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Relative Resistance of Cross Bt Cotton Varieties against Sucking Complex

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Abstract:

Three Bt cotton varieties (Bt.3701, Bt. 886, FH Bt.1000) were evaluated to monitor population dynamics of sucking complex and to compare relative resistance of these varieties and to compare them with commercial cotton variety NIAB-78. The recording of observations was initiated on 26th June, 2011 and lasted on 23rd October, 2011. The population dynamics were assessed for three major insect pests which include whitefly, thrips and jassid. It was noted that whitefly population was significantly higher (2.7144/ leaf) on Bt cotton FH Bt.1000 against 2.5778/ leaf on check variety NIAB-78, while whitefly population on variety Bt.886 was 2.56/leaf. However, the lowest whitefly population of 2.3533/ leaf was recorded on variety Bt.3701. Thrips population was significantly higher (17.357/ leaf) on check variety NIAB-78, while the insect population was 16.862/leaf on variety FH Bt.1000 and 16.579/leaf variety Bt. 886. However, the lowest thrips population of 12.24/ leaf was recorded on variety

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Bt.3701. Jassid population was significantly higher (2.88/leaf) on variety FH Bt.1000, while the insect population was slightly lower (2.8356/ leaf) on check variety NIAB-78 and 2.5811/ leaf on variety Bt. 886. However, the lowest jassid population of 2.5351/ leaf was recorded on variety Bt.3701. 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.

Key words: BT Cotton, Population Dynamics, Sucking Complex, Relative Resistance

Introduction

Cotton, *Gossypium hirsutum* L. is a soft, fluffy staple fiber plant of the genus *Gossypium*; and belongs to family Malvaceae (Dorothy and Stolton, 1999; Stephen, 2004). The greatest diversity of wild cotton species is found in Mexico, followed by Australia, Asia and Africa (Moseley and Gray, 2008). Botanically, there are three principal groups of cotton that are of commercial importance. The first, (*Gossypium hirsutum*), is native to Mexico and Central America and has been developed for extensive use. This group is known as American Upland cotton, and varies in length from about $^{7}/_{8}$ to $1^{5}/_{16}$ inches. Second botanical group, (*G. barbadense*), is of early South American origin. Varying in length from $1^{1}/_{4}$ to $1^{9}/_{16}$ inches, it is known as American Pima, but is also commonly referred to as Extra Long Staple (ELS) cotton. Third group, (*G. herbaceum* and *G. arboreum*), embraces cottons of shorter length, ½ to 1 inch, that are native to India and Eastern Asia (Moseley and Gray, 2008). During 2011-12, the cotton was cultivated on an

area of 2835 thousand hectares, 5.4 percent more than the last year (2689 thousand hectares). 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).

Whitefly, *Bemisia tabaci* Genn. is small insect having four white membranous wings. The nymphs are oval and light yellow in colour and remain in clusters on the under surface of leaves. It breeds all the year, the eggs hatch in 3-6 days. Whitefly eggs are generally laid on the underside of leaves. The newly laid eggs are yellow/green, changing color to dark tan, as they are about to hatch. They are very small (difficult to see with the naked eye), oval shaped, and sit on top of a pedicel (stalk) that fits into a small slit in the leaf made by the female. 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).

Thrips, *Thrip tabaci* Lind are very minute, slender, yellow in colour and active insects. They are pointed at both ends. The males are wingless. The females have four slender wings with fringed hairs. The females lay white bean shaped eggs on the tender leaves or buds which hatch in 5 to 10 days. The nymphs develop into adults in 5 to 10 days and adults live for 10-15 days, the whole lifecycle is completed in 25-35 weeks in cotton season. The pest active from germination of cotton seeds till harvesting. Maximum damage starts when crop is young. The attacked leaves develop a silvery coating on the lower surface of the leaves and the attacked leaves become saucer shaped (Hormchan *et al.,* 2001).

Jassid, *Amrasca devastans* Dist. adult is tinny insect oval in shape, green in colour with four wings. Adult male is smaller in size than female. In shape and colour the nymphs

resemble the adults are wingless. The pest usually rests under side of the leaves during day hours. The female lays eggs singly inside the prominent veins of mature leaves and eggs hatch in about four days. The newly hatched nymph measures 2.28 mm in length and is green in colour. 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).

Bt cotton has been developed through the transfer of a gene from a soil bacterium, *Bacillus thuringiensis*. This gene, when expressed in cotton, produces Cry protein, which is harmful to the larvae of moths, butterflies, beetles, and flies. When insects feed on the plant, the toxin enters the body and binds to the insect's gut. Hence, it disrupts its feeding and digestion process and eventually leads to the death of the insect (Arshad *et al*., 2008; Carroll, 2009). Bt cotton varieties yielded significantly more per acre as compare to non Bt cotton varieties - an average 23-28 maund per acre versus 17-20 maund to traditional cotton varieties. This translates into more than 30 percent increase in yield. It is noteworthy that in Bt cotton crops average number of cotton Bolls per plant are 120 while average Boll weight is approximately 1.75 grams. Bt varieties provides protection only against certain pests (bollworms) such as, American bollworm, Pink and Spotted bollworms; but not against Army bollworm (Rao, 2011).

Research has been conducted extensively on the development of insect resistant cotton varieties. Singh and Lal (1996) 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). Insecticides are necessary tools for management of cotton pests in almost all the cotton production systems (Castle

et al., 1999; Ahmad 2001). High cotton yield depends mainly upon the cultivation of promising varieties with resistance to major insect pests. 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.,* 2004; 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 endotoxin 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). Taken into consideration the long lasting biological solution of insect pest problem in cotton, the development of resistant cotton varieties against various insect pests particularly, the sucking complex is of great significance. The present research was carried out to evaluate relative resistance of cross BT cotton varieties against sucking complex.

Materials and Methods

In order to evaluate the resistance in various Bt cotton varieties against sucking complex; the present research was carried out during 2011-12. The experiment was conducted in the experimental fields of Entomology Section, Agriculture Research Institute, Tandojam. The following *Gossypium hirsutum* L. varieties were included in this research:

1) V_1 Bt. 3701 2) V_2 Bt 886 3) V_3 FH Bt 1000 4) V_4 NIAB-78 (check)

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 20th April, 2011 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 Randomized Complete Block Design (RCBD) with three replications was employed. The plot was 100 x 174 sq ft and row to row distance 2.5 ft and plant to plant distance of 30 cm. The first two irrigations were given frequently after 20 days of seed emergence and thinning was carried out to maintain the required plant to plant spacing. Normal agronomic practices were carried out throughout the growing season of the crop and no pesticides were sprayed in and around the experimental field.

The sucking complex infestation was recorded on Bt cotton varieties in comparison with the infestation on check variety (NIAB-78) to ascertain the resistance level. Moreover, variety with higher infestation was known to be under higher insect preference. For recording infestation, ten plants in each plot (variety) were labeled and infestation was recorded on per leaf basis. Five leaves each from bottom, middle and top of the selected leaf were selected at random and insect population was counted for each insect. All the data collected average reduction % age was subjected to analysis of variance, to discriminate the superiority of treatment mean L.S.D. test was applied followed Gomez and Gomez (1984).

Results

The present research was carried out during the Kharif season of 2011 to evaluate relative resistance of cross Bt cotton varieties against sucking complex. The experiment comprised of three Bt cotton varieties (Bt.3701, Bt. 886, FH Bt.1000). The insect population and resistance was compared with commercial cotton variety NIAB-78. The recording of observations was initiated on 26th June, 2011 and lasted on 23rd October, 2011. The population dynamics were assessed for three major insect pests which include whitefly, thrips and jassid.

Whitefly, *Bemisia tabaci Genn.*

Whitefly, *Bemesia tabaci* is most disastrous insect pest of cotton and vector species for various viral diseases of cotton particularly cotton leaf curl virus disease. The results (Table-1) indicated that statistically the population of whitefly differed significantly for varieties (F=5.40, P=0.0013, DF=3), observation dates (F=58.49, P=0.0000, DF=17) as well as their interaction (F=1.51, P=0.0208, DF=51). Whitefly population was significantly higher (2.7144/ leaf) on Bt cotton FH Bt.1000 against 2.5778/ leaf on check variety NIAB-78, while whitefly population on variety Bt.886 was 2.56/ leaf. However, the lowest whitefly population of 2.3533/plant was recorded on variety Bt.3701. This indicates that among tested Bt cotton varieties, Bt.3701 showed more resistance to whitefly as compared to FH Bt.1000, Bt. 886 and check variety NIAB-78. The LSD test suggested that the differences in whitefly population on cotton varieties Bt. 886, FH Bt. 1000 and NIAB-78 (check) were statistically non-significant (P>0.05), while significant (P<0.05) when compared with variety Bt. 3701.

The data in Table-1 further showed that at first observation on 26th June, the whitefly population was 1.77/plant and whitefly peak population (4.89/ leaf) was

recorded on 24th July observation. The presence of whitefly at higher population persisted from 17th July to 7th August, but later started decreasing and it was in the range of 1.64 to 2.84 from 14th August to 23rd October. However, the insect population persisted and remained present in the cotton fields irrespective of varieties throughout the cotton season. The variety x observation date interaction showed that the whitefly population was highest (5.84/ leaf) in variety Bt. 886 when observed on 24th July; while lowest (1.06/plant) in variety FH Bt.1000 on 3rd July.

Thrips, *Thrip tabaci* Lind.

Thrips, *Thrip tabaci* is an insect of great economic significance that causes considerable economic losses to cotton crop. The results (Table-2) showed that statistically the population of thrips differed significantly for varieties (F=16.98, P=0.0000, DF=3), observation dates (F=797.58, P=0.0000, DF=17) as well as their interaction (F=8.36, P=0.0000, DF=51). Thrips population was significantly higher (17.357/leaf) on check variety NIAB-78, while the insect population was 16.862/leaf on variety FH Bt.1000 and 16.579/leaf on variety Bt. 886. However, the lowest thrips population of 12.24/leaf was recorded on variety Bt.3701. This indicates that among tested Bt cotton varieties, Bt.3701 showed more resistance to thrips with lowest population as compared to FH Bt.1000, Bt. 886 and check variety NIAB-78. The LSD test indicated that the differences in thrips population on cotton varieties Bt. 886, FH Bt. 1000 and NIAB-78 (check) were statistically non-significant (P>0.05), while significant (P<0.05) when compared with variety Bt. 3701.

Table-1. Population fluctuation of whitefly on different cotton varieties

Date of Obs.	Varieties				Mean
	Bt.3701	Bt. 886	FH Bt.1000	NIAB-78 (check)	
26-6-2011	1.44	1.52	1.74	2.38	1.77 g

03-7-2011	1.52	1.62	1.06	1.52	1.68 g
10-7-2011	1.16	1.36	1.52	1.78	1.45 g
17-7-2011	3.02	3.46	3.9	3.58	3.49 c
24-7-2011	5.12	5.84	4.42	4.18	4.89 a
31-7-2011	3.56	4.3	4.32	4.82	4.25 b
07-8-2011	3.34	4.34	5.00	4.12	4.45 b
14-8-2011	1.8	2.24	2.44	2.54	2.25 e
21-8-2011	2.7	2.6	3.18	2.9	2.84 d
28-8-2011	2.26	3.48	2.96	2.5	2.8 d
04-9-2011	1.62	1.44	1.7	1.8	1.64 g
11-9-2011	2.24	2.32	2.4	2.12	2.27 f
18-9-2011	1.88	2.42	2.16	1.92	2.09 f
25-9-2011	2.28	2.14	2.52	2.16	2.27 f
02-10-2011	2.02	1.84	2.3	2.04	2.05 f
09-10-2011	1.94	1.58	1.78	1.62	1.73 g
16-10-2011	1.94	1.76	2.24	1.96	1.97 f
23-10-2011	1.52	1.82	2.22	2.46	2.005 f

	Varieties (V)	**Obs. Dates (D)**	**V x D**
S.E.±	0.0907	0.1924	0.3847
LSD 0.05	0.1785	0.3787	0.7573
LSD 0.01	0.2352	0.4989	0.9977

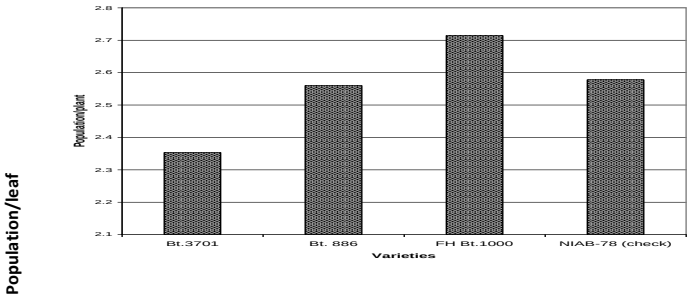

Fig.1. Average Whitefly population/leaf on different cotton varieties

The weekly population of thrips fluctuated significantly ($P<0.05$) and the results (Table-2) showed that at first observation on 26th June, the thrips population was 3.88 leaf t and peak population (139.98/leaf) was recorded on 24th July observation. The thrips population started building up from

10th July, and followed a declining trend from 31st July; reaching to its lowest average (0.91/leaf) on 4th September. However, tendency described that the thrips population remained lower afterwards and it was 1.59/leaf at the last observation on 23rd October. The variety x observation date interaction indicated that the thrips population was highest (158.66/leaf) in variety FH Bt.1000 when observed on 24th July; while lowest (0.90/leaf) in variety Bt. 886 on 4th September.

Table.2. Population fluctuation of thrips on different cotton varieties

Date of Obs.	Varieties				Mean
	Bt.3701	Bt. 886	FH Bt.1000	NIAB-78 (check)	
26-6-2011	3.54	3.62	3.08	4.48	3.68 f
03-7-2011	2.84	4.1	3.76	4.28	3.74 f
10-7-2011	7.4	7.6	7.46	9.66	8.03 e
17-7-2011	26.86	31.26	27.44	31	29.14 c
24-7-2011	97.82	150.64	158.66	152.78	139.98 a
31-7-2011	44.84	67.28	66.62	69.24	61.99 b
07-8-2011	15.5	11.7	13.12	13.32	13.41 d
14-8-2011	2.25	1.98	1.82	2.44	2.19 f
21-8-2011	3.82	4.08	4.54	6.58	4.75 f
28-8-2011	2.48	2.66	3.46	4.28	3.22 f
04-9-2011	1.1	0.9	0.84	0.82	0.91 g
11-9-2011	1.18	0.8	1.42	1.72	1.28 g
18-9-2011	1.7	1.7	2.02	1.78	1.8 f
25-9-2011	1.82	1.5	1.88	2.18	1.84 f
02-10-2011	1.82	2.54	2.14	2.66	2.29 f
09-10-2011	1.54	1.88	1.92	1.82	1.79 f
16-10-2011	1.94	2.24	1.76	2.14	2.02 f
23-10-2011	1.6	1.94	1.58	1.24	1.59 f

	Varieties (V)	Obs. Dates (D)	V x D
S.E.±	0.8127	1.7240	3.4479
LSD 0.05	1.5997	3.3934	6.7868
LSD 0.01	2.1075	4.4707	8.9414

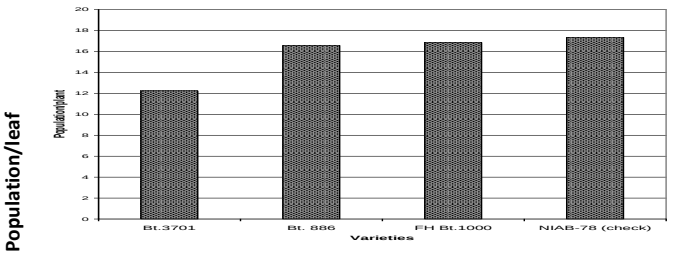

Fig.2. Average Thrips population/ leaf on different cotton varieties

Jassid, *Amrasca devastans* Dist.

Jassid, *Amrasca devastans* is a major insect pest of cotton and every year considerable economic losses happened due to its presence in cotton fields throughout the season. The results (Table-3) indicated that statistically the population of jassid differed significantly for varieties (F=5.42, P=0.0012, DF=3), observation dates (F=214.44, P=0.0000, DF=17) as well as their interaction (F=1.70, P=0.0039, DF=51). Jassid population was significantly higher (2.88/leaf) on variety FH Bt.1000, while the insect population was slightly lower (2.8356/leaf) on check variety NIAB-78 and 2.5811/leaf on variety Bt. 886. However, the lowest jassid population of 2.5351/ leaf was recorded on variety Bt.3701. This showed that among tested Bt cotton varieties, Bt.3701 showed relative resistance to jassid with lowest population more than FH Bt.1000, Bt. 886 and check variety NIAB-78. The LSD test suggested that the differences in jassid population on cotton varieties Bt. 886, FH Bt. 1000 and NIAB-78 (check) were statistically non-significant (P>0.05), while significant (P<0.05) when compared with variety Bt. 3701.

The weekly population of jassid fluctuated significantly (P<0.05) and the results (Table-3) indicated that at first observation on 26th June, the jassid population was 2.25/leaf, gradually increased and reaching its peak population of 9.476/leaf on 24th July observation. Later, the jassid population

started decreasing from 31st July and reached to its lowest population (0.65/leaf) on 4th September. After this lowest infestation, the jassid population again started increasing slightly and remained in the field regularly upto the end of the observation period. The variety x observation date interaction indicated that the jassid population was highest (10.94/leaf) in variety FH Bt.1000 when observed on 24th July; while lowest (0.58/leaf) in variety NIAB-78 on 4th September.

Table.3. Population fluctuation of jassid on different cotton varieties

Date of Obs.	Varieties				Mean
	Bt.3701	Bt. 886	FH Bt.1000	NIAB-78 (check)	
26-6-2011	2.06	1.56	2.28	3.1	2.25 e
03-7-2011	1.36	1.94	2.18	1.66	1.785 f
10-7-2011	1.02	1.42	1.84	1.46	1.435 f
17-7-2011	4.52	4.3	3.78	4.88	4.37 c
24-7-2011	9.28	8.08	10.94	9.6	9.475 a
31-7-2011	5.62	6.82	7.12	7.3	6.715 b
07-8-2011	5.44	5.5	5.48	5.18	5.40 c
14-8-2011	1.56	1.42	1.5	1.26	1.435 f
21-8-2011	2.3	2.44	2.68	3.04	2.615 d
28-8-2011	2.16	2.74	3.36	2.66	2.73 d
04-9-2011	0.64	0.72	0.66	0.58	0.65 h
11-9-2011	1.07	0.8	1.14	1.06	1.018 g
18-9-2011	0.96	1.18	1.56	1.34	1.26 g
25-9-2011	1.06	1.3	1.24	1.6	1.3 g
02-10-2011	1.34	1.36	1.24	1.28	1.305 g
09-10-2011	1.6	1.36	1.4	1.68	1.51 f
16-10-2011	1.72	1.4	1.9	1.42	1.61 f
23-10-2011	1.92	2.12	1.54	1.94	1.88 e

	Varieties (V)	Obs. Dates (D)	V x D
S.E.±	0.1063	0.2254	0.4509
LSD 0.05	0.2092	0.4437	0.8875
LSD 0.01	0.2756	0.5846	1.1692

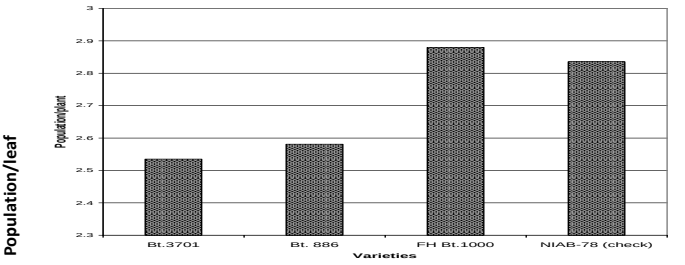

Fig-3 Average Jassid population/ leaf on different cotton varieties

Discussion

Pakistan is one of the major cotton growing countries and cotton export is the main source of foreign exchange earning for the country. The per unit area seed cotton yield is still lower than the potential yields and quality-wise Pakistan cottons did not fetch good prices in world cotton market. The main reasons for low quality cotton production are improper input application and crop management, while insect pest infestation also affects the quality of cotton produce adversely. 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 Bt cotton has proved to have relative resistance against devastating insect pests of cotton. High cotton yield depends mainly upon the cultivation of promising varieties with resistance to major insect pests. The newly released cultivars require thorough evaluation for insect pests. This step is considered important and necessary in development of improved and resistance cultivars (Razaq *et al.,* 2004). The present study was carried out to evaluate **t**hree Bt cotton varieties (Bt.3701, Bt. 886, FH Bt.1000)**,** to monitor population

dynamics of sucking complex and to compare relative resistance of these varieties with commercial cotton variety NIAB-78.

It was noted that whitefly population was significantly higher (2.7144/ leaf) on Bt cotton FH Bt.1000 against 2.5778/leaf on check variety NIAB-78, while whitefly population on variety Bt.886 was 2.56/leaf. However, the lowest whitefly population of 2.3533/leaf was recorded on variety Bt.3701. Syed (2005) 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/leaf) 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.

Thrips population was significantly higher (17.357/leaf) on check variety NIAB-78, while the insect population was 16.862/plant on variety FH Bt.1000 and 16.579/leaf on variety Bt. 886. However, the lowest thrips population of 12.24/plant was recorded on variety Bt.3701. 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. The varieties Shahbaz and NIAB-78 were found less resistant varieties against thrips. Fairbanks *et al*., (1999) found cultivar BG-4740 most susceptible cotton

cultivar with 106.1/leaf, while cultivar ST-373 38.9/leaf 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.

Jassid population was significantly higher (2.88/ leaf) on variety FH Bt.1000, while the insect population was slightly lower (2.8356/ leaf) on check variety NIAB-78 and 2.5811/ leaf on variety Bt. 886. However, the lowest jassid population of 2.5351/ leaf was recorded on variety Bt.3701. 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/ leaf) 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.

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 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.

Conclusion

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.

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