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Oviposition Responses of *Helicoverpa armigera* Towards the Morphological Plant Characters of Some Genotypes of Cotton

Muhammad Afzal,[1] * Muhammad Ashfaq[2] and Muhammad Hamid Bashir[2]
[1]*University College of Agriculture, University of Sargodha, Sargodha*
[2]*Department of Agri. Entomology, University of Agriculture, Faisalabad*

Abstract.- Oviposition responses of *Helicoverpa armigera* were studied in different genotypes of cotton in relation to plant characters *viz.*, trichome density, trichome length and gossypol glands from midrib, veins and leaf lamina, moisture contents and thickness of leaf lamina during 2003 and 2004. Significant variations were observed in oviposition. Maximum number of eggs from upper portion of ten plants was observed from FS-628 which was 23.10, while minimum number was 8.46 which was recorded from S-12. All the characters were negatively correlated with the oviposition, except trichome length on leaf lamina having the correlation coefficient of 0.575. Trichome density on leaf lamina, thickness of leaf lamina and gossypol glands on leaf lamina had significant but negative correlation having the correlation coefficient of -0.783, -0.688 and -0.858, respectively.

Key words: Resistance, Trichome, moisture contents, gossypol glands, herbivores.

INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is a major crop of Pakistan, which has a major share in our food, textiles, and foreign exchange earnings. It is grown over an area of 3 million hectares with an average yield of 633 kg of cotton lint per hectare in Pakistan (Anonymous, 2006). This is much lower as compared to that of many other cotton growing countries of the world. There are many factors responsible for this low yield. Among these factors, insect pests are of most significance which causes heavy losses in the quality as well as quantity of cotton. The losses, of 30 to 40% (Chaudhry *et al.*, 1974), 16-54% (Chaudhry, 1976), 40-50% (Naqvi, 1976) and 1.12 million bales in 1999-2000 (Ahmad, 2000) have been reported during different years under different combinations of conditions. Williams (2000) reported a loss of 7.66% due to insect pests to US cotton. The losses due to insect pests are reported to be 16.1% on an overall basis in the world (Anonymous, 1988).

Almost 1326 species of insects and mites have been reported to feed on cotton plant and *Helicoverpa armigera* (Hubner) is the most serious among them (Butter and Singh, 1996). The failure of cotton crop has been observed in different cotton growing areas all over the world due to the attack of this notorious pest (Zalucki *et al.*, 1986; Fitt, 1989). *Helicoverpa* species are highly polyphagous which is reflected by the long list of wild and cultivated host plants accepted for oviposition and feeding. Eggs and larvae have been recorded on more than 60 plant species belonging to 47 families (Zalucki *et al.*, 1986, 1994). It has been observed being the pest of all the field and horticultural crops but it has the status of major pest of maize, sorghum, tomato, lucerne, tobacco, cotton and cowpea. Larvae cause direct damage to flowering and fruiting parts of the plants. Extensive and indiscriminate use of insecticides has developed resistance in the pest which has resulted in low yield and high control cost. Continuous and indiscriminate use of synthetic insecticides to control the population of *H. armigera* has created health problems not only to humans and animals but polluted the environment as well. XiWu *et al.* (1996), Armes *et al.* (1996), GeMei *et al.* (1997) and Tan and McCaffery (2007) reported that this pest had high resistance to pyrethroid, organophosphate and carbamate insecticides. Even the increased tolerance of this pest to transgenic cotton from China has been reported by Li *et al.* (2007). Increased resistance to insecticides in *H. armigera* (Forrester *et al.*, 1993; McCaffery, 1998; Murray *et al.*, 2005) has lead to provoke the interest in developing alternatives of the chemical control including the development of resistant varieties (Stanton *et al.*, 1990; Wilson *et al.*, 1998). There are

* Corresponding author: chafzal64@yahoo.com
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many plant characters which may have positive or negative effects on plant feeders and their bio-control agents (Krips *et al.*, 1999; Afzal and Bashir, 2007). The morphological characters are known to contribute a lot towards the host plant resistance (Woodhead and Taneja, 1987; Patel and Sukhani, 1990; Kumar, 1992, 1997; Rebe *et al.*, 2004). The morphological characters are most important because they effect the selection of the plant as a preferred host for oviposition and feeding. Understanding the host selection behaviour and effect of various morphological plant characters is an important prerequisite for developing the pest management strategies. The breeders in Pakistan have focused their attention to increase the yield potential and evolved a number of varieties for this purpose. Much attention is required to be paid on the morphological characters or mechanical barriers possessed by the plants, which either prevent the feeding and/ or oviposition on them. Attempts on exploring the methodologies to develop the resistance to pest complex in cotton due to morphological plant characters have been made in Pakistan by Ali and Ahmad (1982), Ahmad *et al.* (1987), Riaz *et al.* (1987), Zia *et al.* (1987) and Bashir *et al.* (2001) but a lot remains yet to be done to arrive at some more definite results.

Considering the above facts the present project was planned to screen 9 cotton genotypes *i.e.*, BH-36, FH-634, FH-645, FH-682, FS-628, MNH-554, RH-295, S-12 and VH-137, which were previously screened out of 25 cultivars, on the basis of preference of *H. armigera* for oviposition with the objective to determine morphological leaf characters responsible for the acquisition of resistance against this pest.

MATERIALS AND METHODS

The present studies were conducted in District Toba Tek Singh and Faisalabad, Punjab (Pakistan) during 1997 and 1998. Preliminary screening trial was carried out by screening of 25 varieties of cotton to test the comparative resistance, susceptibility and intermediate responses against *H. armigera* by using the oviposition preference as a tool to determine resistance at farmer's field level. The test was conducted by using the randomized complete block design with three replications.

Morphological characters of the plant

Moisture percentage in leaves

Three samples, each of 100 g top leaves (5 to 7 days old) of selected genotypes were taken from every plot. All leaves under experiment were cleaned with muslin cloth, weighed, classified and kept into a drying oven run at 100 $\pm$ 5° C for 12 h. The dry matter of leaves was weighed and put back into the oven at the same temperature for another 6 h. After the weight of the dry materials became constant, the moisture percentage was calculated using the following formula: -

$$\text{Moisture (\%)} = \frac{\text{A-B}}{\text{A}} \times 100$$

where A is weight of fresh leaves, and B, weight of dry leaves.

Trichome density

Three fresh leaves (5 to 7 days old) from top portion of the plant of each selected genotype of cotton from each plot were taken. Trichome density was recorded on midrib, vein and lamina of each leaf from three different places under a Binocular Microscope. The trichome density on leaf midrib and veins was measured from 1 cm length and the unit of measurement for leaf lamina was 1 cm^2. The magnification of binocular was kept as 10X.

Trichome length

Three fresh (5 to 7 days old) from top portion of each genotype were used to measure the length of the trichomes. The trichomes were pealed off by using a fine razor. Temporary slides were prepared by placing these trichomes in glycerin. The length was measured with the help of a micrometer fitted in a binocular microscope. Trichome length was recorded from three places each from mid rib, veins and leaf lamina. The measuring unit was mm.

Thickness of leaf lamina

A cross section of leaf from each selected genotype was cut with the help of a fine razor and thickness of lamina was determined from three

different places on each leaf with the help of an ocular micrometer under a binocular microscope.

Gossypol glands

The number of gossypol glands on midrib, vein and lamina were counted under a Carl Zeiss binocular microscope from three different places of each 5 to 7 days old leaf of each selected genotype. The unit area of measurement for midrib and vein was 1 cm in length whereas for lamina it was 1 cm^2.

Data on oviposition

Data on eggs laid by the female *H. armigera* were collected from 10 plants taken at random from each plot. Upper 45 cm of each plant was searched thoroughly to record the data on oviposition as described by Butter and Singh (1996). The observations were recorded at 7-8 days interval between July and November. Finally the data were analysed to determine the role of morphological plant characters in oviposition preference of *H. armigera.*

RESULTS AND DISCUSSION

Data regarding the oviposition and morphological plant characters are packed in Table I. Significant variations were observed in oviposition of *H. armigera* on different cotton varieties. Maximum oviposition was observed on FS-628 (23.10) which is statistically at par with those of on FH-645 (21.43) and FH-634 (21.23). The minimum number of eggs were laid on S-12 which were 8.46 having no difference with 8.76 and 9.03 on RH-295 and FH-682 respectively. These results can be compared with those of JuYing *et al.* (1996), Butter and Singh (1996), Murthy *et al.* (1998), Jallow *et al.* (2001) and Ahmad *et al.* (2004) who reported varied number of eggs laid by *Helicoverpa* spp. on different cotton cultivars.

Significant variations were observed in all the morphological characters except moisture contents in different cotton genotypes. Maximum thickness of leaf lamina was found in FH-682 while minimum was found on FS-628. Maximum numbers of leaf hairs were recorded on midrib of FH-682 (234), veins of FH-645 (215.11) and lamina of S-12 (282) while minimum on midrib (136.66), and vein

Table I.- Comparison of means of oviposition and morphological plant characters.

Variety	Oviposition**	Moisture %ns	Thickness of leaf lamina**	Trichome density			Trichome length			Gossypol glands		
				Midrib**	Vein**	Lamamina**	Midrib**	Vein**	Lamamina**	Midrib**	Vein**	Lamamina**
BH-36	14.50 b	83.33	0.44 d	173.11 d	186.44 b	154.44 f	1.33 e	2.22 c	1.19 bcd	15.66 f	18.67 c	32.22 b
FH-634	21.23 a	83.55	0.55 c	86.22 g	138.33 c	125.00 g	1.55 d	1.67 f	1.91 a	20.44 de	21.19 bc	17.91 c
FH-645	21.43 a	82.33	0.47 cd	159.77 e	215.11 a	107.00 h	2.00 bc	1.33 g	1.33 bc	16.22 f	14.96 d	18.66 c
FH-682	9.03 c	82.00	0.98 a	234.00 a	156.22 c	211.44 c	2.19 b	2.55 b	1.22 bc	19.33 e	26.22 a	41.91 a
FS-628	23.10 a	81.66	0.25 e	173.44 d	153.77 c	189.77 d	2.00 bc	1.85 e	1.33 bc	20.22 de	14.66 d	30.22 b
MNH-554	13.60 b	82.55	0.48 cd	221.22 b	141.44 c	174.22 e	1.91 c	1.91 de	1.41 b	27.91 ab	21.91 b	32.44 b
RH-295	8.76 c	83.11	0.77 b	167.77 de	200.66 ab	267.44 b	0.93 f	1.22 g	1.12 cd	25.67 bc	15.22 d	38.20 a
S-12	8.46 c	82.66	0.54 cd	194.77 c	222.44 a	282.00 a	2.22 b	2.00 d	1.22 bcd	22.91 cd	21.77 b	38.77 a
VH-137	13.70b	82.22	0.52 cd	136.66 f	72.77 d	204.44 c	3.44 a	2.93a	1.09 d	29.66 a	27.22 a	31.91 b

** = Significant at $P \leq 0.01$.
LSD = Least Significant Difference
Means sharing similar letters are not significant different by DMR Test at P = 0.05

Table II: Correlation matrix among morphological plant characters and their impact on oviposition of *H. armigera*

	X1	X2	X3	X4	X5	X6	X7	X8	X9	X10	X11	X12
X1	**1.00**											
X2	**-0.11**	**1.00**										
X3	**-0.548**	**-0.477**	**1.00**									
X4	**-0.156**	**0.214**	**0.266**	**1.00**								
X5	**-0.783****	**-0.127**	**0.402**	**0.168**	**1.00**							
X6	**-0.005**	**-0.596**	**0.015**	**-0.609***	**0.051**	**1.00**						
X7	**-0.286**	**-0.329**	**0.189**	**-0.656***	**0.138**	**0.739***	**1.00**					
X8	**0.575**	**0.394**	**-0.528**	**-0.120**	**-0.569**	**0.251**	**-0.328**	**1.00**				
X9	**-0.688***	**0.088**	**0.320**	**0.063**	**0.373**	**-0.100**	**0.131**	**-0.182**	**1.00**			
X10	**-0.392**	**-0.103**	**0.031**	**-0.544**	**0.489**	**0.405**	**0.256**	**-0.202**	**0.085**	**1.00**		
X11	**-0.452**	**-0.100**	**0.142**	**-0.617***	**0.175**	**0.657***	**0.836****	**-0.059**	**0.433**	**0.427**	**1.00**	
X12	**-0.858****	**-0.245**	**0.724***	**0.081**	**0.845****	**0.053**	**0.387**	**-0.691***	**0.512**	**0.319**	**0.334**	**1.00**

*, Significant at $P \leq 0.05$; * *, Significant at $P \leq 0.01$.

Whereas; X1, oviposition; X2, moisture content (%); X3, trichome density on leaf mirib; X4, trichome density on leaf vein; X5, trichome density on leaf lamina; X6, length of trichome on midrib; X7, length of trichome on veins; X8, length of trichome on lamina; X9, thickness of leaf lamina; X10, gossypol glands on midrib; X11, gossypol glands on veins; X12, gossypol glands on leaf lamina

(72.77) of VH-137 and on lamina of FH-645 (107). Maximum trichome length on midrib was 3.44, veins 2.93 on VH-137 and on lamina 1.91 of FH-634 while minimum trichome length was recorded on midrib (0.93) and veins (1.22) of RH-295 and lamina of VH-137 (1.09). Highest number of gossypol glands on midrib and veins of VH-137, and lamina of FH-682 which were 29.66, 27.22 and 41.91 respectively. The minimum gossypol glands were recorded from midrib of BH-36 (15.66), veins of FS-628 (14.66) and lamina of FH-634 (17.91).

These results are in line with those of Butter and Singh (1996), Raza *et al.* (2000) and Bashir *et al.* (2001) who reported significant variations in the morphological plant characters in different cotton genotypes.

The results (Table II) indicate that there is a weak correlation that exists among other morphological characters and moisture contents of the leaf. None of the morphological characters showed significant correlation with moisture contents. Trichome density on midrib had some correlation with gossypol gland on leaf lamina with 0.724 value of correlation coefficient. Trichome density on leaf vein showed significant correlation with length of trichome on midrib and veins and gossypol glands on veins. Similarly trichome density on leaf lamina had strong correlation with gossypol glands on leaf lamina (0.858**). Length of trichome on midrib showed positive correlation with trichome length on veins and gossypol glands present on veins. Length of trichome on veins also showed significant and positive correlation with gossypol glands present on vein (0.836), but length of trichome on leaf lamina had negative but strong correlation with gossypol glands present on leaf lamina with correlation coefficient of -0.691**.

All the morphological plant characters except trichome length on lamina had negative correlation with the oviposition of *H. armigera*. Significant correlation was observed with trichome density on leaf lamina with -0.783**, thickness of leaf lamina with -0.688 and gossypol glands on leaf lamina with -.0858** values of correlation coefficient.

These results can be compared with those of Lukefahr *et al.* (1971) who suggested that reducing trichome to less than 200 per square inch of leaf surface should reduce oviposition and larval population by 50%. The present findings are also supported by the findings of various workers like Robinson *at el.* (1980), Ramalho (1984), Murthy *et al.* (1998) and Srinivasan and Uthamasamy (2005) who reported that pubescence provided a mechanism of resistance. The present findings are also in conformity with those of Bottger and Patana (1966), Oliver *et al.* (1971), Belcher *et al.* (1983), Nyambo (1985), Parrot *et al.* (1987), Cayaban *et al.* (1990), Hedin *et al.* (1991), McColl and Noble (1992), Benedict *et al.* (1993), Calhoun (1997), Calhoun and Jones (1994), Mohan *et al.* (1996),

Rajarajeswari and Subbarao (1997), Butter *et al.* (1997), Aslam *et al.* (1998, 1999) who reported that the gossypol glands significantly contribute to resistance of the plant against *H. armigera.*

From these studies it can be concluded that understanding of the interactions of plant characters and herbivores is very important in chalking out any control programme because the morphological plant characters affect the behaviour of the pest thus contribute towards resistance.

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Table I.- Comparison of means of oviposition and morphological plant characters.

Variety	Oviposition**	Moisture %ns	Thickness of leaf lamina**	Trichome density			Trichome length			Gossypol glands		
				Midrib**	Vein**	Lamamina**	Midrib**	Vein**	Lamamina**	Midrib**	Vein**	Lamamina**
BH-36	14.50 b	83.33	0.44 d	173.11 d	186.44 b	154.44 f	1.33 e	2.22 c	1.19 bcd	15.66 f	18.67 c	32.22 b
FH-634	21.23 a	83.55	0.55 c	86.22 g	138.33 c	125.00 g	1.55 d	1.67 f	1.91 a	20.44 de	21.19 bc	17.91 c
FH-645	21.43 a	82.33	0.47 cd	159.77 e	215.11 a	107.00 h	2.00 bc	1.33 g	1.33 bc	16.22 f	14.96 d	18.66 c
FH-682	9.03 c	82.00	0.98 a	234.00 a	156.22 c	211.44 c	2.19 b	2.55 b	1.22 bc	19.33 e	26.22 a	41.91 a
FS-628	23.10 a	81.66	0.25 e	173.44 d	153.77 c	189.77 d	2.00 bc	1.85 e	1.33 bc	20.22 de	14.66 d	30.22 b
MNH-554	13.60 b	82.55	0.48 cd	221.22 b	141.44 c	174.22 e	1.91 c	1.91 de	1.41 b	27.91 ab	21.91 b	32.44 b
RH-295	8.76 c	83.11	0.77 b	167.77 de	200.66 ab	267.44 b	0.93 f	1.22 g	1.12 cd	25.67 bc	15.22 d	38.20 a
S-12	8.46 c	82.66	0.54 cd	194.77 c	222.44 a	282.00 a	2.22 b	2.00 d	1.22 bcd	22.91 cd	21.77 b	38.77 a
VH-137	13.70b	82.22	0.52 cd	136.66 f	72.77 d	204.44 c	3.44 a	2.93a	1.09 d	29.66 a	27.22 a	31.91 b

** = Significant at $P \leq 0.01$.
LSD = Least Significant Difference
Means sharing similar letters are not significant different by DMR Test at P = 0.05