INNSPUB

International Journal of Biosciences | IJB |
ISSN: 2220-6655 (Print) 2222-5234 (Online)
http://www.innspub.net
Vol. 15, No. 3, p. 514-523, 2020

RESEARCH PAPER OPEN ACCESS

Resistance of non-Bt., cotton varieties against sucking pests under *vitro* conditions at Sindh, Pakistan

Hakim Ali Sahito[1,2], Zafar Hussain Shah[*1], Tasneem Kousar[1], Wali Muhammad Mangrio[1], Faheem Ahmed Jatoi[1]

[1]*Department of Zoology, Faculty of Natural Sciences, Shah Abdul Latif University, Khairpur, Sindh, Pakistan*

[2]*Date Palm Research Institute (DPRI), Shah Abdul Latif University, Khairpur, Sindh, Pakistan*

Key words: Resistance, Non-Bt., Cotton, Sucking complex, Vitro conditions

http://dx.doi.org/10.12692/ijb/15.3.514-523 Article published on September 30, 2019

Abstract

The different non transgenic cotton varieties (n=09) namely; T_1= Sindh-1, T_2= Bakhtawar, T_3= CRIS-9, T_4= CRIS-129, T_5= CRIS-121, T_6= CRIS-342, T_7= CRIS-134, T_8= Marvi (CRIS-5A) and T_9= CRIS-467 were cultivated to check their varietal resistance against most devasting sucking pests such as; Jassids, whiteflies, thrips and mealybugs under un-sprayed field conditions during, 2018. An experiment was laid out in a Randomized Complete Block Design (RCBD) had nine treatments of size 100sq feet and replicated four times. Twenty plants were randomly selected for data collection from each variety on weekly basis. The maximum mean of the jassid population was observed on CRIS-9 (4.21) and minimum on CRIS-467 (2.22) per leaf. The maximum whiteflies were recorded on CRIS-342 (11.74) and minimum on CRIS-467 (7.38). The maximum thrips were found on Sindh-1 (13.60) and minimum on Marvi (CRIS-5A) (8.62). The maximum mealybugs were observed on CRIS-121 (2.61) while minimum on CRIS-134 (0.43). In overall resistivity of nine non-Bt., cotton varieties, two varieties Marvi (CRIS-5A) and CRIS-467 showed overall good resistance against sucking complex (5.16) and (5.33) respectively, followed by CRIS-129 (5.75), CRIS-121 (5.84), whereas; CRIS-9 (6.05), CRIS-134 (6.20) and Bakhtawar (6.26) showed average resistivity against sucking complex, while cotton varieties Sindh-1 (7.04) and CRIS-342 (7.01) were found to be less resistive and most infested non-Bt., varieties among the tested varieties. So it was concluded that Marvi (CRIS-5A) and CRIS-467 gave good resistance against the above mentioned four sucking pests. Therefore, it is recommended that these varieties Marvi (CRIS-5A) and CRIS-467 should be grown as these were less infested by sucking complex.

* **Corresponding Author:** Zafar Hussain Shah ✉ lakyarializafar@yahoo.com

Introduction

Cotton, *Gossypium hirsutum* L. is the major commercial crop of Pakistan, commonly called "silver fiber" and cash crop as "white gold" that plays a major role in strengthening the country's economy (Sahito *et al.,* 2009). During, 2017 it was cultivated upon 2.489 million hectares and its production was obtained 10.671 million bales. *Among the cotton-producing countries Pakistan is at 4th rank in the world (PCCC, 2018) that* obtains 68% foreign exchange and 7.1% in agriculture value addition and about 1.6% to GDP *(Pakistan Economic Survey, 2015) as* per acre yield, is very low comparatively due to the insect pest infestation (Ahmad *et al*., 2011). It is attacked by more than 1326 insect species all over the world, out of which about; 145 species were reported in Pakistan (Huque, 1994). Among these species, sucking complex had major importance as regular pests of the cotton crop including; jassid (*Amrasca biguttula biguttula),* whitefly (*Bemisia tabaci*), thrips (*Thrips tabaci*), mealybug *(Phenacoccus solenopsis*) and aphid (*Aphis gossypii*) which gave great damage to the crop of cotton.

Jassid is notorious, usually sucks the sap of cells from the lower side of plant leaves and inserts the toxic material within the tissues by which, the leaves become crumpled (Inee and Dutta, 2000). Whitefly also found on the underside of cotton leaves that also sucks the sap of plant cells that reduces about 50% production of the bolls (Ahmad *et al.,* 2002), it is known as vector of cotton leaf curl virus (CLCuV) a well-known disease (Nelson *et al.,* 1998) and it threatens to agriculture by infesting the six hundred host plants (Oliveira *et al.,* 2001). Thrips is a minute pest which found on underside of leaves of cotton seedlings and gave damage to plant by sucking cell sap as a result plant become distorted, malformed, torn leaves of seedling, reduced plant height and leaf area, reduced root growth and apical meristem tissue become injured or dead, delayed fruit maturity, loss of 30-50% lint yield (Cook *et al.,* 2011). Mealybugs suck the sap from stem and leaves of the plant, it sounds to be best for the waxy powdery covering on its adult females (Miller and Williams, 1997), found on so many crops, weeds, ornamental plants and vegetables, recently it became hazardous sucking pest by reducing 14% yield of cotton (Arif *et al.,* 2009). The sucking complex had played a key role in reducing cotton production throughout the country (Khan *et al.,* 2008).

Thus tactic of varietal resistance is of great importance and a better alternate of pesticides (Khan *et al.,* 2003). For developing insect pest management (IPM), its main need to know about the effect of physical characters of the plant for the selection of the host's behavior. Because many insect pests and natural enemies negatively and positively affected by plant characters. Pakistani breeders have focused on to enhance capacity of yield and produced a number of varieties (Afzal and Bashir, 2007) for this purpose many efforts have been taken by Hassan *et al*., (2000), Shad *et al*., (2001), Khan *et al*., (2003) but for obtaining some specific outcomes still a lot remains, yet to be completed. By focusing the resistant cotton varieties the current research work was done to find out the natural resistance of non-Bt., against sucking complex and also the period of the population development of sucking pests that would pave the way to new researchers, farmers and livelihood of the province, Sindh - Pakistan.

Material and methods

The research experiments were performed during the summer season 2018 for observing resistance of non-Bt., cotton varieties against sucking pests i-e, jassid (*A. biguttula biguttula*), whitefly (*B. tabaci*), thrips (*T. tabaci*) and mealybug (*P. solenopsis*) under un-sprayed vitro conditions. For this the seeds of nine varieties namely; T_1= Sindh-1, T_2= Bakhtawar, T_3= CRIS-9, T_4= CRIS-129, T_5= CRIS-121, T_6= CRIS-342, T_7= CRIS-134, T_8= Marvi (CRIS-5A) and T_9= CRIS-467 were sown on ridges in a Randomized Complete Block Design (RCBD), consists on treatment size of 100sq feet of each, which were replicated 4 times and kept insecticides' free. Each plot was separated by keeping a space of 2 feet, ridge to ridge space was kept 18" and plant to plant 9" to 12". All agronomical tactics including thinning, weeding, etc were operated manually and for controlling the weeds the pre-emergence weedicide was applied.

For the observance of sucking complex, the cotton crop was checked weekly after the time of the first appearance of pests. For counting of pest population per treatment/ plot randomly 20 plants of each variety were chosen then three leaves (one each from top, middle and bottom portion) from each plant were kept under observation for population fluctuation of sucking complex. The information was collected on the average counts of the pests per leaf. During the season of the most sucking pest activity, the varietal resistance was observed. Through the various examinations of the mean values, the information on the individual population of each sucking pest species was recorded.

Statistical analysis

At the end by using Statistics (8.1) computer software, student package, USA the means were isolated by comparing Least Significant Difference (LSD) test at ($P<0.05$), through this the relationship framework between the overall and individual population fluctuation of the sucking complex was analyzed on various nine cultivated varieties of non-Bt., cotton.

Results

The varietal resistance was considered to be positive with a decrease in per leaf pest population and it was considered to be negative with an increase in the per leaf pest population.

Jassid (Amrasca biguttula biguttula)

Jassids initially appeared in July and were continuously active up to the end of September or the first picking of cotton. From all the cultivated nine varieties of non-Bt., cotton, the maximum mean of jassid population per leaf was observed on CRIS-9 (4.21), followed by Sindh-1 (4.16), CRIS-342 (4.00), Bakhtawar (3.35), CRIS-129 (3.35), CRIS-134 (3.34), Marvi (CRIS-5A) (3.33) and CRIS-121 (2.30) whereas; the lowest mean of jassid population was recorded on CRIS-467 (2.22) as shown in (Fig. 1). The analysis of variance (ANOVA) showed the least significant difference of varieties in three groups (DF= 11, 8; F= 65.27; P= 0.001) against population of jassid, from which group "A" of non-Bt., cotton varieties showed the least resistance, it includes the CRIS-9, Sindh-1 and CRIS-342, on these three varieties maximum population of jassid was observed, group "B" includes the four cotton varieties, Bakhtawar, CRIS-129, CRIS-134 and Marvi (CRIS-5A), on these four moderate population of jassid was observed, while group "C" includes the two cotton varieties CRIS-121 and CRIS-467, these two non-Bt., varieties of cotton showed the maximum resistance against cotton jassid as lowest population was observed.

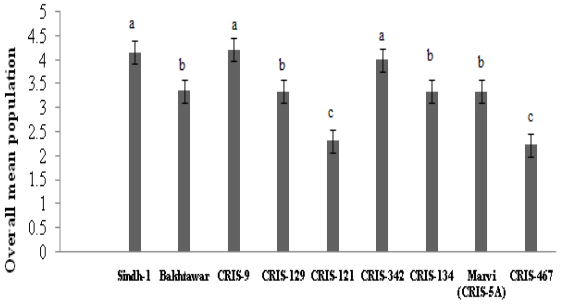

Fig. 1. Overall mean population of jassid on different non-Bt., varieties of cotton crop under field conditions during, 2018.

Whitefly (Bemisia tabaci)

The population of whitefly was also observed on nine non-Bt., cotton varieties, the highest mean of whitefly population per leaf was recorded on CRIS-342 (11.74), followed by CRIS-134 (9.81), Sindh-1 (8.71), Bakhtawar (8.67), CRIS-121 (8.41), Marvi (CRIS-5A) (8.21), CRIS-129 (7.93) and CRIS-9 (7.83) while the lowest mean of whitefly population was observed on CRIS-467 (7.38) as shown in (Fig. 2). The ANOVA showed the least significant difference of varieties in three groups (DF= 11, 8; F= 6.69; P= 0.001) against population of whitefly, of which group "A" of non-Bt., cotton varieties showed the least resistance, it includes the CRIS-342 and CRIS-134, on these two varieties maximum population of whitefly was observed, group "B" includes the four cotton varieties, Sindh-1, Bakhtawar, CRIS-121 and Marvi (CRIS-5A), on these four varieties moderate population of whitefly was observed, while group "C" includes the three cotton varieties CRIS-129, CRIS-9 and CRIS-467, these three non-Bt., cotton varieties showed the maximum resistance against cotton whitefly as minimum population of whitefly was recorded on these three varieties of non-Bt., cotton.

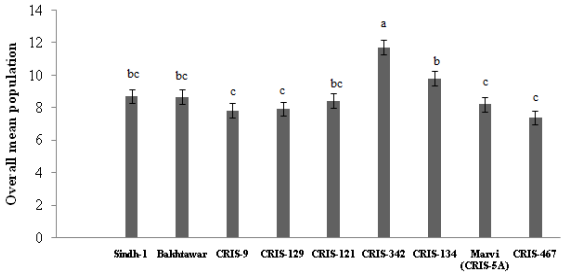

Fig. 2. Overall mean population of whitefly on different non-Bt., varieties of cotton crop under field conditions during, 2018.

Thrips (Thrips tabaci)

The varietal resistance of nine non-Bt., cotton varieties was observed against thrips population, the maximum number of thrips were counted on Sindh-1 (13.60), followed by Bakhtawar (11.64), CRIS-9 (11.59), CRIS-467 (11.27), CRIS-134 (11.20), CRIS-342 (10.78), CRIS-129 (10.41) and CRIS-121 (10.04) while lowest mean population of thrips was found on Marvi (CRIS-5A) (8.62) as shown in (Fig. 3). The ANOVA showed the least significant difference of non-Bt., varieties in five groups (DF= 11, 8; F= 18.25; P= 0.001) against population of thrips, of which group "A" includes the Sindh-1, this variety found to be least resistive as highest population of thrips were counted on it, group "B" includes the two varieties, Bakhtawar and CRIS-9, on these two varieties considerable population of thrips was observed, group "C" includes the three cotton varieties CRIS-467, CRIS-134 and CRIS-342, these three cotton varieties showed the moderate resistance against cotton thrips as moderate population of thrips was observed on these three cotton varieties, group "D" includes the two cotton varieties CRIS-129 and CRIS-121, on these two varieties average population of thrips was observed, while group "E" includes single variety Marvi (CRIS-5A), this variety showed the maximum resistance due to less infestation by cotton thrips.

Mealybug (Phenacoccus solenopsis)

The resistivity of nine varieties of non-Bt., cotton was also checked against mealybug population, it appeared late in mid of the August as it did not appear during the early 4-5 weeks, the maximum number of mealybug was calculated on CRIS-121 (2.61), followed by Sindh-1 (1.67), CRIS-342 (153), Bakhtawar (1.40), CRIS-129 (1.31), CRIS-9 (0.56), Marvi (CRIS-5A) (0.46) and CRIS-467 (0.46), whereas; lowest mean population of mealybug was observed on CRIS-134 (0.43) as shown in (Fig. 4). The ANOVA of non-Bt., varieties showed the least significant difference in four groups (DF= 11, 8; F= 6.55; P= 0.001) against mealybug population, from which group "A" includes the CRIS-121, this variety showed least resistivity as maximum population of mealybug was observed on it, group "B" includes the three varieties, Sindh-1, CRIS-342 and Bakhtawar, on these three varieties considerable population of mealybug was observed, group "C" includes the two cotton varieties CRIS-129, CRIS-9, these two cotton varieties showed the moderate resistance against cotton mealybug as moderate population of mealybug was observed on these two cotton varieties, while group "D" includes the three cotton varieties Marvi (CRIS-5A), CRIS-467 and CRIS-134, these three varieties showed the good resistance among the tested varieties of cotton.

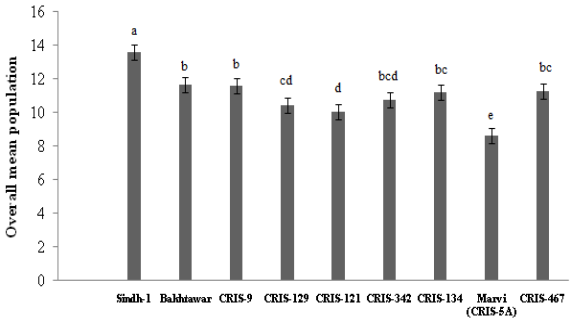

Fig. 3. Overall mean population of thrips on different non-Bt., varieties of cotton crop under field conditions during, 2018.

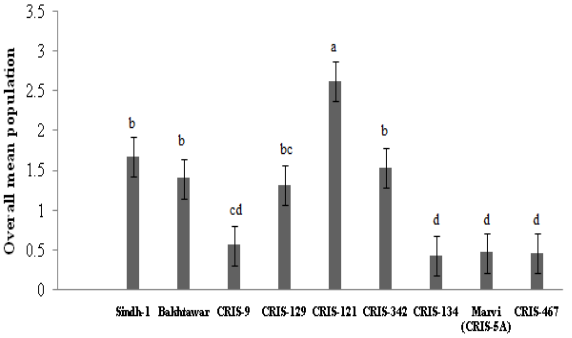

Fig. 4. Overall mean population of Mealybug on different non-Bt., varieties of cotton crop under field conditions during, 2018.

Overall pests

The overall resistivity of nine non-Bt., cotton varieties were calculated against various sucking pests; jassid, whitefly, thrips and mealybug (Fig. 5). It was found that cotton varieties Marvi (CRIS-5A) and CRIS-467 showed overall per leaf good resistance to mean population sucking complex (5.16) and (5.33) respectively, followed by CRIS-129 (5.75), CRIS-121 (5.84), whereas; CRIS-9 (6.05), CRIS-134 (6.20) and Bakhtawar (6.26) showed average resistivity against sucking complex, while cotton varieties Sindh-1 (7.04) and CRIS-342 (7.01) were found to be most infested non-Bt., varieties among the tested varieties and these were found less resistive and most vulnerable non-Bt., cotton varieties. The ANOVA shows the least significant difference among non-Bt., cotton varieties in four groups (DF= 11, 8; F= 21.45; P= 0.001) against overall sucking complex, of which group "A" of non-Bt., cotton varieties showed the least resistance, it includes the Sindh-1 and CRIS-342, on these two varieties maximum population of sucking complex was observed, group "B" includes the three cotton varieties, Bakhtawar, CRIS-134, CRIS-9, on these three varieties considerable population of sucking pests was observed, group "C" includes the two cotton varieties CRIS-121 and CRIS-129, on these two varieties, moderate sucking pests were observed, while group "D" includes two varieties of non-Bt., cotton, CRIS-467 and Marvi (CRIS-5A), these two showed the good resistance against overall four sucking insect pests of cotton crop as minimum sucking pests were observed on these two cotton varieties.

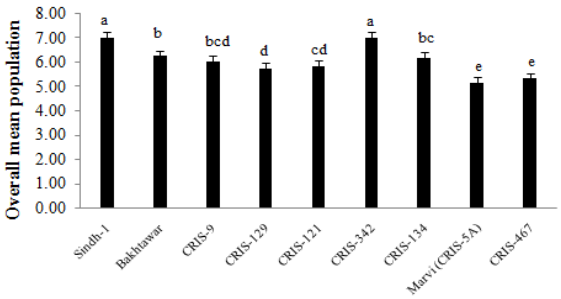

Fig. 5. Overall mean population of sucking pests on different Non-Bt., varieties of cotton crop under field conditions.

Weekly population fluctuation of sucking complex

The mean population of all the four sucking insect pests on nine non-Bt., cotton varieties was shown in (Fig. 6), in which it was indicated that throughout the season overall mean population of jassid was remained high than economic threshold level (ETL) and its per leaf peak population (4.17) was observed during the third week of August. The overall mean of whitefly population was observed below ETL in first two weeks of data collection then its population increased gradually from the last days of July and raised to reach at peak population (14.81) in the second week of September and then slowly declined but remained above the ETL till the harvesting of the crop. Similarly, the mean of thrips population was also observed on the various varieties of non-Bt., cotton crop, in the results its overall population was found below ETL in July then raised to the level of ETL and were found in maximum number (17.30) per leaf in the second week of September and thereafter slowly reduced but not below the ETL. The resistance of nine non-Bt., varieties of cotton was also observed against the mealybug population, it was not found on any of the nine non-Bt., cotton varieties till the first week of August, then its population raised day by day till the end of data collection or harvesting of the crop.

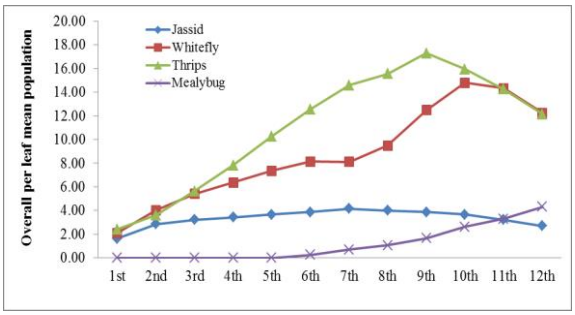

Fig. 6. Weekly infestation ratio of sucking complex on non-Bt., cotton varieties throughout the season during, 2018.

Discussion

In present research work nine varieties of non-Bt., cotton were checked against sucking insect pests population under field conditions, in which per leaf maximum population of jassid was observed on CRIS-9 (4.21), followed by Sindh-1 (4.16), CRIS-342 (4.00), Bakhtawar (3.35), CRIS-129 (3.35), CRIS-134 (3.34),

Marvi (CRIS-5A) (3.33) and CRIS-121 (2.30) while minimum number of jassid mean population was observed on CRIS-467 (2.22), which was found comparatively resistant to cotton jassid when compared with other tested varieties of non-Bt., cotton. Our findings are in resemblance with Khan *et al.,* (2011), Memon *et al.,* (2007) they also found per leaf a huge population of jassid on CRIS-9. Our findings are in similarity with Lanjar *et al.,* (2014) who found the highest population of jassid (3.59) per leaf on Sindh-1. Our results are in similarity with Ahmad *et al.,* (2004) who also reported the lowest population of jassid on CRIS-467; while dissimilarity with him, because he also reported the minimum population on CRIS-134. Our results are in analogy with Pathan *et al.,(* 2007) who found CRIS-467 as the most infested variety against jassid. Our findings are in similarity with Soomro *et al.,* (2000) who also reported the average population of jassid on cotton variety CRIS-134. Our results are in similarity with Lakho *et al.,* (2014) who also found an equal level of tolerance/infestation on CRIS-129 and CRIS-134. Our results are at little difference with Noonari *et al.,* (2015) and Abro *et al.,* (2004) who recorded per leaf highest and lowest jassid population on CRIS-134 respectively. Our results are in dissimilarity with Nizamani *et al.,* (2002) who observed the average resistance of CRIS-9, CRIS-121 and CRIS-129 against cotton jassid.

The infestation of whitefly was also observed on nine varieties of non-Bt., cotton, the highest per leaf mean of whitefly population was observed on CRIS-342 (11.74), followed by CRIS-134 (9.81), Sindh-1 (8.71), Bakhtawar (8.67), CRIS-121 (8.41), Marvi (CRIS-5A) (8.21), CRIS-129 (7.93) and CRIS-9 (7.83) while the lowest mean of whitefly population was observed on CRIS-467 (7.38), which was found most resistive against whiteflies among tested non-Bt., varieties of cotton. Our results are in little similarity with Lanjar *et al.,* (2014) who reported the highest attack of whitefly per leaf on Sindh-1. Our results are in analogy with Pathan *et al., (*2007) who found CRIS-467 as the most infested variety against whitefly. Our results are in analogy with Lakho *et al.,* (2014) who found equal level of tolerance/infestation on CRIS-129 and CRIS-134. Our results are in difference with Khan *et al., (*2011) who found a huge number of whitefly on cotton variety CRIS-9. The varietal resistance of nine non-Bt., cotton varieties was observed against thrips population, the maximum number of thrips were counted on Sindh-1 (13.60), followed by Bakhtawar (11.64), CRIS-9 (11.59), CRIS-467 (11.27), CRIS-134 (11.20), CRIS-342 (10.78), CRIS-129 (10.41) and CRIS-121 (10.04) while the lowest mean of thrips population was recorded on Marvi (CRIS-5A) (8.62), which was found most resistive against cotton thrips. Our results are in similarity with Lanjar *et al.,* (2014) who reported the maximum population of thrips (14.89) per plant on Sindh-1. Our findings are also in similarity with Pathan *et al.,* (2007) who found the maximum thrips population on CRIS-9 and found it relative resistant. Our results are in similarity with Lakho *et al.,* (2014) who also found equal level of tolerance/infestation on CRIS-129 and CRIS-134. Our results are in a little bit different from Khan *et al., (*2011) who found a good number of thrips on cotton variety CRIS-9. Our findings are in analogy with Soomro *et al.,* (2001) who recorded the maximum thrips population on CRIS-9. The resistivity of nine varieties of non-Bt., cotton was also checked against mealybug population, the maximum number of mealybugs was calculated on CRIS-121 (2.61), followed by Sindh-1 (1.67), CRIS-342 (153), Bakhtawar (1.40), CRIS-129 (1.31), CRIS-9 (0.56), Marvi (CRIS-5A) (0.46) and CRIS-467 (0.46), whereas; the lowest minimum mean of mealybug population was observed on CRIS-134 (0.43).

The overall resistivity of nine non-Bt., cotton varieties were calculated against various sucking pests; jassid, whitefly, thrips and mealybug. Among these it was found that cotton varieties Marvi (CRIS-5A) and CRIS-467 showed overall per leaf good resistance to mean population of sucking complex (5.16) and (5.33) respectively, followed by CRIS-129 (5.75), CRIS-121 (5.84), whereas; CRIS-9 (6.05), CRIS-134 (6.20) and Bakhtawar (6.26) showed average resistivity against sucking complex, while cotton varieties Sindh-1 (7.04) and CRIS-342 (7.01) were found to be most infested non-Bt., varieties among the tested varieties and these were found less resistive and most vulnerable

varieties of non-Bt., cotton. Our results are in resemblance with Khan *et al.,* (2011), who also found per leaf a huge population of jassid on CRIS-9. Our results are in similarity with Lakho *et al.,* (2014) who also found equal level of tolerance/infestation on CRIS-129 and CRIS-134. Our results are in analogy with Pathan *et al.,* (2007) who found CRIS-467 as the most infested variety against jassid.

The weekly population of overall all the four sucking pests on nine non-Bt., cotton varieties were checked, the result indicated the overall mean of jassid population was observed above ETL during the entire experimental season and its per leaf peak population (4.17) was recorded during the third week of August. Our results are in similarity with Saleem *et al.,* (2018), Lanjar *et al.,* (2014), Ashfaq *et al.,* (2010), Arshad and Suhail (2010), they all also found peak point of jassid population during the month of august but with little difference of the 2nd, 3rd or 4th week. Our outcomes are in dissimilarity with Asif *et al.,* (2017) who described that the population of jassid was at a peak in June. Our findings are in little bit similarity with Nizamani *et al.,* (2002) who described the peak population of jassid during the July and august month. Our results are in dissimilarity with Memon *et al.,* (2007), who observed the mean of jassid population at peak during the 2nd week of July, after that, the population of pest reduced slowly till the September. While the overall mean population of whitefly was observed below ETL in first two weeks of data collection then its population increased slowly from the end of July and raised to the peak (14.81) in the second week of September and then slowly declined but remained above the ETL till the harvesting of the crop. Our results are in analogy with Lanjar *et al.,* (2014) who found the mean of the whitefly population at peak during the July month. Our results are in dissimilarity with Saleem *et al.,* (2018), Asif *et al.,* (2017), Arshad and Suhail (2010), Inee and Dutta (2000) they reported peak of whitefly population during the august. Likewise, the mean of thrips population was also observed on the different non-Bt., varieties of cotton, in the findings its overall population was found below ETL in July then raised to the level of ETL and were found in maximum number (17.30) per leaf in the second week of September and thereafter slowly reduced but not below the ETL. Our findings are in analogy with Lanjar *et al.,* (2014), Asif *et al.,* (2017), Nizamani *et al.,* (2002), Leghari *et al.,* (2001) who recorded the peak of thrips population in July. Our results are in similarity with Inee and Dutta (2000), Arshad and Suhail (2010) they also described that thrips population reached at peak in August, further support in similar types of results by Abro *et al.* (2004) and Godhani *et al.* (2009). Our results are different from Saleem *et al.,* (2018) who found that thrips population was started to build up from the last week of June and attained the peak in 1st week of August and after that gradually declined. The resistance of non-Bt., cotton varieties (n=9) was also examined against the mealybug population, it was not found on any of the nine non-Bt., cotton varieties till the first week of August, then its population raised day by day till the end of data collection or harvesting of the crop. Our results are in resemblance with Sahito *et al.,* (2009) who also recorded the emergence of sucking insect pest, mealybug after the two months of cultivation of cotton crop and remained active till the harvesting of the crop.

Conclusion

It is concluded that among the resistance of nine non-Bt., cotton varieties (kept un-sprayed) the cotton varieties; Marvi (CRIS-5A) and CRIS-467 gave the better resistance against the sucking complex; jassid, whitefly, thrips and mealybug from seedling till its first picking. While cotton varieties Sindh-1 (7.04) and CRIS-342 (7.01) gave the least resistance and found to be the most infested varieties among the tested non-Bt., cotton varieties. So these varieties; Marvi (CRIS-5A) and CRIS-467 should be cultivated for better production of cotton. The current results may be supportive in the selection of a better variety of cotton at the time of cultivation because varietal resistance is a suitable and environment-friendly tool for the management of sucking complex.

References

Abro GH, Syed TS, Tunio GM, Khuhro MA. 2004. Performance of Transgenic Bt Cotton Against Insect Pest Infestation. Biotechnology **3(1),** 75-81. http://docsdrive.com/pdfs/ansinet/biotech/2004

Afzal M, Bashir MH. 2007. Influence of certain leaf characters of some summer vegetables with incidence of predatory mites of the family Cunaxidae. Pakistan Journal of Botany **39,** 205-209. http://www.pakbs.org/pjbot/PDFs/39(1)/PJB39(1)2

Ahmad M, Arif MI, Ahmad Z, Denholm I. 2002. Cotton whitefly (*Bemisia tabaci*) resistance to organophosphate and pyrethroid insecticides in Pakistan. Pest Management Science **58,** 203-208. https://doi.org/10.1002/ps.440

Ahmad N, Khan MH, Tofique M. 2011. Insect pests management of Bt cotton through the manipulation of different eco-friendly techniques. The Nucleus, **48(3),** 249-254. https://inis.iaea.org

Ahmad S, Shah M, Farooq HMK, Ullah F. 2004. Resistance of cotton against *Amrasca devastans* (Dist.) (Jassidae : Homoptera) and relationship of the insect with leaf hair density and leaf hair length. Sarhad Journal of Agriculture **20(2),** 265-268. http://agris.fao.org/agris-search/search.do?recordID

Arif MI, Rafiq M, Ghaffar A. 2009. Host plants of cotton mealybug (*Phenacoccus solenopsis*): a new menace to cotton agroecosystem of Punjab. International Journal of Agriculture and Biology **11,** 163-167. https://www.cabi.org/isc/FullTextPDF

Arshad M, Suhail A. 2010. Studying the sucking insect pests community in transgenic Bt., cotton. International Journal of Agriculture and Biology **12,** 764-768. https://www.cabdirect.org/cabdirect

Ashfaq M, ul-Ane MN, Zia K, Nasreen A. 2010. The correlation of abiotic factors and physico-morphic characteristics of Bt (*Bacillus thuringiensis*) transgenic cotton with whitefly, *Bemisia tabaci* (Homoptera: Aleyrodidae) and jassid, *Amrasca devastans* (Homoptera: Jassidae) populations. African Journal of Agriculture Reserach **5(22),** 3103-3107. https://academicjournals.org/journal /AJAR/ article-full-text-pdf/F83B2C140198

Asif MU, Muhammad R, Akbar W, Toufique M. 2017. Response of various cotton genotypes against sucking and bollworm complexes. Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences **33(1),** 37-45. https:// pjaaevs. sau.edu.pk/index.php/ojs/article/view/81

Cook D, Herbert A, Akin DS, Reed J. 2011. Biology, crop injury, and management of thrips (Thysanoptera: Thripidae) infesting cotton seedlings in the United States. Journal of Integrated Pest Management **2(2),** B1-B9. https://doi.org/10.1603 /IPM10024.

Godhani PH, Patel RM, Jani JJ, Yadav DN, Korat DM, Patel BH. 2009. Impact of habitat manipulation on insect pests and their natural enemies in hybrid cotton. Karnataka Journal of Agriculture Sciences **22(1),** 104-107. https:// www.cabdirect.org/cabdirect/abstract/20093147180

Hassan M, Ahmad F, Wakeel W. 2000. Role of biochemical components in varietal resistance of cotton against sucking insect pests. Pakistan Entomologist **22,** 69-72. https://www. cabdirect. org/cabdirect/abstract/20053117168

Huque H. 1994. Insect pests of fibre crops. In: Insect pest management, cereal and cash crops (ed. A.A. Hashmi). Pakistan Agricultural Research Council, Islamabad, Pakistan **1,** 193-260.

Inee G, Dutta BC. 2000. Seasonal abundance of cotton jassid, *Amrasca biguttula biguttula* Ishida on okra. Journal of Agriculture Science **13(1),** 22-26. https://www.cabdirect.org/cabdirect/abstract/20013

Khan MA, Khaliq A, Subhani MN, Saleem MW. 2008. Incidence and development of *Thrips tabaci* and *Tetranychus urticae* on field-grown cotton. International Journal of Agriculture Biology **10,** 232-234.

Khan MT, Naeem M, Akram M. 2003. Studies on the varietal resistance of cotton against insect pest complex of cotton. Sarhad Journal of Agriculture **19,** 93-96. http://agris.fao.org/agris-search/search.do

Khan SM. 2011. Varietal performance and chemical control used as tactics against sucking insect pests of cotton. Sarhad Journal of Agriculture **27(2),** 255-261.

Lakho AR, Majidano MS, Bhutto H, Ahsan MZ, Kalhoro AD. 2014. Evolution of Early Maturing, High Yielding and High Got Upland Cotton Variety Cris-129. European Academic Research **2(8),** 10833-10848.

Lanjar AG, Solangi BK, Khuhro SA, Solangi AW. 2014. Insect Infestation on Bt. and Non-Bt. Cotton Cultivars. Food Science and Quality Management **27,** 55-62.

Leghari MA, Kalroo AM, Laghari AB. 2001. Studies on Host Plant Resistance to Evaluate the Tolerance/Susceptibility Against Cotton Pests. Pakistan Journal of Biological Sciences **4(12),** 1506-1508. http://www.docsdrive.com/pdfs/ansinet

Memon AA, Chang MS, Tunio GM. 2007. Response of newly developed high yielding and early maturing cotton strains against population of jassid, *Amrasca devastans* Dist. Pakistan Journal of Agriculture, Agricultural Engineering and Veterinary Sciences **23(1),** 31-33. http://agris.fao.org/agris-search/search.do?recordID=PK2008000102

Miller DR, Williams DJ. 1997. A new species of mealybug in the genus Pseudococcus (Homoptera: Pseudococcidae) of quarantine importance. Proceedings of the Entomological Society of Washington **99,** 305-311.

Nelson MR, Nadeem A, Ahmad W, Orum TV. 1998. Global assessment of cotton viral diseases. pp.161-162. *In* Proc. Beltwide Cotton Conf., San Diego, CA. 5-9 Jan.,1998. http://agris.fao.org/agris-search/search.do?recordID=US1999007111

Nizamani IA, Talpur MA, Khuhro RD, Nizamani SM. 2002. Relative resistance of cotton cultivars to sucking complex. Pakistan Journal of Applied Sciences **2(6),** 686-689. http://www. docsdrive. com/pdfs/ansinet/jas/2002/686-689.pdf

Noonari AM, Abro GH, Sahito HA, Khuhro RD, Buriro AS. 2015. Screening of cotton varieties under field conditions of lower Sindh, Pakistan. Pakistan Journal of Entomology **30(1),** 15-20.

Oliveira MRV, Henneberry TJ, Anderson P. 2001. History, current status, and collaborative research projects for *Bemisia tabaci*. Crop Protection **20,** 709-723. https://doi.org/10.1016/S0261-2194(01)

Pakistan Central Cotton Committee. 2018. Cotistics: Annual Cotton Statistical Bulletin. Ministry of National Food Security and Research. Government of Pakistan. http://www.pccc.gov.pk/pdf%20files /Cotistics%202018.pdf.

Pakistan Economic Survey. 2015. Agricultural Statistics of Pakistan, Govt. of Pakistan. Ministry of Food Agriculture and Livestock, Economic Wing, Finance Division, Islamabad, Pakistan. http://www.finance.gov.pk/survey/chapters_15/02_Agricultre.pdf

Pathan AK, Chohan S, Leghari MA, Chandio AS, Sajjad A. 2007. Comparative resistance of different cotton genotypes against insect pest complex of cotton. Sarhad Journal of Agriculture **23(1),** 141-143.

Sahito HA, Abro GH, Khuhro RD, Buriro AS. 2009. Varietal resistance of cotton crop against mealybug, *Phenacoccus solenopsis* Tinsley. Pakistan Journal of Agriculture Engineering and Veterinary Sciences (Pakistan). http://agris.fao.org/agris-search/search.do?recordID=PK2010000788

Saleem MJ, Hafeez F, Arshad M, Atta B, Maan NA, Ayub MA, Zubair M. 2018. Population Dynamics of Sucking Pests on Transgenic Bt., Cotton in Relation with Abiotic Factors and Physio-Morphological Plant Characters. Journal of Entomology and Zoological Studies **6(6),** 163-166.

Shad SA, Akram W, Abrar R. 2001. Relative response of different cultivars of cotton to sucking insect pests at Faisalabad. Pakistan Entomologist **23(1/2),** 79-81.

Soomro AR, Anjum R, Mallah GH, Leghari MA. 2001. Host Plant Resistance To Insects In Cotton At Central Cotton Research Institute, Sakrand Sindh Pakistan. Pakistan Journal of Botany **33,** 641-645. http://www.pakbs.org/pjbot/PDFs/33(SI)/PJB33(SI)22.pdf

Soomro AR, Soomro K, Soomro AW, Soomro AH, Mallah GH, Panhwar GN, Kalhoro AD. 2000. Progress with Varietal Development at CCRI, Sakrand Sindh. Pakistan Journal of Biological Sciences **3(3),** 466-468. http://docsdrive.com/pdfs/ansinet /pjbs/2000/466-468.pdf