Food Science and Quality Management
ISSN 2224-6088 (Paper) ISSN 2225-0557 (Online)
Vol.27, 2014

Insect Infestation on Bt. and Non-Bt. Cotton Cultivars

Abdul Ghani Lanjar, Bhai Khan Solangi, Sajjad Ali Khuhro* and Abdul Waheed Solangi
Department Of Entomology, Sindh Agriculture University Tandojam
*Corresponding Author: SAJJAD ALI KHUHRO Email: sajjadento.sau@gmail.com

Abstract
A field study was carried out to examine the resistance potential of promising cotton cultivars to insect pest infestation, during the year 2012. Five cotton varieties were examined for their resistance against insect pests including Hari Dost, Shahbaz-95, NIAB-78, Sindh-1 and Bt Cotton. The insect pests monitored in this study included thrips, jassid, whitefly and bollworms. The experimental process for monitoring the insect pests was initiated on 15th June 2012 and lasted on 12th October, 2012. The results showed that thrips population was significantly (P<0.01) lowest (6.28/plant) on Haridost, against 9.22/plant on NIAB-78, 13.79/plant on Bt cotton 14.89/plant on Sindh-1. while the highest thrips population (15.21/plant) was recorded on Shahbaz-95. The peak thrips population was noted on 12th July observation on all three verities while on Bt cotton, the peak thrips population was recorded on 19th July. Bt Cotton. The peak activities of jassid was recorded in the month of August. Overall mean showed that the signifactly highest (P<0.01) population of jassid was recorded as (3.59/leaf) on Sindh1 followed by Bt cotton (2.81/leaf), Shahbaz (2.80/leaf), Niab -78 (2.19/leaf) and Hari dost (1.63/leaf). Similarly, whitefly was found active in month of July and Augest. Significantly, more population (P<0.01) was recorded on Sindh-1 (3.20/leaf) and minimum on Haridost (1.40/leaf). Bollworms infestation was significantly lowest (P<0.01), (2.04/plant) on Bt cotton against 2.56/plant on NIAB-78, 3.04/plant on Haridost, 3.22/plant on Sindh-1; while the highest bollworms population (3.36/plant) was observed on cotton variety Shahbaz-95. Bt cotton variety showed considerable resistance against bollworm complex, while NIAB-78 also showed some resistance against sucking. The infestation of sucking insect pests on haridost. Shahbaz and Sindh-1 as compared to Bt cotton. The infestation of thrips, and whitefly was peaked in the month of July. While Jassid was found most active in August. Bollworms appeared in first week of July and remained active in the field in relatively higher population upto the mid of September and later decreased to negligible level.
Keywords: Cultivar Resistance, Insect Infestation

INTRODUCTION

Cotton, *Gossypium hirsutum* is a natural fibre of great economic importance as a raw material for cloth; and is predominantly cultivated in most of the cotton producing countries of the world including Pakistan (Aiken, 2006). Botanically, there are three principal groups of cotton that are of commercial importance. The first, is native to Mexico and Central America and has been developed for extensive use. The production is reported at 13.6 million bales, higher by 18.6 percent over the last year's production which was 11.5 million bales. The increase in cultivated area and production is attributed to the use of Bt cotton, control over wide spread attack of leaf curl virus and sucking pests (GoP, 2012). Cotton crop is attacked by many insect pests. Generally, the insect pests of cotton are controlled by chemical pesticides (Noonari *et al.,* 1994), which include termite, *Microtermes obesi*; cutworm, *Agrotis ipsilon*; thrips, *Thrips tabaci*; jassid, *Amrasca biguttula biguttula*; whitefly, *Bemisia tabaci*; aphid, *Aphis gossypii*; leaf-roller, *Sylepta derogate*; red cotton bug, *Dyesdercus koenigii*; mite, *Tetranychus macfarlanei*; grey weevil, *Myllocerus undecimpustuletus maculosus*; spotted bollworm, *Earias insulana*; pink bollworm, *Pectinophora gossypiella* and American bollworm, *Helicoverpa armigera* (Dhaka and Pareek, 2007); the insect pests infestation caused deterioration in lint quality and 10–40% losses in crop production (Gahukar, 2006). The insect pests that cause serious damage to cotton every year include whitefly, thrips, jassid, aphid, and bollworms. Whitefly is small insect having four white membranous wings, and both nymphs and adults suck the sap from plants, reducing the vitality and yield of the crop. The nymphs secrete honeydew which promotes the growth of sooty mould (Jech and Husman, 1998). Similarly, is also a tinny insect and both adults and nymphs cause damage to cotton leaves by sucking plant sap and inject toxic saliva into plant tissues. Due to that the edges of leaves become crinkling, which is the characteristic feature of jassid attack (Bhatti and Soomro, 1996). Spotted bollworm is another major insect pest of cotton and its larvae bore inside the buds, flowers and fruits and cause heavy losses by destroying the quality and quantity of fruits (Kaur, 2002). Plant varieties having more spiny hairs on the leaves are liked less by the females for egg laying. Eggs hatch within 3-9 days in okra season (Khan *et al.,* 2003). Singh and Simwat (1998) and Singh *et al.* (1996) studied comparative resistance in different varieties against *Earias spp*., whereas resistance in cotton cultivars against *Helicoverpa armigera* has been evaluated in the past by (Jin *et al.,*1999). Resistance against pink bollworm on cotton cultivars has also been studied (Jin *et al.,* 1999). The newly released cultivars require thorough evaluation for insect pests. This step is considered important and necessary in development of improved and resistance cultivars (Ahmad *et al.,* 2003; Razaq *et al.,* 2004). There are different pest control tactics, in which varietal resistance plays an important role,

as resistant varieties can easily control insect pests without insecticide application (Khan *et al.,* 2003). The crystalline proteins of Bt Kurstaki are active against many lepidopterous larvae when ingested. In susceptible insects, gut paralysis and cessation of feeding occur within minutes after ingestion of the delta endo toxin protein and ultimately death occurs within 3-4 days (Halcomb *et al.,* 1996). The development and introduction of Bt cotton has reduced the pesticide use at the farm level in both the developed and developing countries (Qaim and Zilberman, 2003; Nazli *et al.,* 2010). The present study was carried out to evaluate relative resistance of cross BT cotton varieties against sucking complex.

MATERIALS AND METHODS

The study the resistance potential of promising cotton cultivars to insect pest infestation. The experiment was conducted in the experimental field of Sindh Agriculture University, Tandojam during kharif season of 2012. The cotton cultivars examined for their resistance potential against insect pests such as Hari Dost, Shahbaz-95, NIAB-78, Sindh-1 and Bt Cotton. Following the recommendations regarding the land preparation, the experimental land was ploughed up by cross-wise disc plough. After soaking dose, when the land came in condition, the seedbed was prepared by using cross-wise cultivator followed by rotavator. The clods were crushed completely by clod crusher followed by planking. Sowing of experimental crop was done on 28th April, 2012 by means of single coulter hand drill in rows. All the four varieties were sown in three replicates and channels and bunds were prepared to facilitate the irrigation process and further monitoring of the crop against any pest problem. The plot size was kept as 7.5 ft x 18.0 ft. The experimental cotton crop was surveyed daily for the appearance of the insect-pests. Afterwards, it was visited after an interval of week's time when the picking of the cotton crop started and the presence of insect pests could no longer do it an economic injury. Fifteen plants were selected, at random, per treatment/plot for recording pest population. The observation on the infestation of various insect pests was made on whole plant basis. The data which were based on the average counts of the pest per plant were considered to be an indirect reflection of pest-resistance in plants, under reference. The varietal resistance was decided at the time of a maximum insect-pest activity i.e. at the end of the 8th week. The data on the overall as well as on the individual population of each sucking insect-pest species will be presented through a multiple comparison of the mean values. The means was separated by DMR test (P=0.05).

RESULTS

In order to examine the resistance potential of promising cotton cultivars to insect pest infestation, the study was carried out during the year 2012. Five cotton varieties including and Bt cotton variety were tested which included Hari Dost, Shahbaz-95, NIAB-78, Sindh-1 and Bt Cotton to investigate their resistance potential against the insect pests. The experimental process for monitoring the insect pests was initiated on 15th June 2012 and lasted on 12th October, 2012.

Thrips *Thrips tabaci*

Thrips is one of the major insect pest of cotton and considerable damage to cotton crop is caused by this insect. The data (Table-1) showed that statistically the thrips population varied significantly between varieties (F=4058.42, P=0.0000, DF=4), between observation dates (F=28741.90, P=0.0000, DF=17) as well as their interaction (F=766.78, P=0.0000, DF=68). Thrips population was significantly lowest (6.28/plant) on Bt cotton against 9.22/plant on NIAB-78, 13.79/plant on Haridost, 14.89/plant on Sindh-1; while the highest thrips population (15.21/plant) was recorded on cotton variety Shahbaz-95. On varieties Haridost, Shahbaz-95, NIAB-78 and Sindh-1, the peak thrips population was monitored on 12th July observation; while on Bt cotton, the peak thrips population was seen on 19th July. It was observed that Bt cotton variety showed considerable resistance to thrips infestation; while NIAB-78 also found to be resistant to thrips to some extent. However, cotton variety Shahbaz-95 could not show desirable resistance against thrips infestation as displayed by Bt cotton. It was further noted that thrips population was already present on cotton when insect monitoring was started on 15th June, and the insect population persistently increased reaching its peak level (69.07/plant) on 12th July and then started decreasing. However, the thrips population remained at minor level from 2nd August onwards and reaching to its minimum population (1.14/plant) on 5th October. Regardless the cotton varieties, thrips population followed a sharp decline in August onwards. The data further suggested that thrips population increased markedly in July and throughout the month of July thrips remained active in high population; probably due to increasing temperature and humidity, the insect buildup was enhanced. However, temperature in August is generally moderate and thrips population is simultaneously declined with decrease in the temperature.

Table-1 Resistance potential of different cotton varieties against thrips per leaf.

Obs. Date	Bt Cotton	Shahbaz-95	NIAB-78	Sindh-1	Haridost	Mean
15.6.12	4.81	4.81	1.04	4.73	0.46	3.17 h
21.6.12	5.01	4.92	1.10	5.54	1.28	3.57 h
28.6.12	6.87	5.74	6.25	7.78	1.48	5.62 f
05.7.12	32.71	34.16	10.55	30.14	16.62	24.84 c
12.7.12	70.11	87.98	61.87	92.16	33.25	69.07 a
19.7.12	57.47	76.81	41.54	73.86	35.29	56.99 b
26.7.12	24.44	34.16	11.57	26.76	8.81	21.15 d
02.8.12	12.73	12.44	12.39	6.76	3.38	9.54 e
09.8.12	8.53	2.69	5.23	5.94	2.29	4.94 g
16.8.12	6.87	2.08	2.71	4.35	1.48	3.50 h
23.8.12	2.74	0.61	1.28	1.88	1.14	1.53 i
30.8.12	2.74	0.51	1.57	0.73	1.26	1.36 i
07.9.12	3.15	0.41	1.55	0.79	0.79	1.34 i
14.9.12	2.65	0.91	1.45	1.27	0.46	1.35 i
21.9.12	2.15	1.27	2.19	1.57	1.69	1.77 i
28.9.12	1.71	1.14	2.50	1.14	0.84	1.46 i
5.10.12	1.91	0.66	0.77	1.18	1.16	1.14 i
12.10.12	1.59	2.56	0.32	1.36	1.38	1.44 i
Mean	13.79 c	15.21 a	9.22 d	14.89 b	6.28 e	11.88

	Varieties (V)	Obs. Dates (D)	V x D
S.E.±	0.0876	0.1661	0.3715
LSD 0.05	0.1728	0.3278	0.7331
LSD 0.01	0.2280	0.4326	0.9672
CV%	13.83		

Jassid *Amrasca biguttula biguttula*

Jassid is also one of the major sucking pests of cotton and this insect ravages cotton crop heavily. The data (Table-2) indicated that statistically the jassid population differed significantly between varieties (F=1155.35, P=0.0000, DF=4), between observation dates (F=2938.88, P=0.0000, DF=17) as well as their interaction (F=75.16, P=0.0000, DF=68). Jassid population was significantly lowest (1.63/plant) on Bt cotton against 2.19/plant on NIAB-78, 13.79/plant on Haridost, 14.89/plant on Sindh-1; while the highest jassid population (15.21/plant) was recorded on cotton variety Shahbaz-95. The peak jassid population on all the varieties examined was noted at 12th July observation. Although, none of the cotton varieties examined in this study was completely immune to the jassid infestation; but Bt cotton demonstrated relative resistant to jassid infestation. However, the highest jassid infestation on average was observed on variety Sindh-1. The data in regards to seasonal jassid population dynamics on cotton varieties indicated that initially on 15th June when the insect pest monitoring was started, the jassid population was lower which started buildup gradually and reached to peak infestation level of 8.74/plant and later started decreasing steadily. However, jassid remained active in the field regardless the varieties throughout the cotton growing season; but its population was probably below the economic injury level after 16th August observation. The jassid population increased markedly in middle of July and started lowering its population in August. The findings clearly suggested that the climate with high temperature and humidity favours the population buildup of jassid because July is the hottest month in cotton growing season when the insect population was at peak.

Table-2 Resistance potential of different cotton varieties against jassid per leaf

Obs. Date	Bt Cotton	Shahbaz-95	NIAB-78	Sindh-1	Haridost	Mean
15.6.12	2.18	1.24	1.21	3.06	0.61	1.66 h
21.6.12	2.19	1.67	1.44	2.90	0.37	1.71 h
28.6.12	2.43	2.18	1.88	2.60	1.27	2.07 g
05.7.12	4.67	4.57	2.37	5.06	2.39	3.81 d
12.7.12	10.45	9.26	7.82	11.44	4.74	8.74 a
19.7.12	6.84	7.56	6.25	8.79	3.72	6.63 b
26.7.12	6.08	7.09	4.58	7.57	3.31	5.73 c
02.8.12	2.19	3.30	2.56	3.71	1.59	2.67 e
09.8.12	2.38	2.48	2.74	3.09	1.51	2.44 f
16.8.12	2.23	2.78	2.41	2.70	2.02	2.43 f
23.8.12	1.17	0.73	1.04	1.61	1.99	1.31 i
30.8.12	1.11	0.81	1.14	1.91	1.09	1.21 i
07.9.12	1.20	0.14	1.15	1.68	1.00	1.03 j
14.9.12	1.06	0.89	1.17	2.01	0.79	1.19 i
21.9.12	0.99	1.33	0.12	1.81	0.67	0.99 j
28.9.12	1.01	1.41	0.61	1.71	0.48	1.04 j
5.10.12	1.16	1.46	0.92	1.44	0.90	1.18 i
12.10.12	1.22	1.56	0.09	1.55	0.90	1.06 j
Mean	2.81 b	2.80 b	2.19 c	3.59 a	1.63 d	2.61

	Varieties (V)	Obs. Dates (D)	V x D
S.E.±	0.0307	0.0582	0.1302
LSD 0.05	0.0605	0.1149	0.2569
LSD 0.01	0.0799	0.1516	0.3389
CV%	16.12		

Whitefly *Bemisia tabaci*

Whitefly is considered to be the most devastating insect pest of cotton that causes heavy losses to cotton crop. Moreover, whitefly has been detected as the vector species to develop cotton leaf curl virus disease. The data (Table-3) showed that whitefly population significantly varied on different cotton varieties (F=5945.93, P=0.0000, DF=4), between observation dates (F=6648.20, P=0.0000, DF=17) as well as their interaction (F=181.21, P=0.0000, DF=68). The population of whitefly was significantly minimum (1.40/plant) on Bt cotton against 2.19/plant on NIAB-78, 13.79/plant on Haridost, 14.89/plant on Sindh-1; while the higher whitefly population was recorded on cotton varieties Shahbaz-95 (3.21/plant) and Sindh-1 (3.20/plant). The peak whitefly population on all the varieties examined was noted at 26th July observation. It is obvious that none of the tested cotton varieties were completely immune of the whitefly infestation; but Bt cotton revealed resistant to whitefly infestation. However, Haridost, Shahbaz-95, NIAB-78 and Sindh-1 showed similarity in regards to their resistance to whitefly infestation. The seasonal whitefly infestation indicated that initially at first monitoring on 15th June, the whitefly population was already existed but in minor population; and after every week of observation, there was gradual increase in whitefly buildup reaching its peak level of 5.47/plant on 26th July and later decrease in the population was observed. However, whitefly dynamics were noticed in cotton field throughout its growing period, but from 1st September onwards the population was negligible. During grand growth period of cotton, particularly in July, the whitefly population showed its peak level of infestation and under moderate temperature, the whitefly population came down.

Table-3 Resistance potential of different cotton varieties against whitefly per leaf

Obs. Date	Bt Cotton	Shahbaz-95	NIAB-78	Sindh-1	Haridost	Mean
15.6.12	1.36	0.46	1.17	2.18	0.69	1.17 n
21.6.12	1.71	0.96	1.24	2.01	0.86	1.35 l
28.6.12	1.81	1.71	1.70	2.79	0.91	1.78 k
05.7.12	4.00	3.31	3.32	4.20	2.01	3.37 e
12.7.12	5.85	6.14	4.99	5.99	2.94	5.18 c
19.7.12	5.93	6.75	4.54	6.05	2.98	5.25 b
26.7.12	6.03	7.09	4.99	6.19	3.03	5.47 a
02.8.12	3.66	4.75	3.11	4.64	1.84	3.60 d
09.8.12	3.38	4.42	2.94	4.19	1.70	3.33 e
16.8.12	3.12	4.28	2.84	3.93	1.57	3.15 f
23.8.12	2.71	3.50	2.40	1.83	1.36	2.36 g
30.8.12	2.35	3.20	2.46	2.16	1.18	2.27 h
07.9.12	2.16	3.06	2.05	1.95	1.09	2.06 i
14.9.12	1.94	2.78	2.02	2.20	0.98	1.98 j
21.9.12	1.05	1.67	1.27	2.07	0.53	1.32 l
28.9.12	0.98	1.27	1.03	1.65	0.49	1.08 n
5.10.12	1.59	1.47	0.66	1.99	0.80	1.30 l
12.10.12	0.67	0.92	0.10	1.68	0.34	0.74 o
Mean	2.79 b	3.21 a	2.38 c	3.20 a	1.40 d	2.60

	Varieties (V)	Obs. Dates (D)	V x D
S.E.±	0.0138	0.0261	0.0584
LSD 0.05	0.0271	0.0515	0.1152
LSD 0.01	0.0358	0.0680	0.1520
CV%	12.75		

Bollworms *Earias* spp.

Bollworms generally attack cotton bolls and generally appear in the field later than the sucking complex. The data (Table-4) indicated that bollworms population significantly varied on different cotton varieties (F=428.08, P=0.0000, DF=4), between observation dates (F=3066.09, P=0.0000, DF=17) as well as their interaction (F=37.93, P=0.0000, DF=68). It was observed that bollworms population was lowest (2.04/plant) on Bt cotton against 2.56/plant on NIAB-78, 3.04/plant on Haridost, 3.22/plant on Sindh-1; while the highest bollworms population (3.36/plant) was observed on cotton variety Shahbaz-95. The peak bollworms population on all the varieties examined was noted at 23rd August observation. Not a single cotton variety examined in this experiment was found to be completely immune of the bollworms infestation; but Bt cotton exposed resistance to bollworms complex; while Haridost, Shahbaz-95 and Sindh-1 more infested than varieties NIAB-78 and Bt Cotton. The seasonal population fluctuation indicated that bollworms appeared in the cotton field in the month of July and they steadily established their population reaching peak level of 7.82/plant on 23rd August and later declined. This indicates that month of August is particularly known for development of bolls and with the development of fruiting bodies, the bollworms become active. It was observed that after 21st September onwards, the bollworm population decreased to lowest and negligible. It was further observed that newly developed cotton bolls are more attractive to be ravaged by the bollworm complex as compared to mature and older un open bolls.

Table-4 Resistance potential of different cotton varieties against *Earias* spp.

Obs. Date	Haridost	Shahbaz-95	Niab-78	Sindh-1	BtCotton	Mean
15.6.12	0.00	0.00	0.00	0.00	0.00	0.00 n
21.6.12	0.00	0.00	0.00	0.00	0.00	0.00 n
28.6.12	0.00	0.00	0.00	0.00	0.19	0.04 m
05.7.12	0.26	0.27	0.25	0.44	0.29	0.30 l
12.7.12	1.30	1.36	1.26	1.55	0.46	1.19 j
19.7.12	1.91	1.99	1.85	2.03	2.02	1.96 h
26.7.12	2.53	2.64	2.45	2.63	2.02	2.45 g
02.8.12	6.67	6.94	5.44	7.92	4.12	6.22 d
09.8.12	6.76	8.07	5.57	7.65	4.23	6.46 c
16.8.12	8.25	8.59	7.02	8.89	5.11	7.57 b
23.8.12	8.73	9.09	7.10	9.21	4.97	7.82 a
30.8.12	6.67	6.94	5.37	7.48	3.72	6.03 e
07.9.12	3.57	3.71	3.09	3.97	3.03	3.47 f
14.9.12	3.35	3.49	3.08	3.69	2.89	3.30 f
21.9.12	1.30	1.36	1.26	1.43	1.04	1.28 i
28.9.12	1.71	1.78	1.53	1.70	1.07	1.56 i
5.10.12	0.90	0.94	0.25	1.00	0.86	0.79 k
12.10.12	0.80	0.83	0.48	0.91	0.66	0.73 k
Mean	3.04 c	3.22 b	2.56 d	3.36 a	2.04 e	2.84

	Varieties (V)	Obs. Dates (D)	V x D
S.E.±	0.0371	0.0704	0.1575
LSD 0.05	0.0733	0.1390	0.3108
LSD 0.01	0.0967	0.1834	0.4101
CV%	11.79		

DISCUSSION

Insect pests have always been a threat for this “white gold” agricultural product of Pakistan, but apart from various insect pest control strategies, development of insect pest resistant cotton varieties is considered as the major achievement of research in agriculture. Singh and Lal (1996) reported that cotton varieties may respond differently to insect infestation and cultivation varieties resistant to insect pests could play effective role to combat insect pests biologically. In the present study, thrips population was significantly lowest on Bt cotton as compared NIAB-78, Haridost, on Sindh-1; while the highest thrips population was recorded on cotton variety Shahbaz-95. On varieties Haridost, Shahbaz-95, NIAB-78 and Sindh-1, the peak thrips population was noted on 12th July observation; while on Bt cotton, the peak thrips population was seen on 19th July. Bt Cotton. These results are further supported by Syed (2005) NIAB-78 and FH-901 were found to be relatively tolerant to thrips as compared to rest of the varieties tested. Varieties CIM-499, TH-57/96, FH-901 and CIM-473 showed considerable tolerance against whitefly as compared to other varieties. In a recent study, Hullio (2013) found that thrips population was significantly higher most of the varieties. However, Fairbanks *et al*. (1999) found cultivar BG-4740 most susceptible cotton cultivar with 106.1/plant, while cultivar ST-373 38.9/plant and such population is extremely on higher side, probably depends upon the climatic conditions of that particular area. However, Fairbanks *et al*. (2000) found thrips population of 40 and 47/5 plants, while Murugan and Uthamasamy (2001) have reported maximum population of 2.44/leaf from India on cultivar Paiyur, while population was 1.51/leaf and 1.48/leaf on cultivars LRK and S16, respectively. In Pakistan, Muhammad *et al*. (2004) reported cotton cultivars CIM-473, BH-147 and FNH-945 relatively resistant to sucking complex with average thrips population of 3.1/leaf. Similar results have been reported by Syed (2005) who found that variety Shahbaz was found to have greater relative resistance against jassid as compared to rest of the varieties. The population of jassid and relative resistance of different cotton varieties observed in the present investigation was in concurrence to those of Gupta *et al*. (1997) who reported peak population of jassid in last week of July, while Vennila (1998) reported that hybrid cotton harboured more number of jassid (4.85/plant) as compared to mutants. Dillon *et al*. (1999) recorded jassid population of 5.73 nymphs/leaf on cotton variety B-1007, while Khan *et al*. (2003) found Ravi as the most resistant cotton cultivar with mean jassid population of 1.27/leaf. Muhammad *et al*. (2004) found maximum (1.7/leaf) population of jassid on cotton variety CIM-473. The findings are also agreed Syed (2005) who reported that CIM-499, TH-57/96, FH-901 and CIM-473 showed considerable tolerance against whitefly as compared to other varieties. The varieties Shahbaz and NIAB-78 were found less resistant varieties against whitefly. Simwat and Dhawan (1995) reported abundance of adults of whitefly in the morning, while Kular and Butter (1999) recorded lowest population on cotton cultivar F-414 (47.5 adults/3 leaves) which is quite higher as

compared to the population recorded in this study. However, Murugan and Uthamasamy (2001) found whitefly population of 2.44/leaf on cultivar MCU-9, 1,79/leaf on cultivar Paiyur which are well comparable to the results of the present investigation. Likewise, Khan *et al*. (2003) found highest population of whitefly (7.86/plant) on varieties CIM, BH-147 and FNH-945 on average. However, Muhammad *et al*. (2004) reported whitefly population of only 0.5/leaf on cotton cultivar BH-121 and CRIS-467 on average. In a recent study, Hullio (2013) indicated whitefly population was significantly higher (2.7144/ plant) on Bt cotton FH Bt.1000 against 2.5778/plant on check variety NIAB-78, while whitefly population on variety Bt.886 was 2.56/plant. However, the lowest whitefly population of 2.3533/plant was recorded on variety Bt.3701. These results are further confirmed by Murugan and Uthamasamy (2001) who found that cotton varieties of diversified origin may response differently to insect pests, particularly to bollworm complex. In this study Bt cotton showed considerable resistance against thrips, jassid, whitefly and bollworm complex, while NIAB-78 also showed some resistance against these insect pests. The infestation of thrips, jassid and whitefly was at peak in the month of July and infestation decreased in August onwards; while bollworms appeared in first week of July and remained active in the field in relatively higher population upto the mid of September and later decreased to negligible level. The study of Hullio (2013) concludes that all the Bt cotton varieties as well as check variety NIAB-78 were infested by the sucking complex throughout the cotton growing season. Bt cotton variety Bt.3701 found to be relatively more resistant to sucking complex as compared to rest of the varieties including check. Bt variety FH Bt.1000 was more infested by sucking complex as compared to other tested varieties. Irrespective of varieties, the population of sucking complex was higher in July as compared other growing months of cotton. These results are further supported by Fok and Xu (2007) who found that Bt cotton is resistant to most devastating insect pests. Similarly, Wang and Wang (2009) and Bakhsh *et al.* (2009) found that Bt cotton varieties have relative resistance against sucking and bollworm complex. Zhang and Tang (2009), Abdullah (2010) and Xiao *et al.* (2011) reported that with the introduction of Bt cotton, the farmers are getting higher yields with improved seed cotton quality due to less insect pests infestation.

Conclusions

After going through the results Bt cotton variety showed considerable resistance against bollworm complex, while NIAB-78 also showed resistance against sucking. The infestation of sucking insect pests on haridost. Shahbaz and Sindh-1 as compared to Bt cotton. The infestation of thrips, and whitefly was peaked in the month of July. While Jassid was found most active in August. Bollworms appeared in first week of July and remained active in the field in relatively higher population up to the mid of September and later decreased to negligible level.

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