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IMPACT OF *Bt*- COTTON ON WHITEFLY, *Bemisia tabaci* (Genn.) POPULATION

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Genetically engineered cotton genotypes, *Gossypium hirsutum* L., (*Bt*-121, *Bt*-196, *Bt*-313, *Bt*-333, *Bt*-496, *Bt*-703, *Bt*-802, *Bt*-1524, *Bt*-3701, *Bt*-W1) were evaluated for their resistance against whitefly, *Bemisia tabaci* (Genn.), during the cropping seasons 2008 and 2009. In 2008, *Bt*-496 showed highest susceptibility to *B. tabaci* (4.52 population/leaf) followed by *Bt*-121(3.55 population/leaf) and *Bt*-3701 (3.19 population/leaf) while all the remaining varieties were statistically at par having minimum population per leaf ranging from 1.97 to 2.75. In 2009, *Bt*-496 showed highest susceptibility to *B. tabaci* (4.97 population/leaf) followed by *Bt*-333 (4.25 population/leaf) while all the remaining varieties were statistically at par having population ranging from 2.09 to 3.59 per leaf except *Bt*-703 which showed highest resistance to *B. tabaci* (1.41/leaf). Four physico-morphic characters of the leaves viz., gossypol glands, hair density, hair length and lamina thickness were also studied of the subjected cotton genotypes. In 2008, lamina thickness and gossypol glands were positively correlated with mean *B. tabaci* population/leaf (r = 0.66; r = 0.67 respectively) whereas in 2009, hair length and gossypol glands showed negative and positive correlations respectively (r = -0.65; r = 0.78). Minimum temperature and wind speed were negatively correlated while sunshine had a positive impact on *B. tabaci* population.
Keywords: *Bt- cotton, Gossypium hirsutum, Bemisia tabaci*, physico-morphic characters

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is the most imparative fibre and non-food cash crop of Pakistan and ranks at the top as foreign exchange earners. It accounts for 7.3 percent of the value added in agriculture and about 1.6 percent to GDP of Pakistan but the yield was affected severely mainly due to the infestation of Cotton Leaf Curl Virus (CLCuV) (Anonymous, 2009). Whitefly, *Bemisia tabaci* (Gennadius) is one of the key pest of cotton in Pakistan, sporadically appeared before 1985 and gained the status of a persistent pest of cotton since 1987 (Aslam *et al*., 2001). It causes indirect damage to cotton by transmitting CLCuV (Nelson, 1991), sucking plant sap and secreting honey dews (Ali and Aheer, 2007) which ultimately hampers plant's photosynthetic activities due to the development of sooty mold (Aslam *et al*., 2001). Managing insect pests via chemical measures play a key role but, regrettably, pesticide's imprudent and injudicious use has frequently resulted in unstabilizing agro-ecosystems (Soerjani, 1988; Bashir *et al*., 2001). Insect resistant transgenic crops could be an important tool in integrated pest management because of their potential to reduce applications of chemical insecticides (Ouedejans, 1991; Olsen and Daly, 2000).

Bacillus thuringiensis cotton i.e. transgenic cotton or genetically modified cotton, have a lepidopterous toxic gene of *Bacillus thuringiensis* var. *kurstaki* was introduced in South Africa during the cotton growing season of 1998-99 and has since been widely adopted by farming community. *Bt* cotton is lepidopteran specific and direct mortality of non lepidopteran or non target organisms is not expected (Mallet and Schoeman, 2007). Although *Bt* cotton owing to have a unique physiological set up against lepidopteran insect pests, but plant's morphological characteristics i.e., presence or absence of glandular secretions, pubescence, tissue toughness etc, may bar insects activities by producing physical stimuli (Jenkins, 1995).
Physico-morphic characteristics of plant foliage can have positive or negative impacts on herbivore's activities (Krips *et al*., 1999; Afzal and Bashir, 2007). We, therefore, hypothesized that the physico-morphic characteristics of available *Bt*-cotton genotypes may have an influence to bar *B. tabaci* activity or not.
Keeping in view the plant's physico-morphic characteristics, the present experiment was therefore designed by planting ten commercially available *Bt*-cotton genotypes, with the aim to find the association of hair density, hair length, thickness of leaf lamina and

gossypol glands on leaves and *Bt*-cotton resistance to *B. tabaci.*

MATERIALS AND METHODS

A two year field experiment was planned at post graduate agricultural research station (PARS), University of Agriculture, Faisalabad. Ten transgenic cotton genotypes viz., *Bt*-121, *Bt*-196, *Bt*-313, *Bt*- 333, *Bt*-496, *Bt*-703, *Bt*-802, *Bt*-1524, *Bt*-3701 and *Bt*-W1 were sown during the cropping season of 2008 and 2009 following randomized complete block design (RCBD) with triplicate. The plants were sown in plots (20×08 ft) with 2.50 ft row to row and 1.25 ft plant to plant distance without applying any plant protection measures throughout the cropping season. Sampling for adult *B. tabaci* was performed weekly by leaf turn method following the protocol described by Aslam *et al.* (2001). Twelve plants were randomly selected from each plot and one leaf from each plant was chosen for population counts in such a way that first leaf was taken from top potion of first plant, second leaf from middle portion of the second plant, third leaf from the bottom portion of the third plant and so on.

Four physico-morphic leaf characteristics viz., no. of gossypol glands, density of hair, length of hair on midrib and thickness of leaf lamina, were studied. Three randomly selected plants were chosen per plot and one leaf each from upper, middle and lower portion was taken for physico-morphic studies. CARL ZEISS binocular microscope was used to study the no. of gossypol glands, hair density and length of hair on midrib/cm, from three different places of each leaf. The thickness of leaf lamina was studied by cutting the cross section (one cm^2) from three different places of each leaf with the help of a fine razor and thickness was measured by using an ocular micrometer under binocular microscope. Meteorological data regarding temperature, relative humidity, sunshine and wind speed was obtained from Department of Crop Physiology, University of Agriculture, Faisalabad.

Kolmogorov-Smirnov test (normality test) was applied before any statistical analysis. The data regarding mean population of *B. tabaci* per leaf, physico-morphic characters of the leaves and meteorological data were analyzed statistically by using Statistix 8.1 (Analytical software, 2005) to screen out the susceptible and resistant varieties and determine the role of meteorological and morphological plant characters, mediating host plant resistance.

RESULTS AND DISCUSSION

***B. tabaci* population:** The data regarding mean population of *B. tabaci*/leaf on subjected cotton genotypes during the cropping season of 2008 and 2009 is presented in Table 1. During 2008, *Bt*-496 appeared to be the most susceptible genotype followed by *Bt*-121 and *Bt*-3701, both having non significantly different *B. tabaci* population while all the remaining genotypes showed resistance to *B. tabaci* and were statistically at par. During 2009, again *Bt*-496 had highest mean *B. tabaci* population/leaf while all the other genotypes were statistically at par except *Bt*-703 which had a minimum *B. tabaci* population/leaf.

Correlation was worked out for mean *B. tabaci* population/leaf against physico-morphic leaf characteristics and meteorological parameters

Table 1. Mean *B. tabaci* population (±SE) per leaf in different cotton genotypes during 2008 and 2009

Cotton genotype	***B. tabaci* Population/leaf**	
	2008	2009
Bt-121	3.55 ± 0.51ab	3.58 ± 0.32 abc
Bt-196	2.30 ± 0.55 b	2.58 ± 0.98 abc
Bt-313	1.97 ± 0.84 b	2.58 ± 0.51 abc
Bt-333	2.47 ± 0.22 b	4.24 ± 0.68 ab
Bt-496	4.52 ± 0.49 a	4.97 ± 1.01a
Bt-703	2.53 ± 1.00 b	1.41 ± 0.39 c
Bt-802	2.75 ± 0.95 b	2.78 ± 0.83 abc
Bt-1524	2.17 ± 0.06 b	3.23 ± 1.25 abc
Bt-3701	3.19 ± 0.49 ab	3.59 ± 0.66 abc
Bt-W1	2.36 ± 0.47 b	2.09 ± 0.96 bc
F-ratio	4.28	4.75
P value	<0.01	<0.01

Means sharing the same letters within a column are non significant at P>0.05 (ANOVA and Tukey's HSD test) separately (Table 2). During 2008, *B. tabaci* population was significantly and positively correlated (P<0.05) with gossypol glands and lamina thickness, while among the meteorological parameters minimum temperature (P<0.01) and wind speed showed significant negative correlation (P<0.05) while sunshine was highly significantly and positively correlated (P<0.01) with *B. tabaci* population.

During 2009, *B. tabaci* population showed highly significant and positive correlation with gossypol glands (P<0.01) and significant negative correlation (P<0.05) with hair length. Minimum temperature and Sunshine showed significant (P<0.05) negative and positive correlation with *B. tabaci* population respectively (Table 2).

Physicomorphic characteristics

(1) 2008

Studies on the physico-morphic characteristics of the leaves revealed that hair length (Mµ) on midrib was maximum on *Bt*-703 and minimum on *Bt*-496 while the remaining genotypes were statistically at par (Fig. 1.1). Maximum hair density on midrib/cm was observed on *Bt*-496 followed by *Bt*-196 and *Bt*-W1; both were statistically at par while minimum hair density was observed on *Bt*-333 and *Bt*-3701(Fig. 1.2). *Bt*-196 and *Bt*-496 had highest no. of gossypol glands/cm of midrib while *Bt*-333 had the lowest no. of gossypol glands/cm of midrib (Fig. 1.3). Maximum lamina thickness was observed in leaves of *Bt*-496 while the remaining genotypes were statistically at par (Fig. 1.4).

(2) 2009

During 2009, all the cotton genotypes were non significant with respect to hair length (Mµ) on midrib (Fig. 1.5). Highest hair density/cm of midrib was observed in *Bt*-496 followed by *Bt*-196, remaining varieties had lowest hair density/cm of midrib and were statistically at par (Fig. 1.6). Maximum no. of gossypol glands/cm of midrib was observed in *Bt*-496 while the other genotypes showed non significant behavior (Fig. 1.7). All the tested genotypes were not statistically different from each other with respect to lamina thickness (Fig. 1.8).

Based on mean population of *B. tabaci* per leaf, all the cotton genotypes under study were significantly different in their response against *B. tabaci*. The above findings regarding *B. tabaci* population, but on different sets of cotton genotypes, are in accordance with those of Hassan *et al*., 2000; Raza and Afzal, 2000; Bashir *et al*., 2001; Shad *et al*., 2001; Ali and Aheer, 2007 who reported a significant level of varietal resistance against *B. tabaci*.

All the cotton genotypes showed significant differences regarding physico-morphic characteristics. Similar results were reported by Raza (2000) and Arif *et al*. (2004, 2006). *B. tabaci* laid less number of eggs on sparsely hairy cotton variety and most of the eggs were laid on velvet hairy variety (Butter and Vir, 1991). Gossypol glands (Raza *et al*., 1999; Raza, 2000) and hair density (Riaz *et al*., 1987) on stem internodes and midrib (Bashir *et al*., 2001) showed a significant positive correlation with *B. tabaci* population. Abiotic factors also have a significant role in population fluctuation of insect pests (Murugan and Uthamasamy, 2001; Panickar and Patel, 2001). However, present findings with respect to temperature are not in conformity with those reported by Arif *et al*. (2006).

In conclusion, our study indicates that *Bt* cotton genotypes could provide resistance to *B. tabaci*, if their physicomorphic characters are improved by breeding process.

Table 2. Correlation coefficients of *B. tabaci* population/leaf against physico-morphic leaf characteristics and weather factors during 2008 and 2009

Parameters	***Bemisia tabaci* Population/leaf**	
	2008	**2009**
Gossypol glands	0.67*	0.78**
Hair density	0.61	0.50
Hair length	-0.57	-0.65*
Lamina thickness	0.66*	0.46
Minimum temp. C^o	-0.90**	-0.81*
Maximum temp. C^o	0.51	0.59
Relative humidity (%)	-0.17	-0.36
Sunshine (hours)	0.85**	0.74*
Wind speed (Km/h)	-0.70*	-0.24

*Significant at P<0.05; ** Significant at P<0.01

Figure 1.1

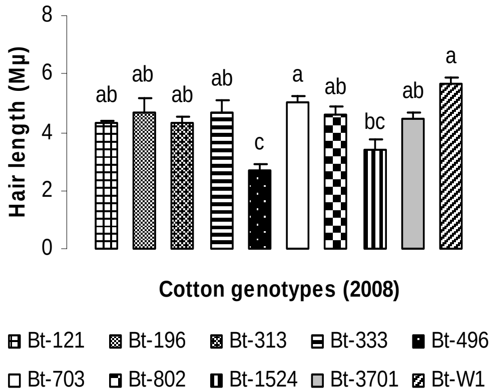


Figure 1.2

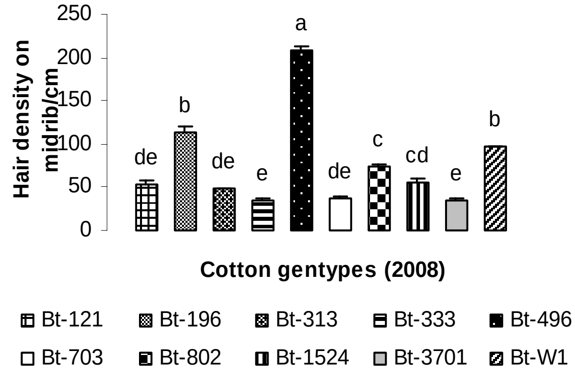
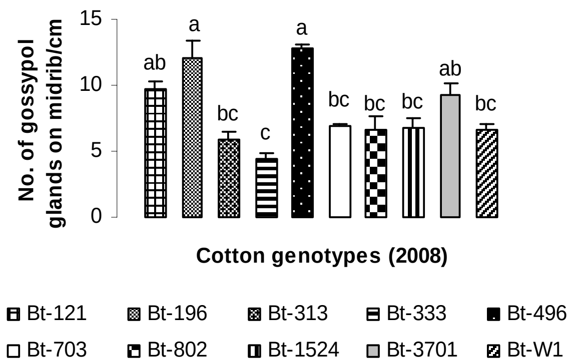


Figure 1.3



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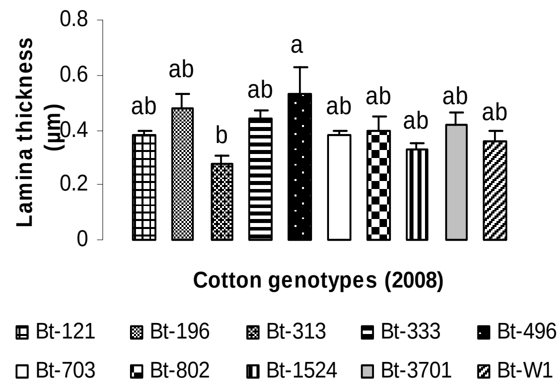

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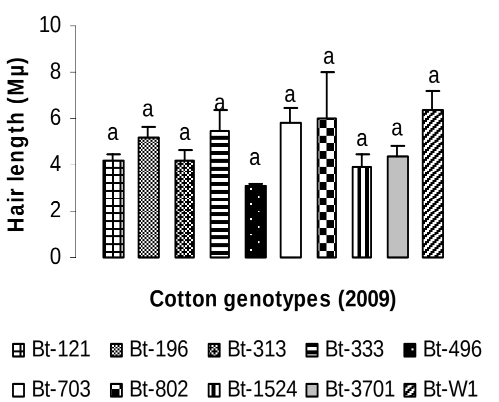

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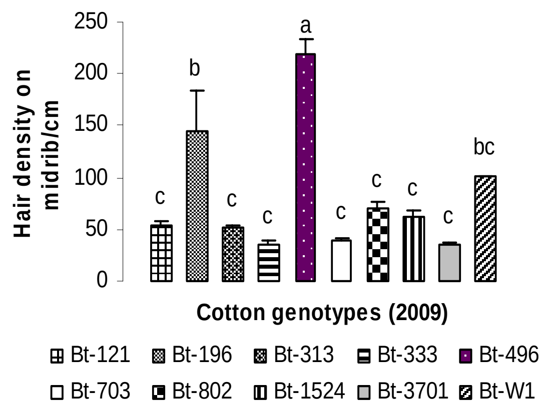

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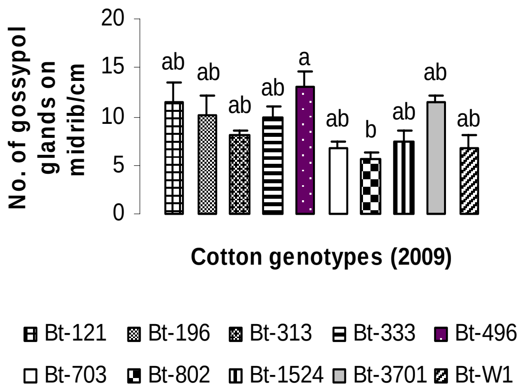
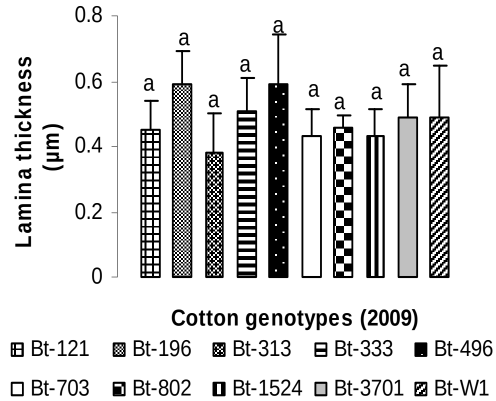


Figure 1.8



Figures from 1.1 to 1.8 represent means±S.E. of respective physico-morphic characteristics of leaves during 2008 and 2009. Bars topped with similar letters are not significantly different at P>0.05 (ANOVA and Tukey's HSD test)

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