Pak. J. Agri. Sci., Vol. 50(4), 617-623; 2013
ISSN (Print) 0552-9034, ISSN (Online) 2076-0906
http://www.pakjas.com.pk

A CASE TO STUDY POPULATION DYNAMICS OF *Bemisia tabaci* AND *Thrips tabaci* ON Bt AND NON-Bt COTTON GENOTYPES

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Studies were conducted to investigate the performance of eight Bt and five non-Bt cotton genotypes against whitefly and thrips and impact of abiotic factors on the population fluctuation of these sucking pests, at Cotton Research Station, Multan, during 2010 and 2011. The results exhibited that Bt genotypes found more susceptible host for the whitefly and thirps than non-Bt genotypes, during the course of years of study. Among Bt genotypes, maximum and minimum temperature showed significant and positive effect on whitefly population whereas relative humidity exerted negative effect during 2010. During 2011, the effect of all the factors was non significant. On cumulative basis, there was positive correlation between population of whitefly and minimum temperature. But in case of non-Bt, it has negative with maximum temperature whereas relative humidity had a positive effect on whitefly population. Similar trend was observed for thrips population on Bt varieties during both years but on non-Bt varieties only minimum temperature exerted strong positive impact on thrips population. Hierarchical regression models for whitefly and thrips revealed that minimum temperature was the most important factor (Bt and non-Bt varieties). Maximum temperature was the major contributing factor for whitefly fluctuation on Bt varieties during 2010.
Keywords: Abiotic factors, *Bemisia tabaci*, *Thrips tabaci*, transgenic cotton

INTRODUCTION

Cotton, being an important cash crop, is vulnerable to be attacked from a large number of pest insects, throughout its growth period. Whitefly, *Bemisia tabaci* (Gennadius); aphids, *Aphis gossypii* (Glover); leafhopper, *Amrasca biguttula biguttula* (Ishida); leaf beetle, *Cerotoma trifurcate* (Forster); red cotton bug, *Dyesdercus koenigii* (Fabricius) are the major sucking insect pests recorded on cotton (Ashfaq *et al.*, 2011). The insects can damage cotton to the tune of 39.50% (Naqvi, 1975; Chaudhry, 1976).
Large amounts of broad-spectrum chemical insecticides are used to control the key pests of cotton. This practice not only creates health problems and environmental pollution, but also develops insecticide resistance in insects (Mohyuddin *et al.*, 1997).
With the invention of Bt cotton, broad-spectrum insecticides have been reduced to greater extent. As a result of this non-target pest insects, with piercing-sucking mouth- parts, such as, leaf bugs, cotton spider mites, cotton aphids, thrips and whiteflies, survive better (Xu *et al.*, 2008) and feed on their host more comfortably. *B. tabaci* (Genn.) is a key pest of many field and horticultural crops, throughout the subtropical region (Naranjo, 2001; Bayhan *et al.*, 2006). It damages the host plants directly by depriving them of their nourishment, because it continuously sucks the cell-sap. This results about 50% reduction in the boll formation. As this acts as vector and helps in the transmission of the viral diseases. CLCV occur due to consistent sucking of whitefly (Malik *et al.*, 1999). Thrips completes its life by sucking cell sap, from under-side the leaves, close to the midribs. Its scouting is a difficult job and a lens is needed to observe the presence. The damage/effected leaves show silvery appearance and at later stages, leaves margins curl upward and a cup-shaped structure is formed. Weather factors played an role in population dynamics of sucking pest insects. Whitefly and jassid populations are usually positively correlated with the temperature while negatively with relative humidity. The rainfall has a positive effect on the whitefly and negative effect on the jassid population build-up (Ashfaq *et al.*, 2010).
Keeping in view, the existing situation of outbreaks of piercing sucking insects on Bt cotton, there is a need to develop an effective and sound pest- management program, that is well suited to the ecological conditions, particularly the weather factors, which play a key role in the multiplication and distribution of pest insects. But, work done in this regard, is still limited and needs more extensive research. Thus, owing to the lack of information, the present study was undertaken to find out the exact degree of relationship between the pest-population and weather factors.

MATERIALS AND METHODS

The present study was carried out to investigate the performance of eight BT (MNH-886, CRSM-2007, FH-114, IR-3701, ASR-802, MG-06, MNH-888 and SITARA-008) and five non-BT (MNH-814, MNH-815, VH-289, CIM-557 and CIM-496) genotypes against whitefly and thrips at Research area of Cotton Research Station, Multan, during Kharif seasons (2010 and 2011). The experiment was laid out under Randomized Complete Block Design (RCBD) with three replications. The plot size was 30×70 feet for each treatment. Certified seed of each variety was ensured from reliable source (Cotton Research Institute, Faisalabad). The crop was sown early, in the month of March. For all treatments, all possible agronomic practices were carried out to minimize the impact of weeds and alternate hosts of the pests. No plant protection measures, including pesticide application were applied.

***Whitefly and thrips sampling*:** The population of whitefly and thrips was recorded from the month of April till the end of October for both cropping seasons. Sampling was done according to Mario method of pest scouting (Carolyn *et al*. 2004). Ten plants were selected randomly, from each replication. Whitefly and thrips population (both adults & nymphs) were recorded from, upper leaf (first plant), middle leaf (second plant), lower leaf (third plant) and so on. The data were recorded fortnightly, for thirteen weeks, continuously, in each cropping season. The meteorological data was also recorded during the course of study.

***Statistical analysis*:** The data were entered in Microsoft Excel version 2010 spreadsheet. Population means and standard error were computed. For statistical analysis, two windows based (Statistix 8.1 & Minitab 16.0) and one DOS based (MSTAT-C) software packages were used. Analysis of variance (ANOVA) of the data, with respect to different varieties and years was computed using MSTAT-C (Anonymous, 1989). Further, means were compared by LSD test (P=0.05), to estimate the significance, among different varieties. The data were also processed for simple correlation between pest population and abiotic factors using Statistix (version 8.1) for windows. The individual and combined effects of abiotic factors i.e. maximum & minimum temperature, relative humidity and rainfall, on the population of whitefly and thrips, in different Bt and Non-Bt varieties were measured by Hierarchical Regression Models using Minitab version 16.0 for windows (Steel *et al*., 1997).

$$Y = a+b_1x_1+b_2x_2+b_3x_3+b_4x_4$$

where Y= Population of insect pest; X_1= Maximum Temperature for every week; X_2= Minimum temperature for every week; X_3= Average relative humidity for every week; X_4= Total rainfall (mm) for every week

RESULTS

ANOVA showed highly significant differences in the population of whitefly on different varieties of Bt and non-Bt cotton crop. While highly significant differences among interaction (Year * Variety) were observed in Bt genotypes and significant differences on non-Bt genotypes. However, thrips population showed highly significant differences among main effect (variety) and interaction effects (Year * variety) in Bt and non-Bt genotypes. Hence, population prevalence of thrips and whitefly on Bt and non-Bt genotypes is very negligible/similar (Table 1). To find out variation in the population of whitefly and thrips on different varieties, LSD test of comparison was carried out. The results revealed that whitefly population ranged 5.46-8.08/leaf during 2010 and 4.20-6.36/leaf during 2011, on Bt varieties. Maximum population per leaf was observed on MG-06 (8.08) which is statistically at par with the SITARA-008 (7.96) and CRSM-2007 (7.63), followed by MNH-888 (6.88), IR-3701 (6.79) and MNH-886 (6.65) which are also at par with each other (during 2010). The minimum whitefly population was observed during 2011, on FH-114 (4.20/leaf) followed by MNH-888 (5.46/leaf) and ASR-802 (5.83/leaf) which are statistically at par with IR-3701 and SITARA-008 (Fig. 1). Thus, FH-114 (during 2010) was found resistant against whitefly population while MG-06, CRSM-2007 and SITARA-008 were found susceptible. The incidence of whitefly on non-Bt cotton varieties ranged from 5.11-7.39/leaf (during both cropping seasons). All varieties exhibited almost similar response towards whitefly and are statistically at par with each other based on population level except VH-289 where slightly lower population per leaf (5.11) was recorded during 2010 (Figure 1). But, as it is above ETL, so this variety can be categorized as comparatively resistant rather than susceptible.

The results regarding thrips population on Bt varieties revealed that none of the tested varieties showed thrips population per leaf below ETL. However, incidence of thrips

Table 1. Analysis of variance for population dynamics of whitefly and thrips on Bt and non-Bt varieties

	Whitefly						Thrips					
	Bt			Non-Bt			Bt			Non-Bt		
SOV	**DF**	**F**	**Prob.**	**DF**	**F**	**Prob.**	**DF**	**F**	**Prob.**	**DF**	**F**	**Prob.**
Year	1	18.83	0.012	1	0.06		1	0.013		1	242.84	0.000
Variety	7	39.63	0.000	4	11.31	0.000	7	113.210	0.000	4	80.64	0.000
Year*Variety	7	6.92	0.000	4	4.68	0.011	7	6.530	0.000	4	38.71	0.000

on different Bt varieties ranged from 10.79-16.35 per leaf. Again FH-114 performed well against thrips in both years (10.79 and 10.89 thrips/leaf during 2010 and 2011, respectively), followed by ASR-802 (12.78/leaf), MNH-886 (12.84/leaf) and IR-3701 (12.95/leaf) which are statistically at par with each other (Fig. 2). On the other hand, maximum population was recorded on MG-06 (16.35/leaf) during second year. Although this variety had maximum number of thrips, yet it was statistically at par with SITARA-008. Unlike Bt varieties, non-Bt varieties showed somewhat greater degree of resistance to thrips. Almost all varieties performed well against thrips except CIM-496, having 12.73 population per leaf during first year but much lower population (6.37/leaf) during second year (Fig. 2).

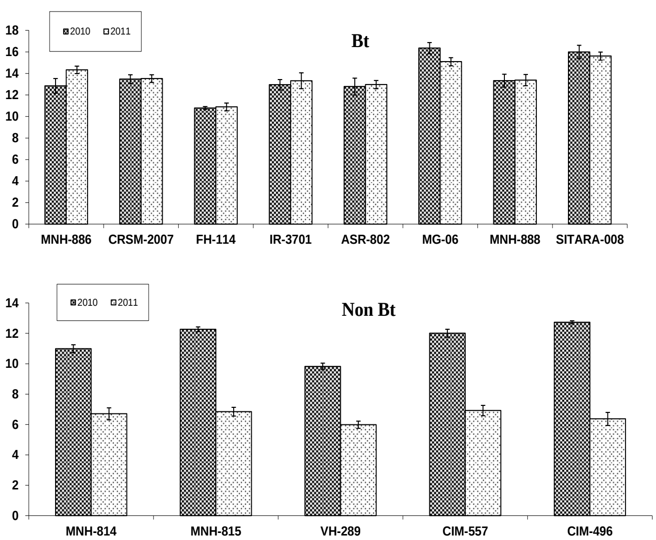

Figure 1. Population buildup of whitefly on Bt and non-Bt varieties

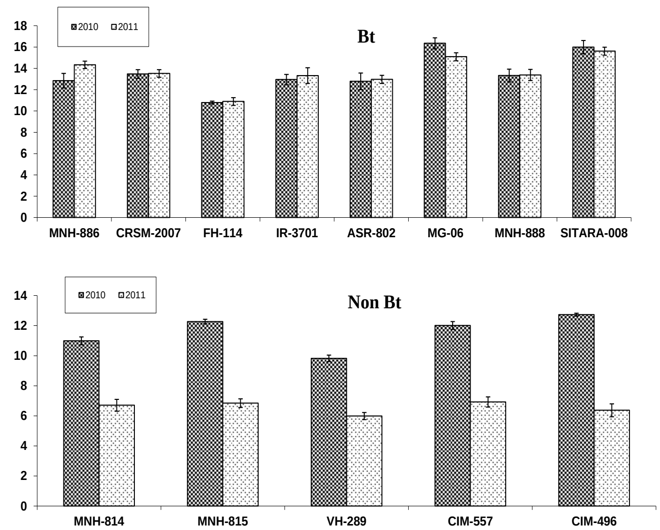

Figure 2. Population buildup of thrips on Bt and non-Bt varieties

Role of abiotic factors in population fluctuation of whitefly and thrips:

***Correlation between whitefly & thrips population and weather factors on Bt and non-Bt cotton varieties*:** The results revealed that among Bt varieties during 2010, maximum and minimum temperature correlated positively with the whitefly population while relative humidity showed negative trend but in 2011 none of the abiotic factors correlated significantly with the whitefly population. On overall basis, only minimum temperature was found significant and positive with the whitefly population (Table 2). In case of non-Bt cotton varieties (during 2010), maximum temperature correlated negatively while relative humidity showed strong positive correlation with whitefly population, whereas minimum temperature was the only abiotic factor that was correlated positively with whitefly

Table 2. Correlation between whitefly population and weather factors on Bt and non-Bt varieties

	Bt			Non-Bt		
	2010	**2011**	**Cumulative**	**2010**	**2011**	**Cumulative**
Max. Temp	0.7434**	0.2202	0.3561	-0.6478*	-0.2783	-0.5012*
Min. Temp	0.5680*	0.3810	0.5940*	0.2564	0.5956*	0.4224
R.H.	-0.6138*	-0.1074	-0.3427	0.7275**	0.4340	0.6189*
Rainfall	-0.1328	-0.1358	-0.1240	0.5321	0.4090	0.4949

Table 3. Correlation between thrips population and weather factors on Bt and non-Bt varieties

	Bt			Non-Bt		
	2010	**2011**	**Cumulative**	**2010**	**2011**	**Cumulative**
Max. Temp	0.5871*	0.7763**	0.4940	0.2114	-0.0581	0.0819
Min. Temp	0.7656**	0.5622*	0.7162**	0.8403**	0.8479	0.8998**
R.H.	-0.4637	-0.7776**	-0.5685*	-0.3239	0.0903	-0.1249
Rainfall	0.0276	-0.3213	-0.1747	-0.0978	0.2439	0.0776

Where, *= Significant at P ≤ 0.05; **= Significant at P ≤ 0.01

population. Overall correlation was found similar as observed in first cropping year. In the same way, thrips population also showed positive correlation with maximum temperature in Bt varieties (during both years) while relative humidity had a negative impact (during 2011). On accumulative basis, minimum temperature showed strong positive correlation while relative humidity correlated negatively with the thrips population. In case of non-Bt varieties, only minimum temperature had a positive correlation (during 2010) with thrips population. Overall, only minimum temperature had a positive influence (Table 3).

Hierarchical regression analysis**:** In order to precisely assess the relative importance of selected weather parameters in explaining the variation of population of whitefly and thrips, the partial regression coefficients of pest population on weather parameters were computed taking population of pest as dependent variables, and maximum & minimum temperatures, relative humidity and rainfall as independent variables. The impact of weather factors on the population of whitely in non-Bt varieties during 2010 showed that maximum temperature exerted 42.0% role in the whitefly population fluctuation which was highest than any factor. The impact of maximum temperature was significantly negative whereas minimum temperature, relative humidity and rainfall had 19.1%, 20.1% and 0.2% role. While minimum temperature contributed 47.7% followed by relative humidity 33.8% to the variation of whitefly population during 2011 (Table 4). The impact of these factors was highly statistically significant and positive. The coefficient of determination values for whitefly population in Bt varieties revealed that minimum temperature exerted maximum role 31.2% and 11.3% during 2010 and 2011 respectively. But others factors contributed very low in whitefly population fluctuation on Bt varieties (Table 5).

The regression model regarding the impact of weather factors on thrips population in non-Bt varieties revealed that minimum temperature was most important factor which contributed maximum i.e. 66.1% and 79.7% in the fluctuation of thrips population. The impact of minimum temperature was positive and highly significant during both years. The contribution of other abiotic factors to the variation of thrips population was very low (Table 6). Similarly in case of Bt varieties during 2010, minimum temperature was the only contributing factor which contributed 53.9% but during 2011 maximum temperature had highest impact in the thrips population fluctuation

Table 4. Hierarchical regression models along with coefficient of determination and role of individual weather factor on the population fluctuation of whitefly on non-Bt varieties

Year	Regression equation	100 R^2	Impact
2010	$Y^* = 33.8 – 0.737\ X_1^*$	42.0	42.0
	$Y^{**} = 24.8 – 0.869\ X_1^{**} + 0.520\ X_2$	61.1	19.1
	$Y^{**} = – 27.4 + 0.087\ X_1 + 0.650\ X_2^{**} + 0.203\ X_3^*$	81.2	20.1
	$Y^{**} = – 28.4 + 0.088\ X_1 + 0.671\ X_2^* + 0.211\ X_3^* – 0.0130\ X_4$	81.4	0.2
2011	$Y = 15.5 – 0.254\ X_1$	7.7	7.7
	$Y^* = 4.23 – 0.421\ X_1^* + 0.658\ X_2^{**}$	55.4	47.7
	$Y^{**} = – 50.1 + 0.573\ X_1^* + 0.793\ X_2^{**} + 0.211\ X_3^{**}$	89.2	33.8
	$Y^{**} = – 51.8 + 0.575\ X_1^* + 0.828\ X_2^{**} + 0.225\ X_3^{**} – 0.0219\ X_4$	90.1	0.9

Where, Y= Population of insect pest; X_1= Maximum temperature for every week; X_2= Minimum temperature for every week; X_3= Average relative humidity for every week; X_4= Total rainfall (mm) for every week; * = Significant at $P \leq 0.05$; **= Significant at $P \leq 0.01$

Table 5. Hierarchical regression models along with coefficient of determination and role of individual weather factor on the population fluctuation of whitefly on Bt varieties

Year	Regression equation	100 R^2	Impact
2010	$Y = – 1.07 + 0.156\ X_1$	15.3	15.3
	$Y^* = – 5.07 + 0.0970\ X_1 + 0.233\ X_2^*$	46.5	31.2
	$Y = 0.9 – 0.013\ X_1 + 0.218\ X_2 – 0.0234\ X_3$	48.6	2.1
	$Y = 1.3 – 0.013\ X_1 + 0.211\ X_2 – 0.0260\ X_3 + 0.0043\ X_4$	48.8	0.2
2011	$Y = 0.37 + 0.082\ X_1$	4.8	4.8
	$Y = – 1.88 + 0.049\ X_1 + 0.131\ X_2$	16.1	11.3
	$Y = – 12.4 + 0.241\ X_1 + 0.157\ X_2 + 0.0408\ X_3$	23.6	7.5
	$Y = – 14.2 + 0.243\ X_1 + 0.195\ X_2 + 0.0553\ X_3 – 0.0236\ X_4$	29.5	5.9

Where, Y= Population of insect pest; X_1= Maximum temperature for every week; X_2= Minimum temperature for every week; X_3= Average relative humidity for every week; X_4= Total rainfall (mm) for every week; * = Significant at $P \leq 0.05$; **= Significant at $P \leq 0.01$

Table 6. Hierarchical regression models along with coefficient of determination and role of individual weather factor on the population fluctuation of thrips on non-Bt varieties

Year	Regression equation	100 R^2	Impact
2010	$Y = 3.0 + 0.222 X_1$	4.5	4.5
	$Y^{**} = -12.3 - 0.005 X_1 + 0.893 X_2^{**}$	70.6	66.1
	$Y^{**} = -1.2 - 0.207 X_1 + 0.865 X_2^{**} - 0.0430 X_3$	71.7	1.1
	$Y^{*} = -5.3 - 0.203 X_1 + 0.949 X_2^{**} - 0.0108 X_3 - 0.0524 X_4$	75.4	3.7
2011	$Y = 11.5 - 0.061 X_1$	0.3	0.3
	$Y^{**} = -5.25 - 0.309 X_1 + 0.977 X_2^{**}$	80.0	79.7
	$Y^{**} = -37.8 + 0.286 X_1 + 1.06 X_2^{**} + 0.126 X_3^{*}$	89.2	9.2
	$Y^{**} = -40.2 + 0.289 X_1 + 1.11 X_2^{**} + 0.145 X_3^{*} - 0.0305 X_4$	90.5	1.3

Where, Y= Population of insect pest; X_1= Maximum temperature for every week; X_2= Minimum temperature for every week; X_3= Average relative humidity for every week; X_4= Total rainfall (mm) for every week; * = Significant at $P \leq 0.05$; **= Significant at $P \leq 0.01$

Table 7. Hierarchical regression models along with coefficient of determination and role of individual weather factor on the population fluctuation of thrips on Bt varieties

Year	Regression equation	100 R^2	Impact
2010	$Y = 8.11 + 0.066 X_1$	0.9	0.9
	$Y^{*} = -1.08 - 0.070 X_1 + 0.535 X_2^{**}$	54.8	53.9
	$Y^{*} = 9.3 - 0.261 X_1 + 0.509 X_2^{*} - 0.0405 X_3$	56.9	2.1
	$Y = 8.2 - 0.260 X_1 + 0.533 X_2^{*} - 0.0316 X_3 - 0.0145 X_4$	57.5	0.6
2011	$Y^{**} = -10.4 + 0.573 X_1^{**}$	60.3	60.3
	$Y^{**} = -15.4 + 0.500 X_1^{**} + 0.290 X_2$	74.4	14.1
	$Y^{**} = -7.1 + 0.347 X_1 + 0.269 X_2 - 0.0324 X_3$	75.6	1.2
	$Y^{*} = -6.7 + 0.347 X_1 + 0.263 X_2 - 0.0348 X_3 + 0.0040 X_4$	75.6	0.0

Where, Y= Population of insect pest; X_1= Maximum temperature for every week; X_2= Minimum temperature for every week; X_3= Average relative humidity for every week; X_4= Total rainfall (mm) for every week; * = Significant at $P \leq 0.05$; **= Significant at $P \leq 0.01$

(60.3%). The impact of maximum and minimum temperature (during both years) was highly significant and positive (Table 7).

DISCUSSION

The results indicated that incidence of whitefly and thrips was more on Bt genotypes than non-Bt as supported by Jeyakumar *et al*. (2008) who noticed higher incidence of whitefly in Bt cotton hybrids. This was, however, probably due to limited or no feeding by bollworms and not because of higher whitefly susceptibility (Wilson *et al*., 1992). Meteorological parameters play an important role in the population fluctuation of sucking insect pests (Gogoi and Datta, 2000; Murugan and Uthamasamy, 2001; Panickar and Patel, 2001). The most important abiotic factor is temperature which has dominant role in pest population variation (Bale *et al*., 2002). The above said parameter affects egg laying, increases rate of feeding, metabolism, herbivory and development (Pedigo, 2002). Relative humidity is also a contributing factor in the population dynamics of whitefly and was negatively correlated (Rote and Puri, 1991; Jagdav and Butter, 1988), whereas contrasting results achieved by Gupta *et al*. (1998). Consonance findings are reported by Safdar *et al*. (2005) who reported that minimum temperature and relative humidity had significant correlation with whitefly population. However, the findings of Ghafoor *et al*. (2011) are different from ours as they found significant negative correlation of maximum and minimum temperature and non-significant correlation with whitefly population. Abdul-Majeed *et al*. (1998) also reported negative correlation of relative humidity and whitefly population. Kumawat *et al*. (2000) investigated the seasonal incidence of whitefly (*B. tabaci*) on okra and reported that maximum temperature was significantly correlated with whitefly density. Deepesh *et al*. (1997) mentioned that *B. tabaci* (Gennadius) population showed a significant positive association with temperature. The results of Bashir *et al*. (2001), who concluded that rainfall negatively correlated with whitefly population also favors the present study. Sahito *et al*. (2012) reported that temperature and relative humidity had negative correlation with whitefly population which is partially similar to present findings. Furthermore, these findings are in agreement with the findings of Ashfaq *et al*. (2010) investigated population of the whitefly on different genotypes and observed that there was a significant and positive correlation between temperature variations and the variations in the population of the whitefly; whereas the humidity had a non-significant and negative correlation with the whitefly population.

The results revealed that with the increase in relative humidity, the population of thrips decreases because relative humidity has strong negative while maximum and minimum temperature has strongly positive correlation with thrips population. These findings are not in conformity with Saleem *et al*. (2013) who reported that relative humidity positively affects thrips population while maximum temperature, minimum temperature and rainfall has non-significant correlation with thrips population. The effect of temperature was also significant and positive on thrips population (Arif *et al*., 2006). The present findings are in consonance to this phenomenon. According to Patel *et al*. (2013) maximum temperature had positive while relative humidity and rainfall had negative impact on thrips population. The present research findings are conformity to the findings of Shahid *et al*. (2012) and Khan and Ullah (1994) who also observed a negative relationship between population buildup of *T. tabaci* and relative humidity and rainfall. These results are also partially similar to the findings of Shivanna *et al*. (2011) who reported increase in population of whitefly and thrips with increase in maximum temperature while relationship of minimum temperature, relative humidity and rainfall with thrips and whitefly population was non-significant. Khan *et al*. (2008) also showed non-significant and negative relation of relative humidity with thrips population.

***Acknowledgements*:** The authors would like to acknowledge Cotton Research Institute (CRI), Faisalabad-Pakistan for the provision of cotton genotypes (Bt and non-Bt).

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