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Cotton Genotypes Morpho-Physical Factors Affect Resistance Against *Bemisia tabaci* in Relation to Other Sucking Pests and its Associated Predators and Parasitoids

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Abstract.- Cotton strains having different hair length and density were evaluated for tolerance to *Bemisia tabaci, Amrasca devastans* and *Thrips tabaci,* and survival of predators and parasitoids. The seed treatment effect on the population of these insect pests and natural enemies were also studied. Population of *B. tabaci* was higher on the strain Cyto-46, having trichome density of 474±12.9 per cm^2 and hair length of 705±44.8 microns and minimum on strain Cyto-12/91, having trichome density of 1011±21.0 per cm^2 and hair length of 644±27.3 µ. However, *A. devastans* was significantly higher on strain Cyto-12/91 whereas, thrips remained significantly less on the same strain Cyto-12/91. the total number of predators were significantly higher on strains having >600 trichomes per cm^2 whereas the level of parasitism remained the same on all the strains. Seed treatment proved effective against *A. devastans* only. However, the number of predators and percent parasitism was not significantly affected by the seed treatment. Present study revealed that the early season sucking pest complex can be managed by choosing the variety having moderate leaf hair density and if variety choice is limited then the early season sucking pest especially jassid could be managed effectively by the seed treatment.

Key words: Cotton strains, hair length and density, *Bemisia tabaci,* sucking pests, seed treatment.

INTRODUCTION

Bemisia tabaci has been infesting cotton in Pakistan since long but was not a major pest until the mid 1980s. It appears in cotton field after crop establishment and continues throughout season under normal environmental conditions. Farmers depend heavily on the use of pesticides for the control of whitefly. Insecticide applied to foliage occasionally provides temporary suppression of whitefly population by killing adults (Gerling, 1967). Whitefly population quickly reappear after insecticide applications because eggs and nymphs are distributed on the underside of leaves on the lower and middle crop canopy (Ohnesorge *et al*., 1980), and are typically not contacted by foliar application of such materials. In addition, a high level of resistance in whitefly has been recorded to organophosphate (OPs) like dimethoate, methamidophos and monocrotophos, and to pyrethroids like cypermethrin and deltamethrin in Pakistan (Ahmad, 1996). In order to achieve an effective control of *B. tabaci*, devising and implementing alternative pest management strategies are inevitable. Some cotton cultivars with certain characteristics have been shown to be resistant to *B. tabaci* (Khalifa and Gameel, 1982; Butler and Henneberry, 1984). However, reaction of these cultivars besides whitefly should also include other cotton pests, since glabrous cottons were reported to show increased sensitivity to jassid (Meredith and Schuster, 1979; Lukefahr, 1977; Bailey, 1982). To overcome problems being posed by chemical control resistance and environmental issues, there is a need to develop some alternative control strategies. Development of cotton cultivars resistance to whitefly is one approach. Therefore, cotton cultivar selection could become an important component of an integrated pest management program to manage *B. tabaci*. The mechanism of resistance in the cotton crop is sometime contradictory *e.g.,* glabrous cotton is resistance to *B. tabaci* and susceptible to *Empoasca* spp., *Heliothis* spp., thrips and cotton aphid. On the other hand high gossypol cotton, which is resistance to *Heliothis* spp. and *Spodoptera* spp. was found to be susceptible to *B. tabaci* (Schuster, 1979). In Pakistan, we have cotton insect pest complex

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therefore, a thorough understanding of the interaction between the insect, natural enemies and their host plants are needed for long term solutions that offer economical and environmental advantages. Host plant resistance has potential as an integrated pest management component for suppression of sweetpotato whitefly populations (Berlinger, 1986) and may provide a more bio-rational approach for reducing the impact of sweetpotato whitefly transmitted viruses and plant disorders than reliance on pesticides.

The objectives of this study were to (i) evaluate the survival of whitefly in relation to jassid and thrips in three cotton strains having different hair length and hair density, (ii) to see the population dynamics of predators, (iii) evaluate the population trend of whitefly parasitoids, and (iv) evaluate the effect of seed treatment on the level of sucking pests, predators and parasitoids.

MATERIALS AND METHODS

The trial was conducted at the experimental area of Central Cotton Research Institute, Multan, Pakistan. Three cotton strains Cyto-46, Cyto-55 and Cyto-12/91 having different hair length and density were selected for this study. Five kgs of delinted seed of each strains were taken and treated with imidacloprid 70WS @ 8 gm/kg seed. The experiment was sown on the 9th June and laid out in factorial design. Main plots were divided into two subplots having seed treated and non-seed treated treatments. Each treatment was replicated 3 times having a plot size of 15.24 X 30.5 meter. Standard cultural practices were followed for growing healthy cotton crop. The study was carried out under unsprayed condition. Sucking pest as well as natural enemies' data was recorded after every 5 days starting from forty days to sixty five days after sowing. Population of sucking insect pest was recorded by using leaf turn method and fifteen leaves were taken from upper, middle and lower portion of the randomly selected plants from each plot (Ellsworth *et al*., 1995; Naranjo *et al*., 1996). Arthropod predators were counted in whole plant counts in which all the plant occurring in 1.33 meter length stick section were scanned visually and the occurrence of predators were registered in each plot. Immature and adult stages of all predator species were pooled when counted. Parasitism was recorded by taking leaves having maximum number of third instars of whitefly nymphs from the each treatment. These leaves were brought to laboratory and 10 leaf disks (each disk size= 5 cm^2) from each plot were kept separately in glass petri dishes covered with lid. Adults of whitefly and its parasitoids were allowed to emerge and percent parasitism was calculated by using the following formula.

$$\text{Percent parasitism} = \frac{\text{Total number of parasitoids emerged}}{\text{Total (whitefly + parasitoids) emerged}} \times 100$$

For determination of leaf hair density and length, ten leaves from 4th to 6th nodes from top portion were collected on 15th June and 15th August. Leaf lamina portion was cut with the help of cork borer and 25-30 leaf discs from each plot samples were kept in 70% alcohol. Hair density on 1 cm^2 of leaf disc was counted with the help of binocular microscope. Hair length was measured in microns by using an ocular and a stage micrometer under microscope.

Data were statistically analyzed and means were separated with Duncan's Multiple Range Test (DMRT) (SAS Institute, 2000).

RESULTS AND DISCUSSION

Whitefly (ETL 5-6/leaf)

Population of whitefly remained below ETL in all the seed treated and untreated strain's plots throughout the study period (Table II). However, seasonal means population was higher on the strain Cyto-46, having trichome density of 474±12.9 per cm^2 and hair length of 705±44.8 microns (Table I) and minimum on Cyto-12/91 having trichome density of 1011±21.0 per cm^2 and hair length of 644±27.3 µ. Similarly, study undertaken by Butler *et al*. (1991) reported that the increased whitefly population and trichome density relationship does not appear valid under extremely high trichome density and adult whitefly density decreased as trichome density increased from 467 to 847 trichome per cm^2 of cotton leaf. However, Mound

(1965) and Chu *et al.* (2000) also did not find adult whiteflies or their eggs on the first two top leaves on some exceptionally hairy cotton plants. Contrarily, it has been well documented that hairy cotton cultivars have higher *Bemisia* densities compared with smooth leaf cultivars (Norman and Sparks, 1977; Sippell *et al*., 1983; Chu *et al*., 1999). Study undertaken by Van Lenteren and Noldus (1990) concluded that moderate as opposed to heavy trichome density habitats were preferred for whitefly colonization.

Table I.- Leaf hair density and hair length (Mean±SE) of Cyto-46, Cyto-55 and Cyto-12/91.

Strains	Hair density / cm^2	Hair length in (μ)
Cyto-46	474±12.85	705±44.85
Cyto-55	633±19.82	762±29.93
Cyto-12/91	1011±21.04	644±27.30
CD 5%	120.4	44.3

Jassid (ETL 2/leaf)

Population of jassid was significantly higher on strain Cyto-12/91 having higher number of hair density (1011±21.04) with less hair length 644±27.3 (Table III). Similarly studies undertaken by Parnell *et al.* (1949) concluded that length of hairs on the underside of the leaf lamina is of prime importance. High density without length is ineffective. Studies in India have also shown the importance of hair length on the under surface of the leaf in reducing oviposition, especially on cultivars on which hair length exceeded the length of the ovipositor (Khan and Agarwal, 1984). Natural enemies are not considered to have a significant effect on population of jassid. The population normally decline during the dry season. Insecticidal control measures are commonly considered necessary when the jassid population reaches two nymphs per leaf. Early sprays against jassid, however, should be avoided, if at all possible, to conserve natural enemies of the total insect pest complex. Where resistant varieties are not sown, insecticide sprays can reduce jassid populations, but as re infestation can occur and plant growth causes rapid dilution of any spray deposits, so repeated sprays are likely to adversely affect the natural enemies of other insect pests. Bhat *et al*. (1984) concluded that cotton yield loss by jassid could be reduced from 25% to 12% by growing a hairy variety.

Thrips (ETL 8-10/leaf)

Population of thrips remained below ETL in Cyto-12/91 in both seed treated and untreated plots throughout the study period (Table IV). Whereas, it was recorded above ETL in strains Cyto-46 and Cyto-55 till 55 DAP in untreated and seed treated plots. Seasonal average population was significantly higher on Cyto-55 and Cyto-46 in untreated plots. Studies undertaken by several authors (Ballard, 1951; Quisenberry and Rummel, 1979; Rummel and Quisenberry, 1979; Walker *et al*., 1979) reported that pubescent and pilose varieties afforded greater thrips resistance than glabrous cultivars. Similarly Zia (1994) and Aheer *et al*. (1999) reported that there existed a negative correlation between thrips population and leaf hair density. In Egypt, Ghabn (1948) reported that in some years *T. tabaci* was responsible for the loss of 50% of young cotton plants. Several cotton cultivars have shown thrips resistance, mostly believed related to various morphological features that protect, leaves from feeding damage or prevent thrips establishment. In present study, Cyto-12/91 having hair density 1011±21.04 have significantly less number of thrips throughout the season.

Predators

Orius insidiosus, *Geocorus punctipes*, *Chrysopa carnea*, Cocinellids, and spider are the major groups of predators recorded during the study period. Number of predators was quite low till 50 DAP in all the treatments. After that, the number of predators' increased and maximum numbers of predators were recorded on Cyto-12/91 and Cyto-55 (Table V). Seasonal average number of predators was higher on Cyto-12/91 followed by Cyto-55. Overall, number of predators was higher in seed treated plots compared with untreated plots.

Predators survival, behavior and control efficacy may be affected by plant characteristics directly or indirectly through their effect on the prey. Guershon and Gerling (1999) reported no difference in prey consumption on smooth vs. pubescent cotton leaves. In the present study, strains Cyto-12/91 and Cyto-55, having > 600 trichomes

Table II.- **Number of *B. tabaci* per leaf on Cyto-46, Cyto-55 and Cyto-12/91 in imidacloprid treated and untreated seed plots 40-65 days after sowing.**

DAS	Untreated plots			Seed treated plots			CD 5%
	Cyto-46	Cyto-55	Cyto-12/91	Cyto-46	Cyto-55	Cyto-12/91	
40	2.1	2.2	0.5	1.6	2.5	1.1	**1.78**
45	0.9	1.2	1.8	3.0	2.2	1.1	**0.94**
50	2.8	2.8	1.9	3.3	2.1	2.0	**0.94**
55	1.1	2.1	2.4	2.1	2.5	1.2	**1.75**
60	1.9	1.3	0.9	0.8	1.1	1.2	**0.49**
65	1.4	2.1	2.1	2.5	2.5	0.8	**1.55**
Seasonal Mean	**1.7**	**2.0**	**1.6**	**2.2**	**2.2**	**1.3**	**0.49**

Table III. **Number of *A. devastans* per leaf on Cyto-46, Cyto-55 and Cyto-12/91 in imidacloprid -treated and untreated seed plots 40-65 days after sowing.**

DAS	Untreated plots			Seed treated plots			CD 5%
	Cyto-46	Cyto-55	Cyto-12/91	Cyto-46	Cyto-55	Cyto-12/91	
40	0.4	0.6	1.2	0.2	0.4	0.2	**0.53**
45	0.9	1.0	2.2	0.1	0.5	0.6	**0.21**
50	1.8	2.3	3.3	0.7	0.5	2.2	**1.13**
55	2.1	2.1	2.7	0.4	1.3	1.2	**0.51**
60	1.3	2.0	2.5	0.6	1.0	0.5	**0.74**
65	2.3	1.2	1.7	2.6	0.7	1.1	**0.56**
Seasonal Mean	**1.5**	**1.6**	**2.3**	**0.8**	**0.8**	**1.0**	**0.12**

Table IV.- **Number of *T. tabaci* per leaf on Cyto-46, Cyto-55 and Cyto-12/91 in imidacloprid seed treated and untreated plots 40-65 days after sowing.**

DAS	Untreated plots			Seed treated plots			CD 5%
	Cyto-46	Cyto-55	Cyto-12/91	Cyto-46	Cyto-55	Cyto-12/91	
40	0.2	0.0	0.1	0.1	0.2	0.0	**0.15**
45	0.8	1.1	0.5	0.1	1.1	0.1	**0.54**
50	0.0	0.9	0.1	0.3	1.3	0.1	**0.26**
55	0.3	2.5	1.2	1.0	4.4	0.5	**1.25**
60	15.9	16.1	1.5	9.1	8.5	2.1	**4.0**
65	9.4	9.6	1.4	5.9	6.3	2.7	**1.77**
Seasonal Mean	**4.4**	**5.0**	**0.8**	**2.8**	**3.6**	**0.9**	**0.68**

Table V.- **Number of predators per stick on Cyto-46, Cyto-55 and Cyto-12/91 in seed treated and untreated plots 40-65 days after sowing.**

DAS	Untreated plots			Seed treated plots			CD 5%
	Cyto-46	Cyto-55	Cyto-12/91	Cyto-46	Cyto-55	Cyto-12/91	
40	3	5	9	6	14	12	**1.75**
45	12	11	14	15	16	14	**3.89**
50	7	13	13	13	10	10	**1.95**
55	26	36	34	18	40	43	**9.36**
60	11	40	34	16	47	38	**12.21**
65	29	38	70	35	41	63	**19.93**
Seasonal Mean	**14.7**	**23.8**	**29.0**	**17.2**	**28.0**	**30.0**	**6.62**

Table VI.- Percent parasitism on Cyto-46, Cyto-55 and Cyto-12/91 in seed treated and untreated plots 40-65 days after sowing.

DAS	Untreated plots			Seed treated plots			CD 5%
	Cyto-46	Cyto-55	Cyto-12/91	Cyto-46	Cyto-55	Cyto-12/91	
40	57.6	77.7	72.7	38.3	75.0	73.7	**12.8**
45	58.0	79.3	75.3	38.3	72.0	82.7	**12.7**
50	66.7	55.0	76.7	69.0	65.0	62.3	**6.9**
55	61.1	77.7	77.3	72.1	80.3	78.7	**10.9**
60	75.0	74.7	65.0	56.3	75.0	73.0	**8.2**
65	37.1	70.0	32.3	77.8	45.7	48.7	**7.34**
Seasonal Mean	**59.3**	**72.4**	**66.6**	**58.5**	**68.8**	**69.9**	**4.81**

per cm^2 have significantly higher number of predators.

Many predators are general feeders, and predation is extremely difficult to positively assess in the field. Gerling *et al*. (2001) listed 114 arthropod predators of *B. tabaci* belonging to 9 orders and 31 families. Hagler and Naranjo (1994a,b) identified 9 predators feeding on *B. tabaci* in Arizona cotton. Study undertaken by Naranjo and Ellsworth (unpublished) in USA revealed that predation by sucking predators (primarily Heteroptera) was responsible for nearly 36% mortality of all immature stage of *B. tabaci*. Using immunologically based gut assays, Jones *et al*. (2000) describe that mortality caused in Uzbekistan by wild *Chrysopa carnea* and *Coccinelidae* (notably *Coccinella septempunctata* Waesmael) appeared to provide important regulation of early season sucking pests.

Parasitoids

Three species of whiteflies parasitoid (*Eretmocerus mundus*, *Encarsia lutea* and *Encarsia sophia*) has been recorded on cotton in Pakistan (Naveed *et al*., 2007, 2008). In the present study, we collectively mentioned the level of parasitism on the candidate strains. Parasitism remained significantly higher on Cyto-55 followed by Cyto-12/91 in untreated plots (Table VI). More than 60% parasitism was recorded in Cyto-55 and Cyto-12/91 in seed treated and untreated plots during 60-65 days of DAS. Apparently, we did not find any significant effect of the morphological character of the leaves on the level of parasitism. Similarly, studies undertaken by Susanne and van Lenteren (1997) on *Gerbera jamesonii* cultivars reported that leaf hair density varying from 80 to more than 1000 trichomes/cm^2 did not affect the walking activity of the parasitoids. Contrarily, Hua *et al*. (1987) and McAuslane *et al.* (1994) found that *Encarsia nigricephala* are known to forage less efficiently on hairy leaves than on hairless leaves.

Effect of seed treatment

Imidacloprid was the first nicotinoid seed treatment that was registered for use against *B. tabaci* (Elbert *et al*., 1990; Mullins and Engle, 1993). As a seed treatment, Imidacloprid has excellent root systemic characteristics, absorbed by the roots and transported mainly in the xylem where it is distributed evenly throughout young, growing plant tissues (Mullins, 1993). In treated plants, the compound and its metabolites are initially toxic to feeding adults, but also repel adults and act as anti-feedants (Nauen and Elbert, 1997; Nauen *et al*., 1998). Consequently, establishment of immature whiteflies on plants is significantly reduced because of suppressed egg deposition. Nymphs that do emerge usually die within a week after feeding on the treated plants (Bethke and Redak, 1997; Stansly *et al*., 1998). Contrarily, in the present study, population of whitefly in the treated and untreated plots were non significant for strains under test. Indicating that imidacloprid has no significant effect on controlling the whitefly population in the field (Table II). Whereas, number of jassid was significantly lower in seed treated plots compared with untreated plots**.** Jassid remained below ETL in seed treated plots till 60 days after sowing (DAS) in Cyto-46, 50 DAS in Cyto-55 and only 45 DAS in

Cyto-12/91. Comparatively seed treatment gave better control of jassid than untreated plots (Table III). Overall, population of thrips in the treated plots was less compared with untreated check plots (Table IV). However, number of predators were more in the seed treated plots compared with untreated plots (Table V). Level of parasitism in most of the plots were found non significant in treated and untreated plots (Table VI). It was also reported by Naveed *et al.* (2010) and Naranjo (2001) that the systemic application of imidacloprid is generally harmless to parasitoids of whitefly.

Cotton crop sowing normally starts from May to mid June in the major cotton growing area of the Punjab province. With the introduction of early maturing varieties fruit formation starts 40-45 days after sowing. Sucking pest like thrips, jassid and whitefly start appearing just after the emergence of the cotton plant. In normal weather conditions none of these pest become problems in the presence of natural enemies. But in case of early monsoon rains when the weather become hot and humid, the populations of jassid flare up and do considerable damage to cotton plants. On the other hand in the absence of early monsoon and in dry and hot weather conditions the thrips and whitefly population start increasing. After the disaster of cotton leaf curl virus in the mid nineties the farmers are more cautious about whitefly and the disease. In both the cases the farmers initiate spray to protect their crop from these pests. Initiation of early spraying not only increase the number of sprays during the season but also has bad effect on the natural enemies as well and in the absence of natural enemies pest like whitefly flare up very rapidly and may even aggregate the problem as also reported in Sudan (Joyce, 1955; Eveleens, 1983); in America (Kraemer, 1966; Miller, 1986) and in Turkey (Sengonca, 1975). As demonstrated in the present study that the early season sucking pest complex can be managed by choosing the variety having moderate leaf hair density, and if variety choice is limited due to the other desirable character then the early season sucking pest especially jassid can be controlled effectively by the seed treatment. As seed treatment is more save towards the predators and parasitoids compared with foliar insecticide application.

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