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SEVERITY OF COTTON WHITEFLY (*Bemisia tabaci* Genn.) POPULATION WITH SPECIAL REFERENCE TO ABIOTIC FACTORS

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Bemisia tabaci is serious insect and constantly destabilizing the cotton production. The research was conducted to evaluate cotton cultivars (transgenic and non transgenic) for resistance against whitefly and further correlated with weather factors such as temperature, relative humidity and rainfall, during the cropping seasons 2010 and 2011. However, peak population (6.36 per leaf) was recorded from FH-113 followed FH-167 and FH-114, whereas minimum population was recorded from FH-4243 in transgenic group whereas peak population (5.24 per leaf) was recorded from FH-941 followed by FH-100 and FH-901 while minimum population was recorded from FH-207, in non transgenic group of cultivars in the year 2010. The incidence and abundance was much high and reaching towards two folds in the year 2011 but the trend of whitefly varied with peak population (11.03 per leaf) recoded from FH-167 followed by FH-4243 and FH113 (from transgenic group of cultivars) whereas a peak of 10.77 per leaf population of whitefly, recorded followed by FH-901 and FH-941 (from non transgenic group of cultivars). FH-207 found more resistant from all ten cultivars studied in 2011. Correlation among weather factors and whitefly population showed that rainfall was negatively correlated while temperature and relative humidity were positively correlated with whitefly population. In addition to that situation is becoming worse because of shifting from conventional to more advanced transgenic cultivars that are susceptible and serve as host. Moreover, climatic conditions provide addition favor and helps in population buildup, abundance and incidence.
Keywords: Cotton, whitefly, transgenic cultivars, non-transgenic cultivars, abiotic factors

INTRODUCTION

Cotton is a major cash crop having significant impact on Pakistan's economy. Cotton yarn, cotton oil lint, cloth and garments are main source of earning and contribute 1.6% of the GDP of Pakistan (Anonymous, 2012). But still per hectare yield is low due to insect pests attack, causing 30-35 % yield loss (Abro *et al*., 2004). The reduction in yield comprised of variety of insect pests. The sucking insect pests including whitefly (*Bemisia tabaci* Genn.), thrips (*Thrips tabaci* Lind.), and jassid (*Amrasca biguttula biguttula* Ishida) attack the crop at vegetative stage and responsible for 40-50 % damage (Naqvi, 1976).

B. tabaci (Genn.) is the major pest of the world. It damages the plant by transmitting viral diseases and grudging the host plant of its sustenance by constantly sucking the cell sap which results in 50% reduction in boll production and plant growth. *B. tabaci* possesses a vital role in the transmission of CLCuV (Malik *et al.,* 1995). Abiotic factors such as temperature, relative humidity and rainfall (during the cropping season) has direct influence on the occurrence and population development of sucking pests with special emphasis to whitefly (Ali *et al.,* 1993 and Aheer *et al.,* 1994). In Pakistan 80% of the pesticide consumption is received by cotton alone (Ahmad and Khan, 1991). Repeated use of chemicals induces problems such as; insect resistance, health problem and environmental pollution (Mohyuddin *et al*., 1997). *B. tabaci* has originated in Indo-pak and spread all over the world, as a pest (Hussain and Trehan, 1933). It comprised of broad range of host plants over 600 host plants (Oliveira *et al*., 2001). As far as the good production of cotton for Pakistan is concerned, it has become mandatory to develop an effective pest management program to understand pest control, varietals resistance and ecological requirements particularly weather factors, which have great impact on multiplication and production. In addition to this, rainfall showed strong correlation in population buildup.

Keeping this rationale in view, a project has been planned to know the population trend of *B. tabaci* on different trangenics and non transgenics cultivars. Moreover, correlation has been estimated with weather factors (temperature, relative humidity and rainfall)

MATERIALS AND METHODS

The research was conducted at Entomological Research Area, University of Agriculture Faisalabad (Punjab), Pakistan to determine the effect of weather factors on the population of *B. tabaci* on different transgenics (FH-113, FH-4243, FH-114, FH-167 and FH-187) and non transgenics (FH-1000, FH-901, FH-941, FH-207 and FH-942) cultivars during 2010-11. The crop was sown in Randomized Complete Block Design (RCBD) with three replications having ten treatments. The plot size was 7.5 × 15 feet. Five rows of one variety were sown in each replication. No plant protection measures were applied throughout the season.

Whitefly population count: Five plants were selected randomly, from each variety, in each replication. Population of whitefly (nymph and adult) was recorded weekly (early morning). Five leaves were selected randomly, from five plants, from each plot, in such a way that one upper leaf from first plant, one middle leaf from second plant and one bottom leaf from third plant and so on, were considered for data count (sixteen weeks). Environmental factors data regarding mean daily temperature, relative humidity and rainfall were collected from Department of Crop Physiology University of Agriculture Faisalabad.

Statistical analysis: Means for whitefly were calculated and subjected to statistical analysis with computer based software: Statistix 8.1 (Analytical software, 2005). LSD Test (at 5%) was applied to test the level of significance / difference between cultivars and dates of observations (Steel and Torrie, 1980), and correlation between whitefly population and weather factors were also estimated.

RESULTS

The data regarding whitefly population per leaf on transgenic cultivars and non transgenic cultivars of cotton in 2010 and 2011 (Fig.1) showed that whitefly prefers more transgenic cultivars than non transgenics. The population of whitefly is doubled in year 2011 in comparison with 2010 (in transgenic and non transgenic cultivars).

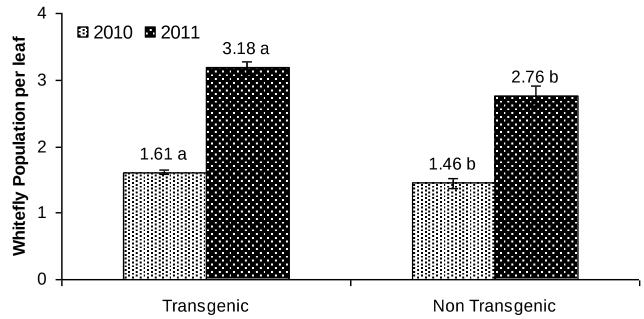

Figure 1. Comparison of transgenic and non transgenic cultivars in 2010 and 2011

Seasonal trend of whitefly population (Table 1 & 2) in different cultivars showed transgenic cultivars are susceptible and preferred host than non trangenics. Moreover, the incidence of whitefly is increased to a great number during the cropping season of 2011 (Fig. 2) that became two fold from the last year (2010).

However, in 2010, the whitefly incidence (table 1) remained low in non transgenic cultivars. The peak population (6.36 per leaf) was recorded from FH-113 followed FH-167 and FH-114, whereas minimum population was recorded from FH-4243 in transgenic group. However, peak population (5.24 per leaf) was recorded from FH-941 followed by FH-100 and FH-901 while minimum population was recorded from FH-207, in non transgenic group of cultivars. The minimum population was recorded on last date of observation.

In 2011, the incidence was high and reaching towards two folds but the trend of whitefly varied from the last year (Table 2). Peak population (11.03 per leaf) was recorded in FH-167 followed by FH-4243 and FH113, from transgenic

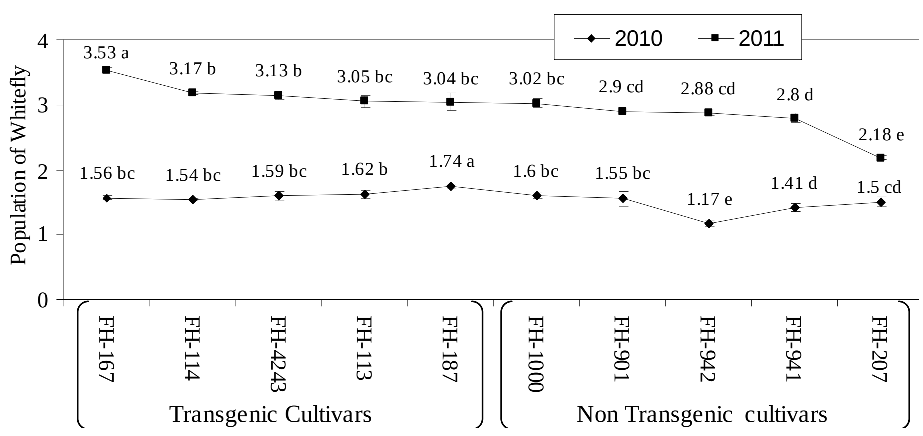

Figure 2. Varietal response of different transgenic and non transgenic cultivars in 2010 and 2011

Table 1. Seasonal distribution of *B. tabaci* during the cropping season in 2010

Dates	FH-167	FH-114	FH-4243	FH-113	FH-187	FH-1000	FH-901	FH-942	FH-941	FH-207
27/6/2010	2.49 ± 0.01 b	2.51 ± 0.02 b	2.51 ± 0.01 b	2.05 ± 0.58 bcd	2.54 ± 0.01 d	1.53 ± 0.02 ef	1.46 ± 0.01 def	1.40 ± 0.01 e	2.14 ± 0.02 c	1.45 ± 0.01 de
4/7/2010	2.36 ± 0.02 bc	2.36 ± 0.01 bc	3.55 ± 0.01 a	3.2 ± 0.01 b	2.97 ± 0.01 c	2.77 ± 0.02 b	2.80 ± 0.02 b	2.03 ± 0.02 c	2.33 ± 0.01 b	2.80 ± 0.01 b
11/7/2010	4.78 ± 0.01 a	4.77 ± 0.02 a	3.54 ± 0.01 a	6.36 ± 0.01 a	4.62 ± 0.01 a	4.67 ± 0.02 a	4.58 ± 0.02 a	3.46 ± 0.02 a	5.24 ± 0.01 a	4.34 ± 0.02 a
18/7/2010	2.12 ± 0.04 d	2.04 ± 0.02 d	2.23 ± 0.04 c	2.20 ± 0.01 bc	3.45 ± 0.01 b	2.89 ± 0.03 b	2.84 ± 0.00 b	1.61 ± 0.01 d	1.83 ± 0.01 d	2.44 ± 0.01 c
25/7/2010	2.25 ± 0.02 cd	2.26 ± 0.02 c	2.02 ± 0.02 d	1.67 ± 0.01 cde	2.05 ± 0.02 e	2.51 ± 0.01 c	2.57 ± 0.01 c	2.39 ± 0.01 b	2.37 ± 0.01 b	2.36 ± 0.01 c
1/8/2010	2.19 ± 0.02 cd	2.27 ± 0.01 c	1.48 ± 0.01 f	1.63 ± 0.01 cde	1.66 ± 0.01 fg	1.70 ± 0.01 d	1.55 ± 0.01 d	1.13 ± 0.01 f	1.03 ± 0.01 g	1.11 ± 0.01 gh
8/8/2010	0.85 ± 0.05 gh	0.84 ± 0.05 gh	0.30 ± 0.01 j	0.72 ± 0.01 def	0.48 ± 0.01 k	0.58 ± 0.03 jk	0.58 ± 0.01 h	0.35 ± 0.02 h	0.45 ± 0.02 k	0.95 ± 0.01 i
15/8/2010	1.03 ± 0.02 g	1.01 ± 0.01 g	0.83 ± 0.01 h	1.34 ± 0.01 cde	1.28 ± 0.01 j	1.22 ± 0.01 h	1.22 ± 0.02 g	1.03 ± 0.01 f	1.46 ± 0.01 e	1.30 ± 0.01 ef
22/8/2010	1.44 ± 0.03 f	1.43 ± 0.01 f	1.77 ± 0.01 e	0.97 ± 0.01 cdef	1.75 ± 0.01 f	0.71 ± 0.02 i	0.68 ± 0.01 h	0.50 ± 0.01 g	0.78 ± 0.01 j	0.98 ± 0.01 hi
29/8/2010	0.76 ± 0.02 h	0.72 ± 0.01 h	1.43 ± 0.00 f	0.74 ± 0.01 def	1.46 ± 0.02 i	1.37 ± 0.01 g	1.45 ± 0.01 ef	0.50 ± 0.01 g	0.96 ± 0.01 gh	1.16 ± 0.01 fg
5/9/2010	0.77 ± 0.02 h	0.72 ± 0.03 h	1.44 ± 0.01 f	0.79 ± 0.01 def	1.59 ± 0.01 gh	1.56 ± 0.01 e	1.54 ± 0.02 de	0.60 ± 0.01 g	0.80 ± 0.00 hi	1.15 ± 0.01 fg
12/9/2010	0.93 ± 0.02 gh	0.88 ± 0.02 gh	0.97 ± 0.01 g	1.40 ± 0.01 cde	1.55 ± 0.01 h	1.41 ± 0.01 fg	1.43 ± 0.01 f	1.04 ± 0.01 f	0.89 ± 0.01 ij	1.26 ± 0.01 fg
19/9/2010	1.67 ± 0.02 e	1.71 ± 0.03 e	1.83 ± 0.01 e	0.91 ± 0.02 cdef	1.54 ± 0.01 hi	1.38 ± 0.01 g	1.29 ± 0.00 g	1.13 ± 0.02 f	1.13 ± 0.01 f	1.60 ± 0.01 d
26/9/2010	0.76 ± 0.02 h	0.80 ± 0.02 h	0.98 ± 0.01 g	1.35 ± 0.01 cde	0.45 ± 0.01 k	0.64 ± 0.01 ij	0.59 ± 0.01 h	1.06 ± 0.03 f	0.77 ± 0.01 j	0.66 ± 0.01 j
3/10/2010	0.48 ± 0.02 i	0.33 ± 0.02 i	0.64 ± 0.01 i	0.55 ± 0.01 ef	0.44 ± 0.01 k	0.48 ± 0.01 k	0.23 ± 0.01 i	0.49 ± 0.01 g	0.25 ± 0.01 l	0.41 ± 0.05 k
10/10/2010	0.01 ± 0.01 j	0.01 ± 0.01 j	0.02 ± 0.01 k	0.0 ± 0.00 f	0.08 ± 0.02 l	0.13 ± 0.01 l	0.00 ± 0.00 j	0.02 ± 0.01 i	0.09 ± 0.02 m	0.01 ± 0.01 l

Table 2. Seasonal distribution of *B. tabaci* during the cropping season in 2011

Dates	FH-113	FH-4243	FH-114	FH-167	FH-187	FH-1000	FH-901	FH-942	FH-207	FH-941
27/6/2011	2.4 ± 0.20 de	3.23 ± 0.09 de	2.03 ± 0.07 de	3.93 ± 0.09 cd	1.60 ± 0.12 ef	2.57 ± 0.12 d	2.20 ± 0.06 ef	2.23 ± 0.09 def	1.5 ± 0.06 efg	1.33 ± 0.00 def
4/7/2011	1.9 ± 0.09 def	2.13 ± 0.09 f	1.77 ± 0.19 de	1.70 ± 0.25 ef	1.80 ± 0.06 de	2.2 ± 0.21 d	1.80 ± 0.21 fg	1.67 ± 0.09 defg	1.63 ± 0.38 rfg	1.33 ± 0.20 def
11/7/2011	10.2 ± 0.21 a	10.13 ± 0.20 a	10.37 ± 0.26 a	10.57 ± 0.20 a	10.00 ± 0.24 a	10.17 ± 0.20 a	9.70 ± 0.15 b	10.47 ± 0.55 a	6.37 ± 0.73 b	9.83 ± 0.20 a
18/7/2011	3.4 ± 0.25 c	3.43 ± 0.18 cd	4.37 ± 0.09 c	5.37 ± 0.22 bc	4.40 ± 0.21 c	2.7 ± 0.15 d	3.20 ± 0.15 d	3.17 ± 0.18 bcd	2.27 ± 0.15 de	3.50 ± 0.21 c
25/7/2011	5.37 ± 0.23 b	5.67 ± 0.12 b	5.80 ± 0.44 b	6.53 ± 0.15 b	5.60 ± 0.15 b	5.37 ± 0.09 b	4.20 ± 0.15 c	4.53 ± 0.15 b	4.13 ± 0.47 c	5.53 ± 0.23 b
1/8/2011	5.23 ± 0.20 b	4.37 ± 0.09 c	4.51 ± 0.15 c	5.90 ± 0.17 b	4.73 ± 0.12 bc	4 ± 0.12 c	4.33 ± 0.15c	4.03 ± 0.15 bc	3.43 ± 0.12 cd	4.30 ± 0.36 c
8/8/2011	10.57 ± 0.03 a	10.63 ± 0.35 a	10.30 ± 0.21 a	11.03 ± 0.29 a	10.53 ± 0.49 a	10.77 ± 0.22 a	10.57 ± 0.37 a	9.43 ± 1.12 a	8.6 ± 0.42 a	10.33 ± 0.35 a
15/8/2011	2.57 ± 0.12 cd	2.43 ± 0.19 def	2.50 ± 0.12 d	3.00 ± 0.12 de	2.90 ± 0.15 d	2.23 ± 0.27 d	2.70 ± 0.21 de	2.67 ± 0.23 cde	1.70 ± 0.15 ef	2.17 ± 0.09 d
22/8/2011	1.63 ± 0.30 efg	1.67 ± 0.12 fg	1.40 ± 0.06 ef	1.70 ± 0.15 ef	1.37 ± 0.07 ef	1.03 ± 0.17 ef	1.37 ± 0.17 fgh	1.2 ± 0.06 efgh	0.80 ± 0.25 efgh	1.23 ± 0.15defg
29/8/2011	0.93 ± 0.07 gh	0.97 ± 0.32 ghi	1.17 ± 0.20 efg	1.13 ± 0.19 f	1.33 ± 0.12 efg	1.13 ± 0.12 ef	1.10 ± 0.06 gh	0.43 ± 0.15 gh	0.87 ± 0.18 efgh	0.90 ± 0.15 fgh
5/9/2011	0.60 ± 0.10 hi	0.57± 0.12 hi	1.33 ± 0.09 efg	1.10 ± 0.06 f	1.70 ± 0.12 e	1.43 ± 0.12 e	1.40 ± 0.10 fgh	0.43 ± 0.15 gh	0.83 ± 0.15 efgh	1.00 ± 0.12 efgh
12/9/2011	1.6 ± 0.21 efg	2.37 ± 0.32 ef	1.93 ± 0.18 de	1.57 ± 0.19 ef	1.54 ± 0.18 ef	2.57 ± 0.12 d	1.53 ± 0.15 fg	1.97 ± 0.09 defg	1.37 ± 0.09 efgh	1.97 ± 0.33 de
19/9/2011	1.50 ± 0.12 fg	1.5 ± 0.17 fgh	1.77 ± 0.18 de	0.87 ± 0.09 f	1.5 ± 0.12ef	1.3 ± 0.12 ef	1.33 ± 0.15 gh	1.23 ± 0.12 efgh	0.93 ± 0.13 efgh	1.27 ± 0.15defg
26/9/2011	0.50 ± 0.06 hi	0.66 ± 0.17 ghi	0.7 ± 0.12 fgh	0.89 ± 0.05 f	0.5 ± 0.12 fgh	0.57 ± 0.12 fg	0.62 ± 0.06 hi	0.83 ± 0.03 fgh	0.32 ± 0.04 fgh	0.43 ± 0.12 fgh
3/10/2011	0.31 ± 0.06 hi	0.24 ± 0.04 i	0.33 ± 0.08 gh	0.17 ± 0.04 f	0.23 ± 0.03 gh	0.21 ± 0.01 g	0.21 ± 0.05 i	0.42 ± 0.04 gh	0.17 ± 0.00 gh	0.27 ± 0.08 gh
10/10/2011	0.06 ± 0.02 i	0.03 ± 0.02 i	0.03 ± 0.00 h	0.07 ± 0.03 f	0.07 ± 0.00 h	0.17 ± 0.03 g	0.10 ± 0.06 i	0.07 ± 0.02 h	0.00 ± 0.00 hi	0.07 ± 0.02 h

Means sharing similar letters are non significant at P<0.05.

Table 3. Correlation coefficient of environmental factors and population of whitefly on different transgenic and traditional varieties of cotton in 2010 and 2011

Cultivars		Year 2010			Year 2011		
		Temperature (°C)	Relative humidity (%)	Rainfall (mm)	Temperature (°C)	Relative humidity (%)	Rainfall (mm)
Transgenic cultivars	FH-113	0.436	0.015	-0.01	0.438	0.183	-0.143
	FH-4243	0.434	0.003	-0.02	0.462	0.189	-0.172
	FH-114	0.459	0.081	-0.109	0.438	0.203	-0.141
	FH-167	0.48	0.204	-0.101	0.529	0.1	-0.144
	FH-187	0.338	0.072	-0.081	0.419	0.219	-0.106
Non Transgenic cultivars	FH-1000	0.28	0.099	-0.026	0.421	0.249	-0.126
	FH-901	0.289	0.122	-0.042	0.415	0.243	-0.117
	FH-942	0.317	0.019	-0.069	0.43	0.172	-0.174
	FH-207	0.282	0.063	-0.071	0.409	0.28	-0.106
	FH-941	0.415	0.154	-0.095	0.443	0.2	-0.158

group of cultivars whereas a peak of 10.77 per leaf population of whitefly, recorded followed by FH-901 and FH-941, from non transgenic group of cultivars. FH-207 found more resistant from all ten cultivars studied in 2011.

The results (Fig.2) also indicated the incidence level of whitefly on different cultivars in transgenic and non transgenic group in year 2010 and 2011. The data explained that transgenic cultivars are more susceptible than non transgenics in both years. However, FH-187 was more susceptible and statistically different from all other cultivars in both groups followed by FH-113, 4243, 167, 114 (transgenic cultivars), 1000, 901, 207 and 941 (non transgenic cultivars) are at par with each other whereas FH-942 found resistant and statistically different from all others, in 2010. The figure also explained mean population trend in 2011 but showing some variation by indicating FH-167 as susceptible and FH-207 as resistant cultivar, during the whole cropping season.

The variation in whitefly population explained that climatic factors such temperature, relative humidity and rainfall etc., influences the population buildup and incidence. The data (Table 3) indicated that population of whitefly is directly proportional to the temperature and relative humidity (2010 and 2011) but inversely proportional to rainfall. The results also showed that temperature and relative humidity strongly influences the whitefly population in 2011 than in 2010.

DISCUSSION

The results explained that whitefly population incidence was doubled during 2010 and 2011, whereas transgenic cultivars are far more susceptible than non transgenics. FH-187 (in 2010) and FH-167 (in 2011) from transgenic whereas FH-1000 (both years) from non transgenic noticed as preferred cultivars. However, FH-114 (in 2010) and FH-187 (in 2011) from transgenic group cultivars whereas FH-942 (2010) and FH-207 (2011) from non transgenics were recorded as comparatively resistant cultivars than others (Fig.2).

The trend of whitefly population showed a single peak in year 2010 and two peaks (mid of July and 2nd week of August) during the year 2011 (Table 1 & 2). Two peaks of whitefly population were found in 2011 during July and August but Monsef and Kashkooli (1978) recorded two peaks of whitefly population during July and September.

The present findings are at par with Ning *et al*. (2001), Bai *et al*. (2002) and Naveen *et al*. (2007), who compared Bt cotton with conventional cotton cultivars in response to sucking insect pests and found that Bt / transgenic cultivars are more susceptible host for the sucking insect pest, especially *B. tabaci*. As Bt toxin don’t have direct effect on the non-target insect species. In the present study, none of the cultivar was found immune to whitefly.

In Pakistan sucking insect pests like cotton whitefly, jassid, thrips, aphid and cotton mealy bug are very destructive pest, during seedling and vegetative phase of cotton as they suck the sap from leaves (Abro *et al*., 2003). Bt cotton can effectively control specific lepidopterous species but there is lack of resistance against sucking insect pests (Hofs *et al*., 2004 and Sharma and Pampapathy, 2006) and hence require continuous use of pesticides and other control tactics for effective management (Hilder and Boulter, 1999 and Hofs *et al*., 2006). A little attention is given on the population dynamics of non-target, sucking insect pests in Bt cotton as most of the studies focus on major target pests. The reduced use of insecticides in Bt cotton can increase the population of sucking insect pests (Men *et al*., 2005).

The present findings are in close contact with the findings of Deng *at al.* (2003) who also reported no resistant in BT cotton against whitefly. Similarly Abro *et al*. (2003) and Sharma and Pampapathy (2006) investigated infestation of sucking insect pests on BT and non-Bt cotton and found non-significant difference. Our results also notified that whitefly population is directly proportional to the temperature and relative humidity whereas inversely proportional to the rainfall. These results are in close conformity with Avidov (1956) and Singh *et al*. (1999) as temperature and relative humidity favors the pest abundance but rainfall decreases the abundance. Whitefly population is on its peak in July-Sep, Sunshine hours were positively associated (Sharma and Rishi, 2004), while rainfall and relative humidity were negatively associated with whitefly population (Rote and Puri, 1991 and Wahla *et al*., 1996). High ambient temperatures favored population increase of *B. tabaci* and high temperature which occurred during the summer season contributed to a decrease in pest population. Nandihalli *et al*. (1993) reported that there is significant negative correlation between whitefly population and maximum and minimum temperature, while significant positive correlation with mean morning relative humidity. Whitefly population is significantly and positively correlated with temperature and relative humidity but negatively with rainfall (Kumashiro *et al*., 1983; Gupta *et al*., 1998). Temperature, light intensity and other such factors affect the honeydew production of *B. tabaci* (Henneberry *et al*., 1999). The correlation between temperatures was positively correlated with the population of whitefly (Bishnoi *et al*., 1996; Wahla *et al*., 1996; Rote and Puri, 1991. Relative humidity also showed positive and significant correlation with the whitefly population (Bishnoi *et al*., 1996 and Nandihalli *et al*., 1993). Umar *et al.* (2003) reported the negative correlation among whitefly population and weather factors i.e., temperature, relative humidity and precipitation.

Conclusion: It is concluded that transgenic cultivars are susceptible and became as host of cotton whitefly in contrast with non transgenic cultivars. In addition to that it became a serious threat to cotton growers because of shifting from conventional to more advanced transgenic cultivars. The situation worsened increasingly, from the previous years. Moreover, climatic conditions are also favoring the cotton whitefly in population buildup, abundance and incidence.

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REFERENCES

Abro, G.h., T.S. Sued and Z.A. Dayo. 2003. Varietal resistance of cotton against *Earias* spp. Pak. J. Biol. Sci. 6:1837-1839.

Abro, G.H., T.S. Syed, G.M. Tunio and M.A. Khuhro. 2004. Performance of transgenic cotton against insect pest infestation. Biotechnol. 3:75-81.

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

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

Ali, A.M., A. Bhatti and K.J. Ahmed. 1993. Role of weather in fluctuating the population of *Amrasca devastans* (Dist.) and *Thrips tabaci* (Lind.). Proc. Pak. Congr. Zool. 13:133-139.

Analytical Software. 2005. Statistix version 8.1: User's manual. Analytical Software, Tallahassee, Florida, USA.

Anonymous, 2012. Economic survey of Pakistan. Ministry of Food, Agriculture and live stock. Govt. of Pakistan.

Avidov, Z. 1956. Bionomics of the tobacco whitefly (*Bemisia tabaci*) in Israel. Isr. Ktcrvm. 7:25-41.

Bai, L., Z. Longwa, C. Xiaobo, F. Hanjin, G. Guohua, Z. Zongqing and S. Chun'e. 2002. Preliminary studies on effects of transgenic cotton varieties on composition of insect community. Chin. J. Biol. Cont. 18:115-119.

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

Deng, S., D. Jxu, Q.W. Zhang, S.W. Zhou and G.J. Xu. 2003. Effect of transgenic Bt cotton on population dynamics of the non-target pests and natural enemies of pests. Acta Entomol. Sonica. 46:1-5.

Gupta, G.P., Mahapatra, G.K., Kundu, S.K. and R. Lal. 1998. Impact of abiotic factors on population dynamics of whitefly in cotton. Ind. J. Ent. 60 :293-296.

Henneberry, T.J., L. Jech, D.L. Hendrix and T. Steele. 1999. *Bemisia argentifolii* (Homoptera: Aleyrodidae): factors affecting adult and nymph honeydew production. Southwest Entomol. 24:207-231.

Hilder, V.A. and D. Boulter. 1999. Genetic engineering of crop plants for insect resistance – a critical review. Crop Prot. 18:177-191.

Hofs. J.L., A. Schoeman and M. Vaissayre. 2004. Effect of Bt cotton on arthropod biodiversity in South African cotton fields. Commun. Agric. Appl. Boil. Sci. 69:191-194.

Hofs. J.L., M. Fok and M. Vaissayre. 2006. Impact of Bt cotton adoption on pesticide use by smallholders: A 2-year survey in Makhatini Flats (South Africa). Crop Prot. 25:984-988.

Hussain, M.A. and K.N. Trehan. 1933. Observations on the life history, bionomics and control of whitefly of cotton (*Bemisia gossypiperda*). Ind. J. Agric. Sci. 3:701-753.

Kumashiro, B.R., Lal, P.Y., Funasaki, G.Y. and Teramoto, K.K., 1983, Efficacy of *Nephasphis amicola* and *Encarsia haitiensis* in controlling *Aleurodicus dispersus* in Hawaii. Proc. Hawaiian Entomol. Soc. 24:261-269.

Malik, A.K., S. Mansoor, N.A. Saeed, S. Asad, Y. Zafar, J. Stanely and P. Markham. 1995. Development of CLCV resistance cotton varieties through genetic engineering. A monograph published by Director of Agricultural Information, Punjab, Pakistan.

Men, X.Y., F. Ge, E. Yardim and M.N. Parajulee. 2005. Behavioral response of *Helicoverpa armigera* (Lepidoptera: Noctuidae) to cotton with and without expression of the CryIAc delta endotoxin protein of *Bacillus thuringiensis* Berliner. J. Ins. Behavior. 18:33-50.

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

Monsef, A.A. and A. Kashkooli. 1978. The cotton whitefly *Bemisia tabaci* Genn. and its control in the Province of Fars. Entomologie et Phytopathologie Appliquees 46:66-77.

Nandihalli, B.S., B.V. Patil and S. Lingappa. 1993. Population dynamics of cotton whitefly, *Bemisia tabaci* (Genn.). Kar. J. Agric. Sci. 6:25-29.

Naqvi, K.M. 1976. Crop protection to boost up the cotton production. Seminar organized by ESSO, Fert. Co. Ltd., Pakistan.

Naveen, A., D.S. Brar and G.S. Butter. 2007. Evaluation of Bt and non Bt version of two cotton hybrids under different spacing against sucking insect pests and natural enemies. J. Cotton Res. Dev. 21:106-110.

Ning, X.Z., Q.P. Song, X.H. Kong, H. Chen, J.W. Meng, Y.Z. He and S.L. Zhang. 2001. A preliminary research on the regularity of population fluctuation of major insects and natural enemies in the field of Bt transgenic cotton in the Xingiang region. China Cottons. 28:12-13.

Oliveira, M.R.V., T.J. Henneberry and P. Anderson. 2001. History, current status, and collaborative research projects for *Bemisia tabaci*. Crop Prot. 20:709-723.

Rote, N. B. and N. Puri. 1991. Population dynamics of whitefly, *Bemisia tabaci* on cotton and its relationship with weather parameters. J. Cotton Res. Div. 5:181-189.

Sharma, H.C. and G. Pampapathy. 2006. Influence of transgenic cotton on the relative abundance and damage by target and non-target insect pests under different protection regimes in India. Crop Prot. 25:800-813.

Sharma, P. and N. Rishi. 2004. Population build up of the cotton whitefly, *Bemisia tabaci* Genn. in relation to weather factors at Hisar, Haryana. Pest. Mgt. Econ. Zool. 12:33-38.

Singh, J., A.S. Sohr, D.S. Brar, I. Denholm, D. Russel. R. Briddon. 1999. Management of cotton leaf curl viral diseases in India. pp. 277-278. In: Proc. ICAC- CCRI Regional Consultation, Insecticide Resistance Management in Cotton. Central Cotton Res. Ins. Multan, Pakistan.

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

Umar, M.S., M.J. Arif, M.A. Murtaza, M.D. Gogi and M. Salman. 2003. Effect of abiotic factors on the population fluctuation of whitefly, *Bemisia tabaci*, in nectaried and nectariless cultivars of cotton. Int. J. Agric. Bio. 5:362-363.

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