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NATURAL RESISTANCE AGAINST INSECT PESTS IN COTTON

Z. M. Din*, T. A. Malik, F. M. Azhar and M. Ashraf

*Department of Plant Breeding and Genetics, University of Agriculture Faisalabad
Corresponding author's email address: zakapbg@gmail.com

ABSTRACT

Insect pest infestation is a major constraint in cotton production and causes heavy yield losses every year. Some studies report that insect pests attack on genotypes/cultivars with the traits, frego bracts, okra leaf, and red leaf color is comparatively lower. Genotypes/cultivars having these traits were assessed for insect pest infestation in comparison to commercial cultivars which did not contain these traits. Experimental plots were separated by fine netting to confine insect pests within the genotype/cultivar. The *Gossypium arboreum* cultivar, FH-170, had lower population buildup of sucking and chewing insect pests. In general, among the *G. hirsutum* genotypes/cultivars, lowest population buildup of jassid, white fly, spotted bollworm and American bollworm was found on Gumbo Okra (okra leaf). Minimum aphid was recorded on Russian Red (red leaf color). PBG-Fb-5 (frego bract) showed the most resistant response against pink bollworm. Population buildup of thrips, mites and aphid was relatively higher under water deficit conditions compared to well water conditions whereas, population buildup of jassid, and white fly was higher under well watered conditions.

Key words: Okra Leaf Cotton; Frego Bract Cotton; Red Leaf Color Cotton; Insect Pests; Relative Water Contents of Cotton leaf.

INTRODUCTION

Insect pest infestation is responsible for huge losses in crop production which may reach up to 70% of the potential production in the absence of pest control measures (Haque, 1991; Thirasack, 2001). Indiscriminate use of pesticides has been responsible for development of insect pest resistance to pesticides (Naik *et al.*, 1993; Razaq *et al.*, 2006) and emergence of new pests (Soomro *et al.*, 2001) as well as creating health hazards to human and animals. Pesticides are a huge source of environmental pollution and reduction in population of beneficial insects (Etienne *et al.*, 1990, Hosoda *et al.*, 1993). Considerable reduction in the population of predators by the application of pesticides has been reported (Younis *et al.*, 2007). Insect pests of cotton are categorized into sucking insect pests such as whitefly (*Bemisia tabacii*), thrip (*Thrips tabacii*), aphid (*Aphis gossypii*), jassid (*Amrasca devastans*) and mites (*Tetranychus spp*) and chewing insect pests; american bollworm (*Helicoverpa armigera*), pink bollworm (*Pectinphora gossypiella*) , spotted bollworms (*Erias insulana*) and army bollworms (*Spodoptera litura*) on the basis of their feeding habits. They feed on leaves, buds, flowers and bolls.

Host plant resistance to insects can be due to morphological traits, physiological features and biochemical characteristics of a plant (Ponti, 1977) which exert pressure for insects to select the plant as host (Painter, 1951). Plant morphological and anatomical features like color, frego bract shape, okra leaf shape, hairs and spines on leaves, deposition of waxes, lignifications of cell walls, sturdiness of tissue etc., alone or in combination influence feeding preferences of insect pests on host plants (Silva *et al.*, 2008; Rahman *et al.*, 2013). Varietal resistance of variable strength against insect pests has been reported by a number of researchers (Goussain *et al.*, 2005; Pathan, *et al.*, 2007; Amjad and Aheer, 2007; Inbar and Gerling, 2008; Ashfaq *et al.*, 2010; Shahid *et al.*, 2012; Nawab *et al.*, 2014).

Bract in cotton is the set of small leaf like structures surrounding the flower bud, flower and boll. There is a considerable variation in flower bract size and shape. Normal bracts are wide and large, close to the boll and provide shelter to insects, however, frego bract is thin, twisted and moves away from boll uncovering it completely and thus do not protect eggs of insect pests and so confers resistance to genotypes against insect pests like bollworm and boll weevil (Aslam *et al.*, 2000; Rahman *et al.*, 2008). Surface area of bract is significantly reduced and does not offer any shelter to larvae of bollworms (Bhat and Basu, 1984) hence, bollworms do not prefer to lay eggs on frego bract genotypes (Bhat and Jayaswal, 1989; Baloch *et al.*, 2001). Red leaf color in cotton has been reported to be developed by the plant as a defensive mechanism against aphids (Hamilton and Brown, 2001). Cotton plants with red leaf color have shown less foliage damage than those with normal green leaf color (Jones *et al.*, 2000). Similarly okra leaf cotton allows light penetration to the lower part of the plant (James and Jones, 1985), hence may affects insect pest build up.

Environmental conditions like temperature, moisture contents, light intensity, CO_2 concentration alter

biological processes of plant, hence affect insect population buildup (Khan *et al*., 2008). It is reported that in cotton, aphids, mites, and thrips infestation increases in dry environments, whereas, ample amount of water reduces their infestation and increase boll worms and jassid attack due to succulence of leaf (Kuepper, 2004). Present study was conducted to find the effect of frego bract, okra leaf and red leaf cotton plant traits on the population build up of insects under optimum leaf moisture and moisture deficit conditions.

MATERIALS AND METHODS

Seven genotypes/cultivars of *G. hirsutum* and one cultivar of *G. arboreum* were grown in the field during a normal crop growing season (June to November) in 2010, in a randomized complete block design with three replications to assess insect pests infestation (Table 1).

Table 1. Genotypes of two cotton species, *G. hirsutum* and *G. arboreum* used in the studies

Sr. No.	Genotype/cultivar	Description
1.	Russian Red	Genotype with red leaf color
2.	PBG-Fb-5	Genotype with frego bract
3.	Gumbo Okra	Genotype with okra leaf type
4.	S-12	Cultivar
5.	MNH-93	Cultivar
6.	FH-1000	Cultivar
7.	FH-170	*G. arboreum* cultivar

Experimental plots were separated by a fine net to keep the insect populations confined within a genotype/cultivar. The soil was a sandy loam with pH of 7.8. Plant to plant and row to row distance was 30 cm and 75 cm respectively. There were 21 rows in each replication (three for each genotype/cultivar). Observations on insect pest populations were taken at ten days intervals beginning 15th of July 2010 to 15th of October 2010. Data were recorded from ten random healthy plants from each experimental unit. Sucking insects (thrip, jassid, white fly, mite and aphid) were examined on a per leaf basis. Three leaves per plant each from top, middle and bottom sections of the plant were examined for both adult and nymph, using magnifying glass (5X). Populations of bollworms (spotted bollworm, pink bollworm and american bollworm) as a percentage of infested bolls, squares and flowers were counted on a per plant basis.

The data for relative water content was recorded twice, 7 days after irrigation (well water condition) and 30 days after irrigation (water deficit condition). The data for relative water contents of fully expanded leaves from middle of plant was recorded from selected plants of each genotype in a replication. The samples were covered with polythene bags immediately after excision and fresh weight was recorded. The leaf samples were submerged in water overnight and turgid leaf weight was recorded. The samples were then dried for 72 hours at room temperature before recording dry weight. Relative water content was calculated using formula described by Barrs and Weatherley (1962).

RWC = [(Fresh weight–Dry weight) / (Turgid weight–Dry weight)] x 100

The data was subjected to analysis of variance and means were separated by applying LSD test as in Steel *et al*. (1997).

RESULTS AND DISCUSSION

The analysis of variance indicated significant differences among the genotypes for RWC and for population build up of all the insect pests studied. Means of RWC for genotypes as well as population of thrips, jassid, white fly, mites, aphid, spotted bollworm, pink bollworm and american bollworm on genotypes under well watered (WW) and water deficit (WD) conditions are given in table-2. The genotype effects are also given in table-2. Comparison of mean population build up of insect pests (taken at 9 different dates) on different genotypes/cultivars is shown in table-3.

Thrips (*Thrips tabacii*) *Gossypium arboreum* cultivar, FH-170 had minimum population build up of thrips, hence was the most resistant cultivar, among genotypes under study. Among *G. hirsutum* genotypes, the genotype Gumbo Okra with okra leaf type had minimum population build up of thrips. Maximum number of thrips were found on S-12. Stanton *et al*. (1992) evaluated 43 accessions for resistance to thrips from 1988 to 1990 at Cotton Experiment Station, Mariana, Arkansas, USA. They reported that *G. arboreum* accessions were comparatively less damaged by thrips. Resistance in okra leaf type cotton was also reported by Syed *et al.* (1996) and Arif *et al*. (2006) which are in conformity with the results of present study. Low population of thrips on Gumbo Okra may be attributed to its reduced leaf surface area. Reduced surface area of okra leaf cotton allows light penetration to the lower part of plant hence exposes the hiding places of thrips. In the present study, maximum number of thrips was observed on normal leaf cotton S-12 and FH-1000. These genotypes are characterized by large and wide leaves.

Table 2. Population build up of insect pests under well watered (WW) and water deficit (WD) conditions on different genotypes, relative water contents (RWC) as well as Mean squares (MS) for genotypes, RWC × insect population and genotype x RWC × insect population

	RWC Means	Thrip		Jassid		White fly		Mites		Aphid		Spotted bollworm		Pink bollworm		American bollworm	
Genotypes	WW WD	WW	WD	WW	WD	WW	WD	WW	WD	WW	WD	WW	WD	WW	WD	WW	WD
Russian Red	55.22 40.03	4.372	4.744	2.254	2.371	4.562	4.871	6.821	7.642	6.490	8.431	7.342	6.967	3.509	4.212	7.121	8.120
PBG-Fb-5	57.15 50.34	4.420	8.032	2.873	2.442	4.851	4.17	5.431	9.101	7.851	12.031	4.033	6.967	1.915	2.003	8.230	6.232
Gumbo Okra	72.77 55.54	3.620	5.832	2.234	2.483	4.561	3.221	6.192	5.870	7.221	9.33	4.033	6.967	4.712	2.631	6. 122	4.011
S-12	54.43 38.23	3.612	7.645	2.843	1.721	5.421	4.741	7.024	10.513	7.352	13.58	6.332	6.967	1.627	4.331	9. 071	6. 021
MNH-93	68.93 49.66	3.223	5.871	2.490	1.380	5.423	4.972	5.375	7.023	7.543	9.13	9.067	8.112	2.891	3.172	10.113	6.973
FH-1000	56.06 41.53	4.661	8.172	2.323	2.163	4.713	4.181	5.823	8.881	7.382	9.121	6.121	5.032	2.772	3.232	7. 032	14.922
FH-170.	89.35 64.10	3.172	5.673	1.921	1.121	3.874	2.472	5.001	7.621	5.524	6.28	5.333	3.121	2.583	1.174	2.415	6.973
Average	63.83 49.22	3.868	6.567	2.419	1.954	4.772	4.089	5.952	8.093	7.051	9.700	6.037	6.305	2.858	2.947	7.156	7.607
MS for Genotype	826.87**	365.63**		393.63**		393.69**		362.40**		341.91**		363.90**		414.51**		331.96**	
MS for RWC × insect Population	2242.12**	1522.27 ns		1171.51 ns		1183.25 ns		1470.68 ns		1563.58 ns		1055.56 ns		1206.66 ns		1025.99 ns	
MS for Genotype x RWC × insect Population	49.26**	21.27ns		21.72 ns		24.05 ns		21.30 ns		14.44 ns		34.10 ns		24.48 ns		36.15 ns	

ns = non-significant ; **= highly significant ($p<0.01$)

Table 3. Comparisons of mean population build up of insect pests (taken at 9 different dates) on different cotton genotypes.

Thrip	Jassid	White fly	Mites	Aphid	Spotted bollworm	Pink bollworm	American bollworm
S-12	PBG-Fb-5	FH-1000	PBG-Fb-5	PBG-Fb-5	FH-1000	MNH-93	FH-1000
7.77a	1.99a	4.8a	8.33a	8.25a	10.66a	2.45a	12.21a
PBG-Fb-5	Russian	MNH-93	S-12	Gumbo	MNH-93	FH-1000	MNH-93
7.49b	Red	4.79a	7.64a	Okra	10.13a	2.23b	8.08b
FH-1000	1.98a	PBG-Fb-5	FH-1000	6.77ab	S-12	S-12	PBG-Fb-5
7.36b	S-12	4.63b	6.50ab	FH-1000	9.90ab	1.96c	7.13b
Russian	1.97a	Russian	Russian	5.58b	Russian	Gumbo	S-12
Red	MNH-93	Red	Red	S-12	Red	Okra	7.12b
6.69c	1.93ab	4.62b	5.56bc	4.03c	8.09b	1.81c	Russian
MNH-93	Gumbo	Gumbo	MNH-93	MNH-93	PBG-Fb-5	Russian	Red
6.63c	Okra	Okra	3.86cd	3.72c	8.13b	Red	6.24b
Gumbo	1.85ab	4.51c	Gumbo	Russian	Gumbo	1.79c	Gumbo
Okra	FH-1000	S-12	Okra	Red	Okra	PBG-Fb-5	Okra
6.11d	1.80 b	4.39d	3.84cd	3.66c	8.11b	1.23d	2.74c
FH-170	FH-170	FH-170	FH-170	FH-170	FH-170	FH-170	FH-170
4. 68e	0.97 c	2.43e	2.61d	1.85d	2.03d	1.08e	2.72c
LSD							
0.146	**0.154**	**0.107**	**0.686**	**0.313**	**0.539**	**0.266**	**0.537**

Note:- The genotypes sharing the same alphabets have non-significant differences

Jassid (*Amrasca devastans*) Minimum number of jassid was present on *G. arboreum* cultivar, FH-170. Among the upland cotton (*G. hirsutum*) FH-1000 and Gumbo Okra had minimum infestation of jassid. Bhatnagar and Sharma (1991) investigated varietal resistance of cotton genotypes against sucking insect pest of cotton and recorded less number of jassid on okra genotypes. Chu *et al*. (2000) studied host plant resistance in normal and okra leaf genotypes against jassid and found okra leaf cotton as resistant compared to normal leaf cotton. Ahmad *et al*. (2005) evaluated ten upland genotypes for plant resistance against jassid and found okra leaf genotype (Okra-170) as the most resistant.

White fly (*Bemisia tabacii*) *Gossypium arboreum* cultivar FH-170 showed minimum white fly infestation. Among *G. hirsutum* genotypes, Gumbo Okra and S-12 had relatively lower population build up of white fly. Relatively higher number of white fly was recorded on FH-1000 and MNH-93. Modifications in leaf morphology such as okra leaf type has been reported to confer high level of resistance against white fly (Painter, 1951; Jones *et al*, 1976).

Soomro *et al*. (2000) evaluated okra leaf upland cotton strains compared to normal leaf cultivars (CRIS-9 and NIAB-78) at seven different locations, and reported as relatively tolerant to white fly. Similar, results have been reported by other researchers (Huffaker and Croft 1976; Bhatnagar and Sharma 1991; Chu *et al*, 2002). Russian Red genotype displayed a medium level of resistance against white fly in the present study. Alexander *et al*. (2004) also reported red leaf color cotton as resistant against white fly. Similarly, Neto *et al*. (2008) reports that cotton genotype with red leaf color is less preferred by white fly compared to normal green plant.

Mite (*Tetranychus spp*) The lowest number of mites was found on *G. arboreum* cultivar, FH-170. Among the *G. hirsutum* genotypes minimum population buildup of mites was present on Gumbo Okra. Kular and Butter (1999) investigated varietal resistance of 51 cotton cultivars and found that okra leaf cotton was least affected by mite infestation. Similarly a normal leaf cotton variety, Deltapine-90 and okra leaf, Siokra-14 were compared and it was found that losses due to mite infestation in term of yield and oil contents in okra leaf genotype was lower compared to normal leaf genotype (Sadras and Wilson, 1996). Syed *et al*. (2003) evaluated 21 genotypes of cotton and recorded minimum population build up of mites on Russian Red and Rode Okra (okra leaf). In the present study, Russian Red also had relatively lower infestation of mites.

Aphid (*Aphis gossypii*) The lowest aphid population build up was recorded on *G. arboreum* cultivar, FH-170. Among upland cotton genotypes, Russian Red had minimum population build up of aphid. Red leaf color genotypes are reported to be less preferred by aphid (Radcliffe and Chapmann 1966; Ali *et al*., 2009). Present study and earlier reports suggest that red leaf trait should be incorporated in cotton cultivars if the problem of aphid infestation is severe in the area. The Bt cotton tailored

with red color may provide additional benefits against this sucking insect pest.

Spotted bollworm (*Erias insulana*) *Gossypium arboreum* cultivar FH-170 had minimum infestation. Among upland cotton genotypes, Gumbo Okra, PBG-Fb-5 and Russian Red had minimum infestation. Maximum damage was recorded on FH-1000. Abro *et al.* (2003) investigated varietal resistance in ten cotton genotypes including okra genotypes against *Erias* spp. and recorded minimum infestation on okra genotypes. Indrayani and Sumartini (2007) reported that floral bract positively associated with bollworm damage. They investigated 18 cotton accessions against bollworm damage, and reported higher damage to bolls in accessions with large floral bract. Results of present study and earlier research show that the traits, okra, red leaf color and frego bract traits confer resistance against spotted bollworm. So cotton cultivars should be tailored with these traits to reduce damage by spotted bollworm.

Pink bollworm (*Pectinophora gossypiella*) *Gossypium arboreum* cultivar, FH-170 had minimum infestation. Whereas, among *G. hirsutum* genotypes; PBG-Fb-5, Russian Red and Gumbo Okra had minimum infestation. Maximum pink bollworm damage was recorded on MNH-93. Mehetre *et al.* (2009) studied genotypes including *arbroreum* and *thurberi* cotton and found least damage to *arboreum* and *thurberi* genotypes by pink bollworm. Okra leaf type genotypes have less surface area and provide better light penetration and air circulation so are resistant to pink bollworm (Wilson and George, 1982; Wilson, 1986). It is also reported that genotypes with frego bract, glabrous and nectariless traits show lower bollworm damage (Nyambo 1985; Jones, *et al*, 1989). Baloch *et al.* (2001) found that narrow and small bract genotypes were less damaged compared to broad and normal bract genotypes. Indrayiani and Sumaitini, (2007) studied different insect resistant traits in cotton and reported that frego bract type genotypes had resistance against bollworm damage. Resistance of frego bract genotypes against bollworm is attributed to narrow, long bracts that keep the boll naked (Rahman *et al*, 2008).

American bollworm (*Helicoverpa armigera*) FH-170, the *arboreum* cultivar was found the most resistant to American bollworm. Among *G. hirsutum* genotypes/cultivars minimum infestation was recorded on Gumbo Okra and Russian Red. Whereas, maximum infestation was noticed on FH-1000. Fitt *et al*. (2002) and Ahmad (2004) have reported that morphological traits (okra leaf, glabrous, hairiness, frego bract, presence and absence of nectars) alter plant environment in such a way that genotypes become less vulnerable to insect pests. Resistance against American bollworm was reported in smooth and okra leaf cotton (Hassan *et al.*, 1990). Insects show preference to color of different plants parts like leaf, flower or stem (Painter, 1951). Red leaf color in plants is due to the presence of anthocynin pigments (Coley and Kursar, 1996; Bohm, 1998; Vargas *et al.*, 2000). Red color has been developed by evolution in plants as defensive mechanism (Hamilton and Brown, 2001) and hence is less affected by insect pests (Jones *et al.*, 2000).

Relative water content and insect pest infestation The relative water content of the genotypes was different under well water (WW) and water deficit (WD) conditions (Table 2). Population build up of thrips, mites and aphid was relatively higher, on genotypes under WD compared to WW conditions and vice versa. Whereas, in case of jassid and white fly, population build up was higher under WW compared to WD conditions. Bollworms population build up on genotypes was almost similar in WW and WD condition and was non-significant. Interaction between the populations build up on the genotypes and RWC was also non-significant. This means that population build up on the genotypes was not due to difference of RWC but was due to insect pest resistance traits (okra leaf, frego bract and red leaf color) of the genotypes. Water balance and abiotic stresses affects cell sap composition and have been reported to contribute toward resistance/susceptibility to insect pest (Cornelissen and Fernandes 2001; Jenks and Hasegwa, 2005; Agele *et al.*, 2006; Vickers, 2011). Kuepper (2004) has reported that mites, thrips and aphid infestation increases in water shortage /low relative water contents conditions. While rainfall enhances the population of jassid (Shuaib *et al.*, 2008, Ashfaq *et al.*, 2010) and white fly (Jalal *et al.*, 2006). The results of present study and earlier reports indicate that relative water content has pronounced impact on population build up of sucking insect pests like thrips, jassid, white fly, mites and aphids.

Conclusion: Insect resistance cotton plant traits frego bract, okra leaf and red leaf color are effective to restrict insect pest population, so these traits should be incorporated in commercial cultivars. Transgenic cotton offers resistance only against bollworms. Bt cotton tailored with insect resistance traits would provide additional resistance against sucking insect pests. Soil water conditions also affects population builds up of sucking insects so this should be taken into account for insect pest control management.

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