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EFFECT OF PHYSICO-MORPHIC CHARACTERS ON POPULATION OF WHITEFLY *BEMISIA TABACI* IN TRANSGENIC COTTON

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We examined the effect of physico-morphological characters on whitefly *Bemisia tabaci* population in transgenic cotton at University of Agriculture Faisalabad research area with available genotypes. Physico-morphological characters such as number of gossypol glands, trichome density count, trichome length, moisture contents (%) in leaves, and thickness of leaf lamina was correlated with whitefly population. The maximum trichome's length on leaf vein was recorded to be 4.73/cm on the leaves of genotype Bt-2016 and differed significantly from those of observed on the leaves of all other genotypes. The maximum moisture percentage in the leaves was recorded to be 78.85% in FH-114 and did not differ significantly from those observed in Bt-2086 and BT-802 with 77.54 and 76.47 percent moisture contents in their leaves, respectively. The maximum trichome's density was recorded to be 490.96/cm on leaf midrib of Bt-2016 and showed significant variation from those of observed in all other genotypes. The genotype FH-113 possessed maximum number of gossypol glands i.e. 43.55/cm on leaf midrib and differed significantly from those of observed in all other genotypes. The maximum thickness of leaf lamina was recorded to be 1.97 mm on genotype BT-2086 and showed significant difference from those found on all other genotypes. The results revealed that hair density on midrib and vein, gossypol glands on midrib, vein and lamina and moisture percentage in the leaves showed significant and positive correlation with the population of whitefly. Hair length and thickness of leaf lamina exerted negative and significant effect on the pest population.
Keywords: *Bemisia tabaci,* Bt. cotton, population, physico-morphic plant characters

INTRODUCTION

Pakistan stands fourth in world cotton producing countries after China, USA and India (Abro *et al.,* 2004). Cotton contributes 22.11% in the national economy by the value added products in agriculture and contributed 11 percent to the economy's gross domestic products (GDP) in 2004-05 (Naqvi and Nosheen, 2008). Introducing novel resistance genes into economically important crops can develop insect resistant crops. This tactic has a potential key role in integrated pest management of several important pests (Gatehouse an Gatehouse, 1998). Most of the research and development has focused on the transfer of genes expressing toxins produced by the soil-borne bacterium, *Bacillus thuringiensis* (Berliner) (Bt) into food, grain and fiber plants (Vaeck *et al*., 1987).

Physical plant traits are the most important aspects in the sustainable pest management of cotton. No study on this approach has so far been conducted with reference to BT-cotton. Whitefly showed positive correlation with hair density and hair length on midrib vein and lamina (Raza *et al*., 2000; Bashir *et al*., 2001). Aheer *et al*. (1999) reported that hair density on vein showed positive and significant correlation with whitefly population. Chu *et al.* (2003) reported that the density of branched stellate trichomes on under leaf surfaces was the basic factor influencing the varietal susceptibility to adult *B. tabaci*. Keeping in view the existing situation of outbreaks of piercing sucking insects on Bt cotton there is a direct need to develop an effective and sound pest-management program that is well suited not only to the ecological requirements particularly the weather factors which play a key role in the multiplication and distribution of insect pests but also to evaluate the physic-morphic make up of the Bt cotton varieties in relation to pest resistance.

As the work done on this aspect is quite scarce and needs extension. Thus the present study has been taken up to find out the exact nature or degree of relationship between pest population and weather factors as well as the physico-morphic traits of different transgenic cotton varieties in relation to these non-target pests.

MATERIALS AND METHODS

The study was conducted on the effect of physico-morphological characters on cotton whitefly *Bemisia tabaci* population at Postgraduate Agriculture

Research Station (PARS) field area of Department of Agri. Entomology, University of Agriculture, Faisalabad during 2006. Available BT genotypes of cotton were sown following RCBD, replicated thrice during 2006. Nine BT genotypes were selected, showing 3 susceptible, 3 resistant and 3 intermediate based on population density count for further investigations. These selected genotypes were again sown in the same experimental area during 2006 following RCBD replicated thrice to study the population dynamics and physico-morphological characters. The population of whitefly nymph and adults were recorded early in the morning at seven days interval. Fifteen leaves were randomly selected from 15 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 was considered for data count.

Physico-morphological Plant Characters

Trichome length (cm)**:** Length of hair was recorded from midrib, veins and lamina of each leaf. Three samples of hairs each from midrib, veins and leaf lamina of each leaf were taken into account. A sample of hair was pealed off with the help of fine razor and mounted on a slide. The slide was observed under a CARL ZEISS binocular microscope to determine the length of hair by using an ocular micrometer. At last, factor for ocular micrometer was calculated with the help of stage micrometer. Then this factor was multiplied with the number of divisions recorded for each sample of hair.

No. of gossypol glands**:** The number of gossypol glands on midrib, veins and leaf lamina were counted from lower side of the leaves under a CARL ZEISS binocular microscope from three different places of each leaf. The area from midrib and veins was 1 cm in length, whereas for lamina, it was one cm^2. For this purpose an iron made dye of 1 cm^2 was used.

Trichome density count**:** Three leaves each selected at random from upper, middle and lower portions from nine genotypes of Bt cotton were taken from each plot. The number of hairs on midrib, veins and lamina were counted from the lower side of the leaves as described above.

Moisture contents in leaves (%): Three samples of 10 grams leaves from upper, middle and lower portions f nine genotypes of Bt cotton were collected from each plot. All the leaves were cleaned with muslin cloth, weighed, classified and kept in a drying oven, running at 100±5°C for 12 hours. Before keeping in oven the leaves were dried in sunshine for 2 days. The dry matter of leaves was weighed and put back into the oven, at the same temperature for another six hours when the weight of dry material became constant. The moisture percentage was counted by the following formula:

$$\text{Moisture \%age} = \frac{\text{Wt. fresh leaves} - \text{Wt. dry leaves}}{\text{Wt. of fresh leaves}} \times 100$$

Thickness of leaf lamina (mm): A cross section of leaves was cut with the help of a fine razor and thickness of leaf lamina was determined from three different places of each leaf with the help of an ocular micrometer under a CARL ZEISS binocular microscope. Again the factor that was calculated for ocular micrometer with the help of stage micrometer was multiplied with the number of divisions recorded for each sample of leaf lamina.

RESULTS

Trichome length (cm)**:** The data regarding trichome's length on leaf midrib on different genotypes of Bt cotton are given in the analysis of variance (Column A of Table 1 and 2) reveals non-significant variation among genotypes. However, the trichome's length on leaf ranged from minimum of 3.33 /cm to 9.45 /cm. Nothing could be concluded from these results as the variation among genotypes was found to be non-significant. Differences were found to be significant ($P < 0.01$) among genotypes regarding trichome length of leaf vein (Column B of Table 1 and 2). The maximum trichome's length on leaf vein was recorded to be 4.73/cm on the leaves of genotype Bt-2016 and differed significantly from those of observed on the leaves of all other genotypes. The minimum length of trichomes was recorded to be 3.18 mm in the leaves of AA-703 and also differed significantly from all other genotypes. The genotypes Bt-1402, Bt-802, FH-114, Bt-2086, FH-113, Bt-121 and Mg-6 possessed 4.22, 4.06, 3.27, 3.89, 3.39, 3.63 and 3.75 mm trichome's length on the vein of their leaves, respectively and differed significantly from one another. From these results it is concluded that the genotype Bt-2016 showed maximum length of trichomes on the vein whereas AA-703 had minimum trichome's length on the vein of its leaves.

Significant variations were found to exist among genotypes regarding trichome's length on leaf lamina (Column C of Table 1 and 2). The maximum length of trichomes on was recorded to be 3.15/cm^2 on the leaves of Bt-802 and differed significantly from those of recorded on the leaves of all other genotypes. The

Table 1. Analysis of variance (mean squares) of the physico-morphic characters plant factor in different genotypes of Bt cotton

SOV	DF	Trichome Length			Trichome Density			Gossypol Glands			Thickness	Moisture
		Midrib/cm (A)	Vein/cm (B)	Lamina/cm^2 (C)	Midrib/cm (D)	Vein/cm (E)	Lamina/cm^2 (F)	Midrib/cm (G)	Vein/cm (H)	Lamina/cm^2 (I)	of Lamina /cm² (J)	(K)
Variety	8	10.732^{NS}	0.7419**	0.5949**	34714.9**	25402.5**	39835.0**	152.29**	26.259**	317.29**	0.8969**	8.42777**
Error	18	9.293	0.0015	0.00092	98.9	43.2	166.00	5.997	0.3093	6.092	0.0007	2.0185

Table 2. Means comparison of the data regarding physico-morphic traits in different Bt cotton

Genotypes	TRICHOME LENGTH			TRICHOME DENSITY			GOSSYPOL GLANDS			THICKNESS OF LAMINA/cm² (mm) (J)	MOISTURE % age (K)
	midrib/cm (A)	vein/cm (B)	lamina/cm^2 (C)	midrib/cm (D)	vein/cm (E)	lamina/cm^2 (F)	midrib/cm (G)	vein/cm (H)	lamina/cm^2 (I)		
MG-6	3.96 b	3.75 e	2.64 d	184.29 f	123.56 f	202.70 f	29.33 d	5.86 d	35.96 d	1.547 c	74.59 cd
AA-703	3.77 b	3.19 i	2.37 e	156.96 g	101.63 g	165.07 g	26.41 def	4.63 e	30.61 e	0.370 h	75.62 bcd
BT-121	3.33 b	3.63 f	2.01 h	216.63 e	136.37 e	234.85 d	22.81 f	5.44 de	28.85 e	1.777 b	74.13 cd
FH-113	3.68 b	3.39 g	2.26 f	216.63 e	133.93 ef	228.88 de	43.55 a	12.96 a	58.40 a	0.970 f	75.22 bcd
BT-2086	4.05 b	3.89 d	2.15 g	235.63 d	156.33 d	211.81 ef	34.89 c	3.44 f	23.37 f	1.977 a	77.54 ab
FH-114	3.52 b	3.27 h	3.06 b	350.33 b	228.55 b	362.30 c	39.33 b	9.37 b	43.34 b	1.047 e	78.85 a
BT-802	9.44 a	4.07 c	3.16 a	365.07 b	223.29 b	385.63 b	35.55 bc	7.18 c	40.12 bc	0.663 g	76.47 abc
BT-2016	4.22 ab	4.73 a	2.98 c	490.96 a	403.85 a	519.96 a	27.96 de	9.11 b	37.34 cd	1.757 b	75.95 bcd
BT-1402	4.14 b	4.23 b	3.07 b	320.22 c	196.33 c	345.66 c	24.22 ef	5.44 de	30.18 e	1.190 d	73.55 d
S.E	2.489	0.032	0.025	8.12	5.32	10.519	2.00	0.454	2.015	0.021	1.16
LSD	5.229	0.067	0.052	17.06	11.27	22.101	4.20	0.954	4.234	0.045	2.44

genotypes FH-114 and Bt-1402 showed non-significant difference with each other having 3.05 and 3.06/cm^2 trichome's length, respectively and were next in descending order from the maximum figure. The minimum trichome's length on leaf lamina was observed to be 2.01/cm^2 in Bt-121 and showed significant variations from those of recorded in all other genotypes. The genotypes MG-6, AA-703, FH-113, BT-2086 and Bt-2016 possessed 2.63, 2.37, 2.26, 2.15 and 2.97/cm^2 trichome's length on leaf lamina, respectively and differed significantly from one another. From these results it is concluded that Bt-802 had maximum length of trichomes on leaf lamina whereas Bt-121, had the minimum.

Moisture contents in leaves: Differences were found to be significant among genotypes regarding moisture percentage in their leaves (Column K of Table 1 and 2). The maximum moisture percentage in the leaves was recorded to be 78.85% in FH-114 and did not differ significantly from those observed in Bt-2086 and BT-802 with 77.54 and 76.47 percent moisture contents in their leaves, respectively. The genotype FH-113 had 75.22% moisture content in leaves and showed non-significant variation with those recorded on all genotypes of cotton except FH-114. The moisture content ranged from 73.55 to 77.54 percent. From these results it is concluded that FH-114 showed maximum moisture content whereas BT-1402 had minimum moisture percentage in their leaves.

Trichome's density: The results (Column D of Table 1 and 2) reveal significant ($P < 0.01$) difference among genotypes regarding trichome's density on leaf midrib. The maximum trichome's density was recorded to be 490.96/cm on leaf midrib of Bt-2016 and showed significant variation from those of observed in all other genotypes. The minimum trichome's density was found to be 156.96/cm on the leaf midrib of AA-703 and also showed significant difference from those recorded on all other genotypes. Non-significant difference was found to exist between Bt-121 and FH-113 each showed 216.63 trichome's density per cm, respectively and in between FH-114 and Bt-802 with 350.33 and 365.07 trichome's density per cm, respectively. The genotype MG-6, Bt-2086 and Bt-1402 possessed 184.29, 235.63 and 320.22 trichome's density per cm, respectively and differed significantly from one another as well as from those of observed in all other genotypes. It is concluded from these results that the genotype Bt-2016 possessed maximum trichome's density on midrib whereas AA-703 showed minimum trichome's density.

Significant variations were found among genotypes regarding trichome's density on leave vein in different genotypes of Bt-cotton (Column E of Table 1 and 2). The maximum trichome's density was recorded to be 403.85/cm on leaf vein of BT-2016 and differed significantly from those recorded on all other genotypes. The minimum trichome's density was found to be 101.63/cm on leaf vein of AA-706 and also showed significant difference with those observed on all other genotypes. The genotypes FH-114 and BT-802 possessed 228.55 and 223.29 trichome's density per cm, respectively and did not differ significantly with each other. Similarly non-significant variation was found to exist in between BT-121 and FH-113 showing 136.37 and 133.93 trichome's density per cm, respectively. The number of trichomes was recorded to be 123.56, 156.33 and 196.33/cm on MG-6, BT-2086 and BT-1402, respectively and showed significant variation with one another as well as from all other genotypes. From these results it was concluded that the genotype BT-2016 showed maximum number of hair on leaf vein whereas AA-703 possessed minimum trichomes.

The results (Column F of Table 1 and 2) reveal significant difference among genotypes regarding trichome's density on leaf lamina. The maximum trichome's density was recorded to be 519.96/cm^2 on Bt-2016 and differed significantly from those observed in all other genotypes. The minimum trichome's density on leaf lamina was found to be 165.07/cm^2 on AA-703 and also differed significantly from those recorded on all other genotypes. The genotype MG-6 possessed 202.70 trichome's density per cm^2 on leaf lamina and did not differ significantly with those of observed on Bt-2086 with 211.81 trichome's density per cm^2. Non-significant difference was found to exist in between FH-114 and Bt-1402 with 362.30 and 345.66 trichome's density per cm^2 on their leaf lamina, respectively. The genotype Bt-121 showed 234.85 trichome's density per cm^2 and did not differ significantly from those observed on FH-113 with 228.88 trichome's density per cm^2. The genotype Bt-802 showed 385.63 trichome's density per cm^2 and differed significantly from those of observed in all other genotypes and ranked in 2nd descending order from the maximum. It is concluded from these results Bt-2016 showed maximum trichome's density whereas AA-703 had minimum trichome's density on their leaf lamina.

Gossypol glands: Significant differences $P < 0.05$ were found to exist among genotypes regarding gossypol glands on midrib (Column G of Table 3.1 and 3.2). The genotype FH-113 possessed maximum number of gossypol glands i.e. 43.55/cm on leaf midrib and differed significantly from those of observed in all

Table 3. Correlation coefficients of physico-morphic characters with whitefly population in 2006

Morph. characters	Leaf part	Population
Hair density	Midrib	0.613**
	Vein	0.428*
	Lamina	0.256*
Hair length	Midrib	0.287ns
	Vein	0.334ns
	Lamina	-0.658**
Gossypol glands	Midrib	0.660**
	Vein	0.716**
	Lamina	0.486*
Thickness of leaf lamina		-0.446*

* P<0.05, ** P<0.01, ns=non significant

other genotypes. The minimum number of gossypol glands was found to be 22.81/cm on midrib of Bt-121 and did not show significant difference with those of observed on AA-703 and Bt-1402 with 26.40 and 24.22 number of gossypol glands per cm on midrib, respectively. The genotype Bt-802 possessed 35.55/cm number of gossypol glands and did not show significant difference with those recorded on FH-114 and Bt-2086 with 39.33 and 34.89 gossypol glands per cm, respectively. The genotype MG-6 showed 29.33 number of gossypol glands and was statistically at par with those recorded on AA-703 and Bt-2016 with 26.40 and 27.96/cm gossypol glands, respectively. From these results it was concluded that the genotype FH-113 had maximum number of gossypol glands whereas Bt-121 possessed minimum number of gossypol glands.

Variations were found to be significant among genotypes regarding gossypol glands on vein (Column H of Table 3.1 and 3.2). The maximum gossypol glands was recorded to be 12.96 per cm on leaf vein of FH-113 and differed significantly from those observed in all other genotypes. The minimum gossypol contents was found to be 3.44/cm of leaf vein on Bt-2086 and also showed significant variation from those observed in all other genotypes. The genotype FH-114 possessed 9.37 number of gossypol glands per cm and did not differ significantly from 9.11/cm number of gossypol glands on Bt-2016. The genotype BT-802 possessed 7.18/cm number of gossypol glands and differed significantly from those observed in all other genotypes. Bt-1402 showed 5.44 number of gossypol glands per cm and did not differ significantly from those found on BT-121, AA-703 and MG-6 with 5.44, 4.62 and 5.85 number of gossypol glands per cm on leaf vein, respectively. From these results it is concluded that genotype FH-113 had maximum number of gossypol glands whereas Bt-2086 showed minimum number of gossypol gland on leaf vein.

The results pertaining to number of gossypol glands on leaf lamina on different genotypes of BT cotton are given in Column I of Table 3.1 and 3.2. The results reveal significant difference among genotypes. The maximum number of gossypol glands was recorded to be 58.40/cm^2 on leaf lamina of FH-113 and differed significantly from those recorded on all other genotypes. The minimum number of gossypol glands was observed to be 23.37/cm^2 on leaf lamina of Bt-2086 and also showed significant difference from those observed on all other genotypes. The genotype 1402, AA-703 and BT-121 possessed 30.18, 30.60 and 28.85 number of gossypol glands per cm^2, respectively and did not differ significantly with one another. Non-significant variation was also found to exist in between MG-6 and BT-2016 with 35.96 and 37.34 number of gossypol glands per cm^2 on leaf lamina, respectively. Similarly FH-114 and BT-802 also showed non-significant difference with each other showing 43.33 and 40.12 number of gossypol glands per cm^2 on leaf lamina, respectively. The later mentioned figure also showed non-significant difference with those observed on Bt-2016 with 37.34 number of gossypol glands per cm^2 on leaf lamina. From these results, it was concluded that FH-113 possessed maximum number of gossypol glands whereas BT-2086 had minimum number of gossypol glands per cm^2 on leaf lamina.

***Thickness of leaf lamina (mm)*:** The analysis of variance (Table 1 Column J) reveals significant difference (P ≤0.01) among genotypes regarding thickness of leaf lamina. The means were compared by DMR Test at P=0.05 (Column J of Table 2). The maximum thickness of leaf lamina was recorded to be 1.97 mm on genotype BT-2086 and showed significant difference from those found on all other genotypes. The minimum thickness of leaf lamina was found to be 0.37 mm on AA-703 and also showed significant variation from those observed on all other genotypes.

The genotypes BT-121 and BT-2016 showed non-significant difference with each other showing 1.77 and 1.75 mm thickness of leaf lamina, respectively. The genotypes MG-6, BT-1402, FH-114, FH-113 and Bt-802 showed 1.54, 1.19, 1.04, 0.97 and 0.66 mm thickness of leaf lamina, respectively and differed significantly from one another. It is concluded from these results that BT-2086 showed maximum thickness of leaf lamina whereas AA-703 had minimum thickness of leaf lamina.

Physico-morphic plant characters versus population of whitefly

Various physico-morphic plant characters were correlated with the pest population and the results are given in Table 3 It is evident from the results that hair density on vein and gossypol glands on lamina showed positive and significant ($P<0.05$) correlation with the pest population showing r-values of 0.428 and 0.486, respectively. Thickness of leaf lamina had negative and significant ($P<0.05$) correlation with the pest population having r-value of -0.446. Hair length on lamina also showed negative and significant effect ($P<0.01$) on the population of the pest, whereas, gossypol gland on vein, on midrib, hair density on midrib and moisture percentage in the leaves exerted positive and significant correlation ($P<0.01$) with the pest population showing r-values of 0.716, 0.660, 0.613 and 0.725, respectively. Hair density on lamina and hair length on midrib and vein had non-significant correlation with the pest population. From these results it is concluded that moisture content, gossypol gland on vein and midrib, hair length on lamina and hair density on midrib were the most important character which showed maximum effect on the population of the pest.

The results based on multiple linear regression analysis of variance between physico-morphic characters and population of whitefly on transgenic cottons is given in Table 4 It is evident from the results that hair density on midrib showed maximum contribution in population fluctuation of white fly i.e., 42.72 percent and followed by hair density on vein, length of hair on lamina, length of hair on midrib and thickness of leaf lamina with 13.62, 10.28, 6.38 and 5.32 percent impact on the population fluctuation of the pest, respectively. The other factors like hair density on lamina, length of hair on vein, length of hair on lamina, gossypol glands on vein and gossypol glands on lamina showed negligible contribution towards per unit change in population of whitefly having 1.12, 1.08, 3.2, 0.24 and 1.11 percent impact, respectively.

DISCUSSION

Our studies clearly demonstrate positive and significant association of hair density on mid rib and veins with that of whitefly population. However the effect of hair

Table 4. Multivariate regression model between physico-morphic characters and population of whitefly on transgenic cottons

	R^2	Impact (%)
Y = 1.52 – 0.0264 X1**	42.7	42.7
Y = 1.59 – 0.0139 X1* – 0.0335 X2	56.3	13.6
Y = 1.58 – 0.0244 X1 – 0.0344X2 + 0.0265 X3	57.4	1.1
Y = 1.27 – 0.030 X1 – 0.0341 X2* + 0.0204 X3 + 0.1675 X4**	63.8	6.4
Y = 1.65 – 0.0199 X1 – 0.0367 X2 + 0.0355 X3 + 0.1876X4* – 0.1787X5	64.9	1.1
Y = 2.87 – 0.0271 X1 – 0.0411 X2 – 0.0441 X3 + 0.1256 X4* –0.2341 X5 – 0.7111 X6	68.1	3.2
Y = 3.89 – 0.022 X1** – 0.0413 X2 – 0.0256 X3 + 0.0739 X4 –0.2748 X5 – 0.778 X6* – 0.0189 X7	78.8	10.7
Y = 2.58 – 0.029 X2 – 0.046 X2 – 0.024 X3 + 0.098 X4* –0.199 X5 – 0.779 X6* – 0.039 X7 + 0.018 X8	79.0	0.2
Y = 1.88 – 0.030 X1 – 0.042 X2 – 0.028 X3 + 0.090 X4 –0.199 X5* – 0.784 X6- 0.059 X7 + 0.019 X8 – 0.023 X9	80.1	1.1
Y = 3.37 – 0.0301 X1* – 0.033 X2 – 0.019 X3 + 0.099 X4 –0.200 X5* – 0.797 X6 – 0.072 X7 – 0.023 X8 + 0.036 X9 – 0.456X10	85.4	5.3

* $P<0.05$ ** $P<0.01$

Where, Y = Population of the pest, X1 = Hair density on midrib, X2 = Hair density on veins, X3 = Hair density on lamina, X4 = Length of hair on midrib, X5 = Length of hair on veins, X6 = Length of hair on lamina, X7 = Gossypol glands on midrib, X8 = Gossypol glands on veins, X9 = Gossypol glands on lamina, X10 = Thickness of leaf lamina density on the leaf lamina had non-significant results. The present studies have been reviewed in the light of achievements made by Chu *et al*. (2003); Javed *et al*. (1992); Aheer *et al*. (2000) and Hussain et al (1999) who found similar trends in white fly population. Our findings have further been confirmed, by Chou *et al*. (2003) on the basis of number of eggs and nymphs on hairy variety which are exactly at par with our studies.

Our results on gossypol glands on mid ribs, vein and lamina have been found in accordance with the population of whiteflies the results are supported by Raza *et al*. (2000) who found that white fly population have positive correlation with the gossypol glands present on the mid ribs and veins. However these studies are not in accordance with those of Murtaza *et al.* (1999) who reported that whitefly population is negatively associated with gossypol glands on the selected cotton cultivars.

Our findings on the length of the hairs on the leaf lamina have revealed significantly negative association of white fly population, however the length of hair on the midrib and vein were found to have positive and non-significant relation with the whitefly population. Our findings are in close contact with the results of Raza *et al*. (2000) and Bashir *et al*. (2001) who reported that the length of the hairs on midrib, vein and lamina are positively associated with the adult population of whiteflies. Similarly our studies on the lamina thickness and white fly population was found to have negative correlation, the present parameter was not found in accordance with that of Murtaza *et al*. (1999).

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