Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2018; 6(4): 725-727

Received: 21-05-2018
Accepted: 22-06-2018

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Effects of weather variables on population build up of cotton whitefly (*Bemisia tabaci*, Gennadius) and its predator natural enemies

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Abstract
The studies revealed that whitefly adults population reached two peaks on 37th and 38th Standard Meteorological Weeks (SMW *i.e.* 2nd and 3rd weeks of September) with 6.11 and 5.96 adults per leaf, whereas nymphs population was as high as 8.44 and 8.74 nymphs per leaf during 36th and 37th Standard Meteorological Weeks (*i.e.* 1st and 2nd weeks of September), respectively. Whitefly adults had significant positive relation with maximum temperature (r=0.728) and bright sunshine hours (r=0.808) but significant negative correlation with morning (r= -0.699), evening relative humidity (r= -0.625) and rainfall (r= -0.786) and nymphs population was found to have significant positive correlation with maximum temperature (r=0.642) and bright sunshine hours (r=0.781) but negative significant relation with morning relative humidity (-0.639) and rainfall (-0.699). All weather variables collectively accounted for 81, 69 and 65 percent variability in the adults, nymphal and natural enemies (NEs) population.

Keywords: Whitefly, Natural enemies, correlation, regression, weather variables

Introduction
Cotton (*Gossypium* spp.) popularly known as "White Gold" is a commercial crop of paramount importance. It is considered as the landmark achievement of any civilization because it provides clothing to human beings and gainful employment to millions of people in the field of agriculture and industry [10].

Cotton production is constrained by a number of factors like various diseases, pest attacks, disorders, nutrient deficiencies and harsh climatic conditions etc. Amongst the sucking pests, whitefly has been reported as a major pest during mid to late cotton growing season causing 50 percent reduction in boll production, great damage due to high population of the pest which may remove significant amounts of phloem sap to reduce plant vigour [6].

The weather is changing at every instant. Whitefly population is greatly affected by abiotic factors and several workers have attributed abiotic factors as one of the major contributing factors to the outbreaks of insect [11]. The maximum population of whitefly was found to be 19.75 adults/leaf, on transgenic genotype RCH-134 and 54% variability in whitefly population was due to various abiotic factors reported by Rawal *et al.* [8] in the year 2014 at Haryana condition. The findings of Mehra and Rolania [7] indicated that the influence of all the weather parameters was high and significant on whitefly adults (R^2=0.68) and nymphal (R^2=0.49) population in Haryana conditions.

Thus keeping in view the devastating effect of whitefly in Punjab and Haryana in the year 2015, the present studies were undertaken with an aim to determine the manner in which correlation existed between weather factors and cotton crop, whitefly and it's NEs so as to manage the pest.

Materials and Methods
The experiment was conducted during *kharif* season of 2016 at Entomology Research Area of CCS Haryana Agricultural University, Hisar. That was laid out in split plot design (SPD) with American cotton variety (H1117) and the population **o**f whitefly, *Bemisia tabaci* was recorded at weekly interval starting from 30 days after sowing (first week of June, 2016) till maturity of crop (second week of October). Five plants from each plot were selected randomly and tagged. Whitefly adult population was recorded by observing undersides of three fully formed leaves

from upper, middle and lower canopy of plants from each plot. The meteorological data regarding the minimum and maximum temperature, relative humidity, sunshine hour, rainfall etc were collected from Meteorological Observatory of Department of Agro-meteorology, CCSHAU, Hisar. Then the adults, nymphs, NEs population data were correlated with the weather variables.

Results and Discussion

The data of population dynamics studies of the whitefly on cotton presented in Table-1 revealed that whitefly adults population reached two peaks on 37th and 38th SMW (*i.e.* 2nd and 3rd weeks of September) with the number as high as 6.11 and 5.96 adults per leaf during the course of investigation and the nymphs population also reached two peaks *i.e.* on 36th and 37th SMW (*i.e.* 1st and 2nd weeks of September) with the number as high as 8.44 and 8.74 nymphs per leaf, respectively. The present findings are in accordance with Mehra and Rolania [7] who noticed that there were two peaks of whitefly adults found on 34th and 38th SMW on cotton. The maximum population of nymphs and adults were found at a mean temperature of 29.8 ºC, which was seemed to favour the multiplication of the pest population. The results are in agreement with Kedar [3] who reported a mean temperature of 29.1 ºC found favourable for the pest multiplication in cotton crop.

As evident from Table-2, whitefly adults had significant positive correlation with maximum temperature (r=0.728) and bright sunshine hours (r=0.808). These finding are in confirmation with Madankar *et al.* [4] who performed an experiment in *Bt* cotton found that there was a positive correlation of whitefly population with the maximum temperature.

The morning relative humidity (r= -0.699) and evening relative humidity (r= -0.625) had negative and significant correlation with adult and morning relative humidity (r= -0.639) had negative significant correlation with whitefly nymph population and evening relative humidity had negative and non-significant correlation with the population of nymphs. The findings were in accordance with Kaur *et al.* [2] who found the significant negative correlation of whitefly on cotton with the relative humidity.

The findings revealed that rainfall (r= -0.786) had negative but significant correlation with adult whitefly population and it (r= -0.699) had negative and significant correlation with whitefly nymph population. That indicated the decrease in whitefly population with increase in the rain fall amount. The result were at par with the findings of Kalkal *et al.* [1] who revealed the whitefly population was negatively correlated with rainfall on cotton.

Table 1: mean populations and weather variable corresponding to SMW

Standard Meteorological week	Natural enemy	Adult	Nymph	Temperature °C		Relative Humidity %		Bright sunshine hours	Rainfall (mm)	Avg.WS Km/h
				Max.	Min.	Morn.	Even.			
29	0.67	1.81	1.87	33.9	25.3	92	71	4.5	73.3	5.2
30	1.2	3.86	8.19	36.7	26.0	89	70	8.0	27.0	6.9
31	0.72	1.23	2.6	32.5	25.2	93	74	4.2	47.0	4.9
32	0.76	3.03	4.72	34.6	26.1	92	76	6.0	4.3	7.1
33	1.28	3.5	5.38	34.8	24.7	86	60	6.5	4.5	5.0
34	1.66	3.71	6.51	34.0	26.4	88	61	5.1	8.4	5.8
35	0.89	1.5	2.36	32.8	25.3	94	78	6.0	63.2	5.1
36	1.43	5.29	7.67	34.2	23.8	87	60	9.3	0.0	5.8
37	1.57	6.11	8.74	35.8	23.7	83	53	9.6	0.0	5.0
38	1.20	5.96	6.08	36.4	24.9	89	54	8.9	0.0	4.2
39	1.53	5.18	7.18	35.0	24.2	85	49	8.0	2.8	5.1
40	1.33	3.77	3.18	35.2	24.7	90	57	5.3	12.0	3.1
41	0.61	3.32	4.42	35.1	20.4	83	37	8.7	0.0	2.9

Table 2: Correlation (r) of different abiotic and biotic factors with whitefly and its natural enemies

Factors	Adult	Nymph	NEs
T_{max}	0.728*	0.642*	0.369
T_{min}	-0.233	-0.072	0.174
RH_m	-0.699*	-0.639*	-0.451
RH_e	-0.625*	-0.397	-0.312
SSH	0.808*	0.781*	0.351
RF	-0.786*	-0.699*	-0.554*
WS	-0.057	0.323	0.116
Adult	-	-	0.723*
Nymph	-	-	0.725*

*Significant at p=0.05 level

Table 3: Regression analysis between weather factors and Population of *B. tabaci* and their natural enemies population

	Regression equation	R^2
Whitefly adult	Y= -10.37 + 0.31 T_{max} + 0.02 RHm - 0.01 RHe + 0.36 SSH - 0.03 RF	0.81
Whitefly nymph	Y= -11.46 + 0.28 T_{max} + 0.035 RHm + 0.67 SSH - 0.031 RF	0.69
Natural enemies (NEs)	Y=2.65 + 0.16 A + 0.08 Ny – 0.11 T_{max} + 0.014 RHm + 0.001 RF	0.65
(NEs)biotic	Y=0.469 + 0.085 A + 0.067 Ny	0.58

The present results revealed that whitefly adult mean population had significant positive correlation with bright sunshine hours (r=0.808) and nymphs mean population had a significant positive correlation with bright sunshine hours (r=0.781). The present findings got the support of Mehra and Rolania [7] who reported that the whitefly adult population have significant positive correlation with sunshine hours on cotton crop. The present findings revealed that whitefly adult mean population had negative non-significant correlation with average wind speed while the nymphs population had a positive non-significant correlation with average wind speed. The present findings are in accordance with Sharma and Rishi [9] who reported that there was a non-significant negative correlation of whitefly population with wind speed on cotton.

Regression analysis results shown in Table-3 revealed that all weather variables collectively accounted for 81 and 69 percent variability in the adult and nymphal populations. In case of natural enemies both biotic, abiotic factors (R^2=0.65) and the biotic factor (R^2=0.58) alone have significant influence on the population of natural enemies. The results are in accordance with Mahalakshmi *et al.* [5] who revealed that the total influence of abiotic factors was about 50 percent in all cotton hybrids.

Conclusion

Overall effects of weather parameters were found high and significant on the population of whitefly and its natural enemies. This correlation results and regression results can be utilized for prediction of pest population and help in decision making of initiation of any control tactics.

Acknowledgments

I am thankful to Department of Entomology, College of Agriculture, CCSHAU for conducting the experiment. I am also thankful to my guide Dr. R. S. Jaglan and co-guide Dr. K. K. Dahiya for their guidance and for their sincere efforts; I am able to successfully complete my research work.

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