as preferred hosts compared to transgenic cultivars. Population data recorded on different dates showed that jassid populations began to build up on July 15 and continued to increase until November 18.

Table 1: *Mean population of jassid on various transgenic and traditional cultivars of cotton recorded from 15 July to 18 November.*

Date	Transgenic cultivars							Traditional cultivars						
	AA-703	AA-802	SITARA 08	FH-113	CRSM -07	Mean	SE	CIM -496	FH-1000	FH-941	FH-942	FH-901	Mean	SE
15-Jul	2.37	1.37	2.30	1.33	2.17	1.91	0.85	2.27	1.53	2.57	2.43	2.07	2.17	0.36
22-Jul	2.13	1.27	1.50	1.80	2.00	1.74	0.84	2.03	1.43	1.77	1.53	0.97	1.55	0.35
29-Jul	1.40	0.97	1.70	1.67	1.73	1.49	0.72	1.77	0.93	1.43	1.07	1.70	1.38	0.33
05-Aug	2.27	1.73	1.80	1.60	1.93	1.87	0.85	3.37	2.20	2.03	1.93	2.03	2.31	0.54
12-Aug	2.33	1.97	2.03	2.33	2.27	2.19	1.06	2.87	1.97	2.63	1.83	1.87	2.23	0.43
19-Aug	1.93	1.13	1.70	1.20	1.40	1.47	0.55	2.13	0.97	1.87	1.77	2.00	1.75	0.41
26-Aug	0.63	0.20	0.57	0.37	0.53	0.46	0.19	0.77	0.43	0.63	0.60	0.63	0.61	0.11
02-Sep	0.53	0.47	0.57	0.43	0.47	0.49	0.21	0.57	0.47	1.13	0.87	0.97	0.80	0.25
09-Sep	0.57	0.27	0.67	0.57	0.70	0.56	0.27	0.87	0.63	0.77	0.70	0.83	0.76	0.09
16-Sep	1.50	0.67	1.57	1.43	1.53	1.34	0.60	1.53	1.30	1.47	1.13	1.17	1.32	0.16
23-Sep	0.53	0.30	0.47	1.40	0.47	0.63	0.04	0.97	0.60	1.07	0.73	0.87	0.85	0.17
30-Sep	0.43	0.20	0.53	0.53	0.57	0.45	0.22	1.43	0.50	1.00	0.80	0.83	0.91	0.30
07-Oct	0.53	0.27	0.33	0.27	0.37	0.35	0.14	1.30	0.30	0.77	0.47	0.77	0.72	0.34
14-Oct	0.90	0.07	0.63	0.77	0.97	0.67	0.32	1.17	0.60	1.33	0.90	0.83	0.97	0.26
21-Oct	1.47	0.33	1.13	0.93	1.17	1.01	0.40	1.43	0.57	1.03	0.77	0.83	0.93	0.29
28-Oct	2.53	0.83	1.17	1.03	1.33	1.38	0.37	1.67	0.77	1.13	0.93	1.07	1.11	0.30
04-Nov	1.67	1.23	1.37	1.33	1.47	1.41	0.66	1.77	1.17	1.33	1.13	1.27	1.33	0.23
11-Nov	1.37	0.70	1.13	0.93	1.47	1.12	0.59	1.47	0.93	1.27	1.03	1.07	1.15	0.19
18-Nov	1.23	0.73	0.87	0.83	1.30	0.99	0.54	1.27	0.87	1.13	0.93	0.97	1.03	0.15
Mean	1.33	0.77	1.16	1.09	1.25	1.91	0.19	1.58	0.96	1.39	1.14	1.20	2.17	0.21
SE	0.60	0.45	0.49	0.45	0.50	0.48		0.52	0.41	0.43	0.40	0.40	0.42	

Table 2: *Analysis of variance for overall mean data of jassid population on various transgenic and traditional cotton cultivars.*

Source of variations	df	SS	MS	F value	P value
Replication	2	0.00641	0.00321		
Cultivar	9	1.37171	0.15241	27.99	0.0000
Error	18	0.09802	0.00545		
Total	29	1.47614			

Note: Highly Significant (P<0.01).

Table 3: *DMR test for mean comparison of jassid population and cultivars.*

Cultivars	Means	SE	P value
CIM-496	6 1.5807 A	0.81	0.047
FH-941	8 1.3877 AB	0.76	0.040
AA-703	1 1.3281 BC	0.80	0.041
CRSM-07	5 1.2544 BCD	1.09	0.039
FH-901	10 1.1965 BCD	0.51	0.037
SITARA-08	3 1.1596 CDE	0.22	0.051
FH-942	9 1.1351 CDE	0.24	0.051
FH-113	4 1.0877 DE	0.44	0.044
FH-1000	7 0.9561 EF	0.60	0.044
AA-802	2 0.7737 F	0.17	0.033

Means having similar letters are not significantly different by DMRT test at (P=0.05).

The maximum jassid population recorded on July 15 was 2.17/leaf on traditional cultivars, compared to 1.91 on transgenic cultivars. On August 12, the maximum population was 2.23/leaf on traditional cultivars, slightly higher than 2.19 recorded on transgenic cultivars. From August 19 to September 9, the jassid population decreased, but traditional cultivars still showed higher infestation levels during this period. A peak population was recorded again on September 16, where the transgenic cultivars had a slightly higher jassid population (1.34/leaf) compared to traditional cultivars (1.32/leaf). The lowest jassid populations were recorded on August 26 and October 7, with values of 0.61 and 0.72 per leaf on traditional cultivars, compared to 0.46 and 0.35 per leaf on transgenic cultivars, respectively. The population trend began increasing again from October 28 to November 4, during which transgenic cultivars exhibited higher jassid populations (1.38 and 1.41 per leaf) compared to traditional cultivars (1.11 and 1.33 per leaf), as shown in Table 1.

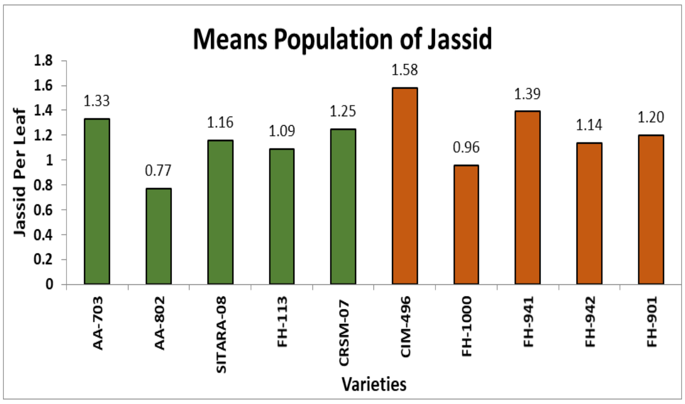

Figure 1: *Overall mean data of jassid population on transgenic and traditional cultivars of cotton without pesticides spray was recorded from 15 July to 18 November.*

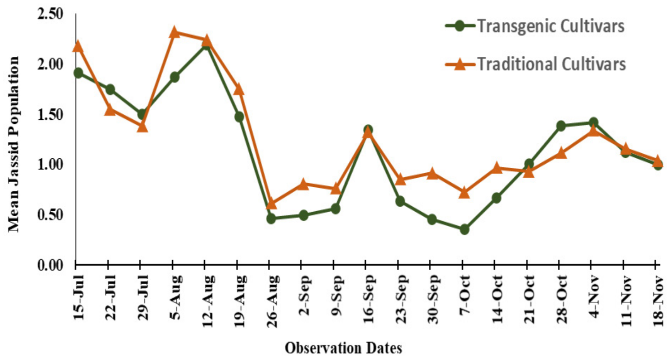

Figure 2: *The fluctuations of jassid population per leaf on various transgenic and traditional cultivars of cotton without pesticides spray was recorded from 15 July to 18 November.*

Correlation among weather factors, jassid, transgenic and traditional cotton cultivars

Weather factors and jassid population correlation presented in Table 4 which described that there was a positive correlation between air temperature and population of jassid on all transgenic (AA-703 (0.2327), AA-802 (0.3383), SITARA-08 (0.3600), FH-113 (0.4329), CRSM-07 (0.2239) and traditional cultivars (CIM-496 (0.3803), FH-1000 (0.3791), FH-941 (0.4925*), FH-942 (0.4681*), FH-901 (0.4441). The traditional cultivars FH 941(0.4925*) and FH-942 (0.4681*) showed a positive along with a significant effect between air temperature and density of the jassid population. Whereas, humidity was negatively and non-significant correlated with density of the jassid population on all cultivars of transgenic (AA-703 (-0.2797), AA-802 (-0.1889), SITARA-08 (-0.2180), FH-113 (-0.3943), CRSM-07 (-0.2554) and traditional cultivars of cotton (CIM-496 (-0.4353), FH-1000 (-0.2926), FH-941 (-0.3835), FH-942 (-0.2722), FH-901 (-0.1318) along with rainfall also negatively and non-significant correlated with density of jassid on all transgenic (AA-703 (-0.1706), AA-802 (-0.1851), SITARA-08

(-0.0981), FH-113 (-0.3442), CRSM-07 (-0.2442) and traditional cultivars (CIM-496 (-0.1779), FH-1000 (-0.2529), FH-941 (-0.2013), FH-942 (-0.0716), FH-901 (-0.0293) of cotton. These findings are an agreement of (Bishnoi *et al*., 1996; Inee-Gogoi and Dutta, 2000; Wahla *et al*., 1996; Saini *et al*., 2017; Patel and Radadia, 2018; Ali *et al*., 2021), who mentioned that density of jassid population positively correlated with temperature of air and relative humidity negatively correlated with it whereas, disfavour the result of (Inee-Gogoi and Dutta, 2000) about the relative humidity who reported that density of jassid population was positively correlated with the relative humidity. Results of these correlations concluded that the climate factors have a prominent effect on the population fluctuation of jassid on all transgenic and traditional cultivars.

Table 4: *Correlation coefficient of jassid population density and abiotic factors on various transgenic and traditional cultivars recorded from 15th July to 18th November.*

Cultivars	Temperature °C	Relative humidity (%)	Rainfall (mm)
AA-703	0.2327	-0.2797	-0.1706
AA-802	0.3383	-0.1889	-0.1851
SITARA-08	0.3600	-0.2180	-0.0981
FH-113	0.4329	-0.3943	-0.3442
CRSM-07	0.2239	-0.2554	-0.2442
CIM-496	0.3803	-0.4353	-0.1779
FH-1000	0.3791	-0.2926	-0.2529
FH-941	0.4925*	-0.3835	-0.2013
FH-942	0.4681*	-0.2722	-0.0716
FH-901	0.4441	-0.1318	-0.0293

*Note: *= Significant (P<0.05), **= Highly significant (P <0.01)*

Morpho-physical plant traits

Various morphological plant traits viz., hair density, length of hair, gossypol glands on mid rib vein and lamina and thickness of leaf lamina were recorded on various cultivars on cotton. The objective of this study was to find out the role of these morpho-physical plant traits toward resistance against insect pests.

Hair density

Hair density of leaf lamina results was analyzed by comparison of means that determined that the maximum hair density was recorded to be 706.30/ cm^2 on AA-802 which was found to be significant different from all other cultivars. It was followed by FH-1000 (593.72/cm^2) which also differed significantly from all other cultivars. Minimum hair density was recorded on CIM-496 (231.67/cm^2) which significantly differed from all other cultivar. The cultivar A-703 (303.94/cm^2) also has minimum hair density and differed significantly from all other cultivars. All transgenic and traditional cultivars were highly significant different from each other for the presence of hairs on leaf lamina (Table 5). Hair density on leaf midrib results regarding comparison of means determined that the maximum hair density was recorded to be 199.57/cm on FH-1000 which was recorded to be significant different from cultivars. It was followed by AA-802 (179.81/cm) which also significantly differed from all other cultivars. Minimum hair density was observed on FH-941 (90.67/cm) which significantly differed from all other cultivars. The cultivar AA-703 (108.33/cm) also has minimum hair density and differed significantly from all other cultivars. All transgenic and traditional cultivars were highly significant different from each other for the presence of hairs on leaf midrib (Table 5). Hair density on leaf veins revealed that comparison of means of maximum hair density was recorded to be 155.27/cm on AA-802 which was recorded to be significant from all other cultivars. It was followed by FH-901 (154.30/cm) which also significantly differed from all other cultivar. Minimum hair density was found on CRSM-07 (80.84/cm) which significantly differed from all cultivar. The cultivar FH-941 (92.79/ cm) also has minimum hair density and differed significantly from all other cultivar. All transgenic and traditional cultivars were highly significant different from each other for the presence of hairs on leaf vein (Table 5).

Gossypol glands

Gossypol glands on leaf lamina result regarding comparison of means found that the maximum gossypol glands were recorded to be 213.35/cm^2 on FH-942 which is statistically at par with cultivar AA-703 (207.29/ cm^2). It was followed by cultivar AA-802 (189.18/cm^2) which is statistically at par with cultivar SITARA-08 (176.02/cm^2) and CRSM-07(171.74/ cm^2). Minimum number of gossypol glands was observed on CIM-496 (123.02/cm^2) which differed significantly from all other cultivars. The cultivar FH-1000 (146.78/cm^2) also have minimum number of gossypol glands which is statistically at par with cultivar FH-941 (147.78/cm^2) and FH-113(148.75/ cm^2) cultivars. All transgenic and traditional cultivars were highly significant different from each other for the presence of number of gossypol glands on leaf lamina (Table 5). Gossypol glands on leaf midrib result regarding comparison of means disclose that the maximum gossypol glands were recorded to be 32.57/cm on FH-942 which is statistically at par with all other cultivars of cotton. Minimum gossypol glands were observed on AA-802 (19.33/cm) which did not differ significantly from FH-113 (19.33/cm) and CRSM-07 (19.44/cm) (Table 5). Gossypol glands on leaf vein result regarding comparison of means disclose that the maximum gossypol glands were recorded to be 19.76/cm on FH-942 which is at par with all other cultivars of cotton. Minimum gossypol glands were observed on SITRA-08 (12.06/cm) which did not differ significantly from FH-113 (12.67/cm) and FH-1000 (12.64/cm). All transgenic and traditional cultivars were non-significant with each other for presence of number of gossypol glands on leaf veins (Table 5).

Length of hair

Length of hair on leaf lamina result for comparison of means revealed that the maximum length of hair was recorded to be 2.71mm on CRSM-07 which is statistical at par with FH-901, AA-802, FH-1000, AA-703 which had 2.71mm, 2.70mm, 2.68mm, 2.67mm length respectively. Minimum hair length was observed on FH-941 (1.71mm) which statistically at par with FH-942 (1.72mm). SITRA-08 (2.38mm) is found to be statistically at par with FH-113(2.35mm) and CIM-496(2.15mm) cultivars. All transgenic and traditional cultivars were highly significant different for the presence of hairs length on leaf lamina (Table 5).

Result of hair length on leaf midrib by comparison of means showed that the maximum length of hair was recorded to be 5.01 mm on FH-1000 which was recorded to be significant different from all cultivars. Minimum hair length was observed on cultivars FH-941 (3.01mm) which is statistical at par with cultivars FH-113 (3.02mm), CIM-496(3.02mm) and FH-942 (3.02mm). All transgenic and traditional cultivars were highly significant different for the presence of hairs length on leaf midrib (Table 5). Result of hair length on leaf vein by comparison of means disclosed that the maximum length of hair was recorded to be 4.42 mm on FH-1000 which was found to be significant different from all other cultivars. Minimum hair length was observed on CIM-496(1.71mm) which was found significant different from all other cultivars. FH-901 had hair length 2.39mm which statistically at par with SITRA-08 (2.36mm), FH-113 (2.34mm) and FH-941 (2.34mm) cultivars. All transgenic and traditional cultivars were highly significant different from each other for the presence of hairs length on leaf vein (Table 5).

Thickness of lamina

Result of lamina thickness by comparison of means showed that the maximum thickness of lamina was recorded to be 0.80 mm on AA-802 which was declared to be significant different from all cultivars. Minimum hair thickness was observed on cultivars FH-941 (0.60mm) which differ significantly from all cultivars. FH-1000 (0.75mm) is found to be statistically at par with SITARA-08 (0.72mm), FH-113(0.73mm), CRSM-07(0.65mm), FH-942 (0.68mm) and FH-901 (0.63mm) cultivars. All transgenic and traditional cultivars were non-significant with each other for thickness of lamina (Table 5).

Table 5: *Multiple comparison test for means values of physico-morphic characters of traditional and transgenic cultivars of cotton.*

Cultivars	Trichome density			Gossypol glands			Length of hair			Thickness of lamina (mm)
	Lamina/ cm^2	Midrib/ cm	Vein/cm	Lamina/ cm^2	Midrib/ cm	Vein/cm	Lamina (mm)	Midrib (mm)	Vein (mm)	
AA-703	303.94EF	108.33F	121.74C	207.29A	25.00A	17.8B	2.67A	4.02B	3.33B	0.59B
AA-802	706.30A	179.81B	155.27A	189.18AB	19.33 A	14.78B	2.70A	4.24B	3.01BC	0.80A
SITARA-08	416.34D	162.76C	107.78D	176.02AB	21.89 A	12.06B	2.38B	3.38C	2.36DE	0.72AB
FH-113	475.04C	169.00C	131.93B	148.75BC	19.33 A	12.67B	2.35B	3.02D	2.34DE	0.73AB
CRSM-07	408.52D	126.04E	80.84F	171.74AB	19.44 A	10.89B	2.71A	3.63C	2.68CD	0.65AB
CIM-496	231.67F	140.79D	132.00B	123.02C	32.30 A	17.30B	2.15B	3.02D	1.71F	0.57B
FH-1000	593.72B	199.57A	124.21C	146.78BC	14.77 A	12.64B	2.68A	5.01A	4.42A	0.75AB
FH-941	319.92E	90.67G	92.79E	147.78BC	26.41 A	14.98B	1.71C	3.01D	2.34DE	0.60B
FH-942	411.41D	143.07D	118.82C	213.35A	32.57 A	19.76B	1.72C	3.02D	2.03EF	0.68AB

FH-901	390.82D	166.23C	154.30A	146.79D	23.01 A	14.62B	2.71A	3.41C	2.39DE	0.63AB

Table 6: *Correlation coefficient values of jassid population and physic-morphic plant character in various transgenic and traditional cultivars of cotton crop.*

Character	Jassid
Trichome density	
Leaf Lamina	-0.9724**
Leaf midrib	-0.7149*
Leaf vein	-0.3954 ns
Gossypol glands	
Leaf Lamina	-0.6572 ns
Leaf midrib	-0.3461 ns
Leaf vien	-0.2996 ns
Length of Hair	
Leaf Lamina	-0.4020 ns
Leaf midrib	-0.5790 ns
Leaf vien	-0.5268 ns
Thickness of leaf lamina	-0.9456**

*Note: *= Significant ($P<0.05$), **= Highly significant ($P<0.01$)*

Correlation coefficient physico-morphic plant characters and jassid population

The result regarding correlation among density of jassid population and physic-morphic plant characters declared that density of jassid population revealed negative and highly significant correlation with the hair density on leaf lamina (-0.9724**), significant correlation with hair density of leaf midrib (-0.7149*) and found non-significant correlation with the hair density of vein (-0.3954 ns) (Table 6). This is an agreement of Javeed *et al.* (1992), Ali *et al.* (1999), Bashir *et al.* (2001), Ashfaq *et al.* (2010) and Naveed *et al.* (2011) because they had concluded that density of jassid population correlated negatively with hair density. Jassid population showed negative and non-significant correlation with the gossypol glands of leaf lamina (-0.6572 ns), midrib (-0.3461 ns) and vein (-0.2996 ns) (Table 6). This supported the result of (Aheer *et al.*, 1999; Ahmed and Khan, 1991; Bhatanger and Sharma, 1991; Bashir *et al.*, 2001) who described that gossypol glands were showed negative correlation with the density of jassid (adults and nymph) population. Jassid population showed negative and non-significant correlation with the length of hair of lamina (-0.4020 ns), midrib (-0.5790 ns) and vein (-0.5268 ns) (Table 6). These finding can be compared with Ali *et al.* (1995) and Bashir *et al.* (2001) who concluded that jassid (Adult and nymph) is negatively correlated with hair length while contradict with the result of Irfan *et al.* (2008) who described that jassid population showed positive response with the gossypol glands, density and length of hairs. Jassid population showed negative and significant correlation with the thickness of leaf lamina (-0.9456**) (Table 6). This is confirmed by the result of (Ali *et al.*, 1995; Bashir *et al.*, 2001; Ashfaq *et al.*, 2010) who reported that jassid (adults and nymph) is negatively correlated with thickness of leaf lamina.

Conclusions and Recommendations

The present project aimed to evaluate the effect of weather factors and physic-morphic plant characteristics on the resistance or susceptibility of 10 transgenic and traditional cotton cultivars to jassid infestation. Based on the results and discussion regarding the impact of abiotic factors on the jassid population, it was concluded that the maximum jassid population occurred on 15 July and 12 August, while the minimum population was observed on 26 August and 7 October across the cotton cultivars. Traditional cultivars CIM-496, FH-941 followed by transgenic cultivar AA-703 were found to be more susceptible while transgenic cultivar AA-802 and traditional cultivar FH-1000 were found to be more resistant to jassid population buildup. The correlation analysis between weather factors and the jassid population revealed that temperature had a positive correlation with jassid density, whereas relative humidity and rainfall showed a negative correlation. All cultivars exhibited significant positive effects when analyzed in relation to temperature. A simple correlation was also established between jassid population density and physic-morphic plant traits. It was determined that the jassid population had a negative correlation with hair density, gossypol glands, hair length, and leaf lamina thickness. The cotton plants resistance traits are effective for management of jassid, therefore these traits should be considered at commercial level.

Acknowledgements

The authors sincerely acknowledge Dr. Khuram Zia, Assistant Professor, Department of Entomology University of Agriculture Faisalabad for supervising and providing lab facilities to complete this research.

Novelty Statement

The combined study of jassid population development with environment and abiotic resistance of cotton cultivars is a novel approach for jassid management.

Author's Contribution

Muhammad Afzal: Prepared research plan, conducted research and manuscript write up.
Khuram Zia: Supervised research and helped in write up.
Sohail Alam: Helped in data recording and review the manuscript.
Habib Anwar, Muhammad Imran, Shafqat Saeed, Hasan Riaz, Muhammad Ishtiaq, Muhammad Saleem: Review and proof read the manuscript.
Muhammad Qasim: Helped in statistical analysis and edited the manuscript.

Animal and human rights statement
This research article does not have any studies with human and animal subjects accomplished by any of the authors.

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

References

Abhilash, P.C. and N. Singh. 2009. Pesticide use and application: An Indian scenario. J. Hazard. Mater., 165(1–3): 1–12. https://doi.org/10.1016/j.jhazmat.2008.10.061

Aheer, G.M., A. Ali and S. Hussain. 2006. Varietal resistance against jassid, *Amrasca devastans* (Dist.). in cotton and role of abiotic factors in population fluctuation. J. Aric. Res., 44(4): 299-305.

Aheer, G.M., A. Ali and M. Saleem. 1999. Morpho-physical factors affecting resistance in cultivars of cotton against some sucking insect pests. Pak. Entomol., 21(1-2): 99-103.

Aheer, G.M., K.J. Ahmad and A. Ali. 1994. Role of weather in fluctuating aphid density in wheat crop. J. Agric. Res., 32: 295-301.

Ahmad, M. and M.R. Khan. 1991. Insecticide resistance management strategies in cotton pests in Pakistan. Pak. Entomol., 13(1-2): 99-103.

Ahmed, G., M.J. Arif and M.R.J. Sanpal. 2005. Population fluctuation of Jassid, *Amrasca devastans* (Dist.) in cotton through morpho-physical plant traits. Caderno de Perquisa Ser. Bio., Santa Cruz do Sul., 17(1): 71-79.

Ali, A., A. Khaliq and M. Ashraf. 1995. Physical factors affecting resistance in cotton against jassid, *Amrasca devastans* (Dist.) and thrips, Thrips tabaci (Lind.). J. Agric. Res., 33(2): 173–178.

Ali, A., G.M. Aheer and M. Saeed. 1999. Physico-morphic factors influencing resistance against sucking insect pests of cotton. Pak. Entomol. 21(1-2): 53-55.

Ali, S., M.A. Khan, A. Habib, S. Rasheed and Y. Iftikhar. 2005. Management of yellow vein mosaic disease of okra through pesticide/bio-pesticide and suitable cultivars. Int. J. Agric. Biol., 7(1): 145-147.

Ali, T., M.H. Bashir, B.S. Khan, A. Ghaffar, D. Riaz, M.Z. Haq, S. Nawaz, A. Ali, I. Hassan, I.U. Haq and M.K. Shahzad. 2021. Response of sucking insect pest fauna towards Bt and Non Bt cotton genotypes under varying climatic condition. J. Innov. Sci., 7(2): 304-311. https://doi.org/10.17582/journal.jis/2021/7.2.304.311

Amjad, B.M., M. Batool, H. Khan, M. Shahid Nisar, H. Farooq, M. Hashem, S. Alamri, M.A. El-Zohri, R.A. Alajmi, M. Tahir and R. Jawad. 2022. Effect of temperature and humdity on population dynamics of insects pest complex of cotton crop. PLoS One, 17(5): p.e0263260. https://doi.org/10.1371/journal.pone.0263260

Arshad, M., N. Illahi, M. Rashid and Z.U. Qamar. 2001. Estimation of useful heterosis in intraspecific F1 cotton hybrids. J. Agric. Res., 39(2): 101-106.

Ashfaq, M., M. Noor-ul-Ane, K. Zia, A. Nasreen and Mansoor-ul-Hasan. 2010. The correlation of abiotic factors and physico-morphic charateristics of (*Bacillus thuringiensis*) Bt transgenic cotton with whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae) and jassid, *Amrasca devastans* (Homoptera: Jassidae) populations. Afr. J. Agric. Res., 5(22): 3102–3107.

Attique, M.R. and A. Rashid. 1983. Efficacy of pyrethroid pesticides for the control of cotton pests. J. Agric. Res., 4: 65-67.

Bashir, M.H., M. Afzal, M.A. Sabri and A.B.M. Raza. 2001. Relationship between sucking insect pests and physic-morphic plant character toward resistant/susceptibility in some new cultivars of cotton. Pak. Entomol., 23(1-2): 75-78.

Bhatnagar, P. and P.D. Sharma. 1991. Comparative incidence of sucking insect pests on different isogenic lines of cotton variety. J. Insect Sci., 4: 170-171.

Bishnoi, O.P., M. Singh, V.Y.M. Sao, R. Niwas and P.D. Sharma. 1996. Population dynamics of cotton pests in relation to weather parameters. Ind. J. Entomol., 58: 103-107.

Farooq, A., J. Farooq, A. Mahmood, A. Shakeel, K.A. Rehman, A. Batool, M. Riaz, M.T.H. Shahid and S. Mehboob. 2011. An overview of cotton leaf curl virus disease (CLCuD) a serious threat to cotton productivity. Aust. J. Crop Sci., 5(13): 1823-1831.

Gilden, R.C., K. Huffling and B. Sattler. 2010. Pesticides and health risks. J. Obstet. Gynecol. Neonatal. Nurs. 39(1): 103-110. https://doi.org/10.1111/j.1552-6909.2009.01092.x

Government of Pakistan, 2022-23. Pakistan bureau of statistics, agricultural statistics of Pakistan, Ministry of Planning, Development and Special Initiatives Ministry of food, Agriculture and livestock, Islamabad, Pakistan.

Government of Pakistan, 2023-24. Economic Survey of Pakistan, Eco. Advisory wing, Finance Div. Islamabad: 21-25.

Inee Gogoi, I.G. and B.C. Dutta. 2000. Seasonal abundance of cotton jassid, *Amrasca biguttula biguttula* (Ishida) on okra. J. Agric. Sci., 13(1): 22-26.

Irfan, M., I. Mumtaz, A.B.M. Raza, K. Ahmad, Z.I. Khan and N. Arif. 2008. Effect of leaf morphology on the incidence of sucking insect pests in some cotton genotypes. Int. J. Cell Mol. Biol., 1(3): 285–291.

Javed, H., M.R. Khan, and M. Ahmad. 1992. Role of physico-chemical factors imparting resistance in cotton against some insect pests. Pak. Entomol, 14(1-2): 53-55.

Lopez, D.C. and G.A. Sword. 2015. The endophytic fungal entomopathogens *Beauveria bassiana* and *Purpureocillium lilacinum* enhance the growth of cultivated cotton (*Gossypium hirsutum*) and negatively affect survival of the cotton bollworm (*Helicoverpa zea*). Biol. Contr., 89: 53-60. https://doi.org/10.1016/j.biocontrol.2015.03.010

Malik, T.H. and M.Z. Ahsan. 2016. Review of the cotton market in Pakistan and its future prospects. OCL, 23(6): D606. https://doi.org/10.1051/ocl/2016043

Mawblei, C., N. Premalatha, A. Manivannan and K. Senguttuvan. 2024. Characterization and screening of cotton (*Gossypium hirsutum* L.) germplasm for leafhopper (*Amrasca biguttula biguttula* (Ishida)) resistance. J. Cotton Res., 7(1): 19. https://doi.org/10.1186/s42397-024-00182-1

Mohyuddin, A.I., G. Jillani, A.G. Khan, A. Hamza, I. Ahmad and Z. Mahmood. 1997. Integrated Pest Management of major cotton pests by conservation, redistribution and augmentation of natural enemies in Pak. J. Zool., 29(3): 293-298.

Naveed, M., Z.I. Anjum, J.A. Khan, M. Rafiq and A. Hamza. 2011. Cotton genotypes morpho-physical factors affect resistance against *Bemisia tabaci* in relation to other sucking pests and its associated predators and parasitoids. Pak. J. Zool., 43(2): 229–236.

Patel, R.K. and G.G. Radadia. 2018. Population dynamics of cotton jassid, Amrasca biguttula biguttula (Ishida) and natural enemies in relation to weather parameters under rainfed conditions. J. Entomol. Zool. Stud., 6(6): 664-672.

Saini, A., K.C. Ahir, B.S. Rana and R. Kumar. 2017. Population dynamics of sucking pests infesting chilli (*Capsicum annum* L.). J. Entomol. Zool. Stud., 5(2): 250-252

Singh, B.B. and T. Matsui. 2002. Cowpea varieties for drought tolerance in challenges and opportunities for enhancing sustainable cowpea production. pp. 287–300.

Steel, R.D. and J.H. Torrie. 1980. Principles and procedures of statistics. McGraw Hill Book Co. Inc. New York, USA.

Thirasack, S., 2001. Yield losses assessment due to pests on cotton in Lao PDR. Agric. Nat. Res., 35(3): 271-283.

Wahla, M.A., J. Arif and M. Afzal. 1996. The impact of physical factors on the population dynamics of sucking pest complex of "FH-87" cotton variety. Pak. Entomol., 18(2): 566-585.