Advances in Agriculture and Biology (2018) 1(1): 40-46
RESEARCH PAPER

Varietal performance against sucking insect pest of cotton (*Gossypium hirsutum* L.) under Multan ecological conditions

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Received: 14 March 2018
Accepted: 9 July 2018

Key Message: The study assessed ten cotton varieties for their resistance to common sucking insect pests in Multan. SLH-284 and VH-156 showed resistance to whitefly and thrips, making them promising choices for integrated pest management (IPM). Their resistance could help minimize pest damage and boost yield.

Abstract

The ten cotton varieties were screened for resistance against whitefly, jassid and thrips at the experimental farm of Cotton Research Institute (CRI), Multan. Among the selected genotypes, SLH-284 exhibited relative resistance to whitefly, while VH-156 showed low susceptibility to thrips (0.7/Leaf). Notably, SLH-284 displayed greater resistance to whitefly attack. In August, a high jassid population (5.6/Leaf) was observed. Cotton genotypes BH-167, FH-113, and VH-148 were found to be susceptible to high infestations of insect pests, resulting in reduced cotton yield. In addition, jassid indicated peak population during August. The result indicated that VH-156 showed the resistance against thrips. From this experiment, it was observed that low infestation of whitefly and thrips occurred on SLH-284 and VH-156 cultivars. So, the overall results showed that VH-156 and SLH-284 can be used in IPM program. The study aimed to explore the impact of varied spacing and abiotic factors such as temperature, rainfall, and relative humidity on the population dynamics of sucking insect pests (specifically *Bemisia tabaci*, Thrips tabaci, and *Amrasca devastans*) within unsprayed conditions. A simple correlation analysis was employed to discern the relationships between these variables. The results of the analysis revealed that rainfall and temperature had a significant and positive impact on jassid populations, whereas relative humidity showed a non-significant effect. Similarly, temperature exerted a positive influence on both thrips and whitefly populations, while relative humidity and rainfall did not exhibit a significant impact on thrips. For whitefly, a significant and positive correlation was observed with relative humidity, but rainfall did not show a significant impact. To further quantify the relationships, Multivariate Regression Analysis computed the coefficient of determination (R2). The results indicated that temperature, humidity, and rainfall collectively influenced 53 %, 36.8 %, and 66.4 % of the population fluctuation of jassid, thrips, and whitefly, respectively. These findings underscore the intricate interplay of abiotic factors in shaping the dynamics of sucking insect pests, providing valuable insights into the environmental determinants of their populations under unsprayed conditions.

Keywords: Abiotic factors, Correlation analysis, Cotton genotypes, IPM, Resistant, Sucking insect pests, Yield

Citation: Ali, M., & Shahid, M. R. (2018). Varietal performance against sucking insect pest of cotton (*Gossypium hirsutum* L.) under Multan ecological conditions. *Advances in Agriculture and Biology, 1*(1), 40-46.

Introduction

Cotton (*Gossypium hirsutum* L.) stands as a pivotal fiber and cash crop, playing a vital role in the Pakistani economy (Tayyib et al., 2005; Ali et al., 2012). Contributing significantly to foreign exchange earnings, cotton accounts for 68% of the total in Pakistan (Government of Pakistan, 2009). This versatile crop yields a soft and durable fiber found within cotton bolls, enveloping the cotton seeds (Zia et al., 2015). The composition of cotton fiber primarily comprises pure cellulose, along with traces of waxes, lipids, pectin, and water. Native to tropical and subtropical regions, including America, Africa, and India, the cotton shrub exhibits the highest diversity of wild species in Mexico, followed by Australia and Africa. The cultivation history of cotton spans both the Old and New Worlds. Dating back to 6000 BC in Peru, the use of cotton for textile production has a rich ancient heritage. Currently, global cotton production reaches approximately 25 million tonnes annually, utilizing around 2.5% of the world's arable land. India holds the title of the world's largest cotton producer, with the United States leading as the primary exporter over the years.

There are four commercially grown species of cotton, all domesticated in antiquity: *Gossypium hirsutum*, *Gossypium babadense*, *Gossypium arboretum*, and *Gossypium herbaceum*. Hybrid varieties are also cultivated, with the majority of modern cotton production dominated by the two New World varieties. However, the two Old World varieties were widely utilized before the 1900s. While cotton fibers naturally occur in colors such as white, brown, pink, and green, concerns about genetic contamination have led many cotton-growing regions to prohibit the cultivation of colored cotton varieties. Cotton cultivation, particularly with *Gossypium hirsutum*, involves extensive farming practices that necessitate substantial financial investment to combat insect pests. Synthetic chemicals are widely employed to enhance crop growth and protect against pests, contributing to the overall cost of cotton production (Deguine et al., 2008). Insect pests pose a significant challenge, not only diminishing the quality of cotton produce but also reducing overall yield (Zia et al., 2018a, 2018b). The economic constraints faced by farmers, especially in developing countries with limited land resources, make it difficult to afford extensive protective measures. Unfortunately, the widespread use of chemical inputs contributes to environmental pollution (Fitt, 2000).

In addition to insect pests, plant pathogens pose a threat to certain areas in cotton cultivation, although their impact is generally not as substantial as that of inputs and agrochemicals. Weeds, on the other hand, emerge as a crucial biotic agent, competing with cotton plants for nutrients and space. While advancements have been made in controlling these pathogens through chemical means, there is still a significant yield loss, reaching approximately 30 %. The potential losses associated with non-utilization of inputs and weed interference account for around 40% and 9 % of total losses, respectively, with pathogens and viruses contributing to the remaining losses. Despite the extensive use of artificial chemicals in cotton farming, losses still amount to almost 29 %, underscoring the complexity of managing and mitigating challenges in cotton cultivation. Finding sustainable and environmentally friendly solutions remains a critical goal to balance productivity and environmental impact in the cotton farming sector.

In Pakistan, the cultivation of cotton has heavily relied on artificial chemicals, with farmers depending on synthetic pesticides for an extended period, leading to an intensified and challenging situation. This overreliance on toxic chemicals poses a threat not only to the environment but also to human health (Iqbal et al., 1997; Tariq et al., 2007; Damalas, 2009; Damalas & Eleftherohorinos, 2011). To protect yields from insect pests and pathogens while also enhancing agricultural productivity in terms of both importance and cost-effectiveness, farmers globally should adopt judicious chemical use. Given the potential risks associated with the excessive use of toxic chemicals, there is an urgent need to educate the public, particularly farmers, about proper cotton crop management practices, including the control of insect pests and pathogens (Iqbal et al., 1997; Tariq et al., 2007; Damalas, 2009; Damalas & Eleftherohorinos, 2011). Moreover, farmers are actively exploring new methods for managing these devastating pests, as the expenses incurred in pest control significantly impact both the quantity and quality of the produce. Despite Pakistan ranking 4th among all cotton-producing countries, the per-acre cotton production remains notably low compared to other nations. The primary cause of this low yield in Pakistan is attributed to the relentless attacks by insect pests. Notably, there are recorded instances of 162 insect pest species feeding on cotton at various growth stages in Pakistan (Kannan et al., 2004). Acknowledging and addressing these challenges is essential to achieve sustainable and resilient cotton production practices in the country.

The pests that pose a threat to cotton crops can be categorized into two types: sucking and chewing. Thrips (*Thrips tabaci*), jassid (*Amrasca devastans*), and whitefly (*Bemisia tabaci*) are particularly damaging as they extract cell sap from leaves. Additionally, dusky and red cotton bugs can negatively impact seed germination and lint quality. On the other hand, boll feeders such as pink bollworm (*Pectinophora gossypium*), spotted bollworm (*Earis* spp.), and American bollworm (*Helicoverpa armigera*) target the cotton bolls. The combined effect of these insect pests results in yield losses ranging from 5-10 %, which may escalate to 40-50 % under severe conditions (Chudhary, 1976). Whitefly infestations, occurring from seedling to maturity, contribute significantly to lower yields and compromised quality (Amer et al., 1999). Jassid and thrips, on the other hand, are responsible for a substantial 38% loss in yield (Baloch et al., 1986). The economic impact of pest attacks was estimated at 3.1 million during the 1998-99 period (Ahmad & Poswal, 2000). In response to these challenges, farmers often resort to insecticides. However, the use of insecticides raises concerns about environmental pollution and poses health risks to humans, animals, and birds. Furthermore, it contributes to the development of insecticide-resistant pest populations (Mohyuddin et al., 1997).

To address these issues, there is a crucial need to develop resistant cotton cultivars. Resistant varieties offer protection against insect pests without sacrificing yield, in conjunction with other control measures (Chaudhary & Arshad, 1989). In Pakistan, breeders have directed their efforts towards enhancing yield potential and expanding the number of varieties. Numerous plant characteristics, both morphological and physiological, can influence the populations of harmful and beneficial insects (Krips et al., 1999; Afzal & Bashir, 2007). It is imperative to focus on developing diverse cotton genotypes that are resistant to both chewing and sucking insect pests to ensure sustainable and resilient cotton cultivation. Recognizing the vital role of cotton in Pakistan's economy, the establishment of an Integrated Pest Management (IPM) program for cotton becomes imperative. Accurate knowledge of optimal plant spacing and ecological requirements, including key weather factors such as temperature, relative humidity, and precipitation, is crucial for effective pest management. These factors significantly influence the multiplication and distribution of insect pests, making them central to pest control strategies. Despite their significance, progress in this area has been slow among entomologists in Pakistan due to a lack of information. In response to this knowledge gap, the present study was initiated.

The primary objective of this study is not only to evaluate the overall population dynamics of sucking insect pests on cotton under different plant spacing conditions but also to determine the precise nature and extent of the relationship between pest populations and weather factors. The ultimate goal is to provide entomologists with valuable insights to develop the most effective Integrated Pest Management (IPM) strategy for controlling notorious insect pests affecting cotton crops.

Materials and Methods

This research study was carried out at Cotton Research Institute (CRI), Multan under RCBD design, with ten genotypes (MNH-789, FH-901, MNH-786, VH-156, FH-207, VH-148, RH-514, FH-113, BH-167, and SLH-284) in three replications. The genotypes were sown in June 2007, each occupying a plot size of 250 m^2. Cultivated under natural field conditions with standard agronomic practices, no control measures were implemented against insect pests. Data collection extended from June to the end of August. Sucking insect populations, including jassid, whiteflies, and thrips were assessed by randomly selecting three leaves (one from each upper, middle, and lower position) from three plants per plot. Population data were then standardized to a per leaf basis. The quantification of sucking insect pests was based on the number of adults/nymphs per leaf. Sampling involved ten plants from each treatment, and insect populations were recorded on various leaves of each plant. Subsequently, the collected data underwent rigorous statistical analysis, including the application of Duncan's Multiple Range (DMR) test at a 5% probability level. This analysis aimed to elucidate the impact of plant spacing on insect pest populations. Moreover, correlations between cotton insect pest populations and various weather factors were assessed to enhance our understanding of the ecological dynamics at play. Yield measurements for each plot were obtained through two harvests conducted during the season.

Statistical analysis

Statistical analysis was performed using ANOVA with the Statistix software. The significance of differences in mean pest populations and yield was determined at a 5% probability level using Tukey's Honestly Significant Difference (HSD) test. This method allowed for the identification of significant distinctions among genotypes concerning pest populations and yield, providing valuable insights into the performance variations among the cultivated varieties. For mean population following formula was used:

$$\text{Mean population} = \sum x/n$$

Where
X = sum of insect per leaf, n = Total no. of leaves observed

Results and Discussion

The results presented in Table 1 underscore significant variations among experimental genotypes concerning pest populations across different months. Notably, infestation surpassed the Economic Threshold Level (ETL) in September, with MNH789 exhibiting the highest infestation (4.29/ Leaf) and FH-113 displaying the lowest (2.74/ Leaf) in July, followed closely by BH-167 (2.87/ Leaf). August marked the peak infestation in all genotypes above ETL, notably BH-167 (5.20/ Leaf), FH-113 (5.27/ Leaf), VH-156 (5.24/ Leaf), and VH-148 (5.20/ Leaf). Overall, MNH-789 demonstrated greater tolerance, recording the lowest infestation (2.74/ Leaf). In September, BH-167, FH-113, FH-207, FH-901, MNH-786, MNH-789, RH-514, VH-148, and VH-156 exhibited no thrips infestation. However, peak activity was observed in August, with VH-156 showing significant results. Whitefly infestation peaked in August, with SLH-284 (5.34/ Leaf) and BH-167 (5.24/ Leaf) experiencing the highest infestation. Conversely, SLH-284 displayed the lowest whitefly infestation (2.84/ Leaf) in July. These findings suggest that July and August are conducive months for whitefly and jassid population growth. Peak thrips population occurred in July, contrary to the higher levels of jassid infestation observed in August and September, differing from the findings of Swidrak et al. (2013), possibly due to genotype and ecological variations. The attack of sucking insect pests (jassid, whitefly, and thrips) significantly impacted the yield across all experimental genotypes. MNH-789 demonstrated higher tolerance to jassid, while VH-156 exhibited maximum resistance to thrips and whitefly. Numerous researchers including Bhatnagar and Sharma (1991), 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) have emphasized host plant resistance against these pests. Glandless varieties were found to be more infested than frego bract and okra leaf cotton varieties. VH-156 and FH-113 exhibited minimal thrips attack, while FH-207 and VH-148 were more susceptible. Hernandez et al. (1999) also reported negligible differences in yield among various cotton varieties regarding whitefly occurrence.

Table 2 presents the correlation between abiotic factors and the populations of jassid, thrips, and whitefly. Significant and positive correlations were observed between rainfall and temperature with the jassid population, while relative humidity exhibited a non-significant effect. Similarly, temperature displayed a significant and positive correlation with thrips and whitefly populations, whereas relative humidity and rainfall did not exhibit significant positive correlations with whitefly population. These findings partially align with Bishnol et al. (1996) who recorded a significant relationship between mean air temperature and relative humidity with jassid populations. Additionally, El-Mezayyen et al. (1997); Gogoi et al. (2000) highlighted the significant impact of temperature and relative humidity on insect pest populations, supporting our results that temperature plays a significant positive role in population dynamics. In agreement with Seif (1980), Majeed et al. (1995), Umar et al. (2003), our findings indicate a consistent positive correlation between temperature and pest populations. However, there is partial agreement with Rote and Puri (1991), Murugan and Uthamasany (2001), Panickar and Patel (2001), who reported significant weather-related influences on insect pest population fluctuations. For whitefly, negative correlations were observed with maximum temperature, rainfall, and sunshine. Rainfall accounted for an 8.5 % influence on whitefly population fluctuation, increasing to 33.5 % when temperature was considered. When data for all three factors were combined, rainfall, temperature, and relative humidity showed a significant 66.4 % influence on whitefly population fluctuation. These results are consistent with Seif (1980), Isler and Ozgur (1992), Majeed et al. (1995), and Sohi et al. (1995), highlighting the complicated relationship of abiotic factors in shaping whitefly population dynamics.

Table 1 Response of varieties toward sucking insect pest of cotton observed at different intervals

Varieties	July			August			September		
	Whitefly	Jassid	Thrips	Whitefly	Jassid	Thrips	Whitefly	Jassid	Thrips
BH-167	3.17	2.87	1.47	5.24	5.60	1.9	4.20	4.24	0.4
FH-113	3.00	2.74	0.97	5.04	5.27	2.5	4.02	4.02	0.7
FH-207	3.34	3.10	1.04	4.80	4.67	1.9	4.07	3.89	0.7
FH-901	3.07	3.17	1.40	3.84	4.47	1.4	3.79	3.82	0.6
MNH-786	3.14	3.37	1.44	4.94	4.40	1.2	4.04	3.89	0.7
MNH-789	2.97	3.77	1.14	4.44	4.80	1.4	3.70	4.29	0.4
RH-514	3.30	2.94	1.14	4.24	4.47	1.7	3.67	3.70	0.5
SLH-284	2.84	3.40	0.87	5.34	4.64	1.2	4.09	3.90	0.5
VH-148	3.04	3.27	1.07	5.00	5.20	2.3	4.02	4.24	0.6
VH-156	2.84	3.30	1.07	4.54	5.24	0.7	3.69	4.27	1.1

WF = Whitefly, J = Jassid, TH = Thrips

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)

Min= minimum temperature, Max = maximum temperature, RF = Rainfall, RH = Relative humidity%, SS = Sunshine

Results revealed that jassid had negative correlation with maximum temperature, rain fall and sunshine. The current findings align with Butter et al. (1992), who similarly observed a higher jassid population at lower plant spacing. However, our results deviate from those of Sohi et al. (1995), who found a less significant incidence of jassid with varying spacing. Moreover, disparities exist with Joginder et al. (1998); Gogoi et al. (2000), who reported different peak population periods for jassid compared to our observations. This variability can be attributed to distinct ecological conditions and study periods. Notably, our study emphasizes the multifaceted influence of abiotic factors on jassid populations. Minimum temperature and relative humidity exhibited a positive correlation with jassid dynamics (Table 3). Rainfall alone accounted for a substantial 32.4 % of the fluctuation in jassid population, and this effect increased to 48.4 % when considering additional factors like temperature. The cumulative impact of abiotic factors reached a noteworthy 53 % when relative humidity was included in the analysis. These results highlight the complex interaction of environmental factors shaping the dynamics of jassid populations.

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)

The study outcomes revealed a positive correlation between thrips and maximum temperature, rainfall, and sunshine. These findings align with the notion that abiotic factors collectively influence the thrips population. Specifically, the results indicate a 7.7 % contribution of these factors to thrips population fluctuation. However, when considering the additional impact of temperature, this influence substantially increased, reaching up to 36.8%. Interestingly, our findings diverge from those reported by Al-Faisal and Kardu (1986), who observed two population peaks in early May and late June or early July. In contrast, our study shows a negative correlation between thrips and minimum temperature, as well as relative humidity. This suggests an indirect relationship between thrips dynamics and climatic variables, emphasizing the complexity of ecological interactions in thrips population dynamics. The findings of this study will contribute valuable insights towards the development of sustainable and effective IPM strategies for managing insect pests in cotton cultivation.

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)

Conclusion

The VH-156 and SLH-284 genotypes exhibited resistance to the sucking pest complex, resulting in superior seed cotton yields. These resilient genotypes hold significant promise for incorporation into future breeding programs aimed at enhancing resistance. Moreover, their inclusion in integrated pest management (IPM) strategies can effectively mitigate pest-related risks, minimizing yield losses and contributing to sustainable cotton cultivation practices.

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