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Influence of weather parameters on population of whitefly, *Bemisia tabaci* in American cotton (*Gossypium hirsutum*)

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Abstract
The experiment was conducted to investigate the performance of 23 genotypes whitefly and impact of abiotic factors on the population fluctuation of the pest during *kharif* 2014 and 2015. The incidence of whitefly was observed throughout the crop season. The maximum adult population of whitefly was recorded at 34th and 31st SMW (standard meteorological week) during 2014 and 2015, respectively. The maximum mean incidence was recorded in Western Niroga 151 BGII (45.95 adult/leaf) and 49.70 adult/leaf during 2014 and2015, respectively. Whitefly population was significantly and negatively correlated with the maximum temperature while significant and positive correlation showed with morning and evening relative humidity, during 2014. During 2015, whitefly significantly and positively correlated with the minimum temperature, morning and evening relative humidity while, significantly and negatively correlated with maximum temperature.

Keywords: Whitefly, *Bemisia tabaci,* American cotton, Weather parameters

1. Introduction

Cotton (*Gossypium* spp.) often referred to as "White gold" is an important cash crop of India. It is grown commercially in the temperate and tropical regions of more than 70 countries on all types of soil barring pure sand, saline and water logged soils. Cotton is also known for its oil content properties, providing raw material to the oil and textile industries, contributes to approximately 30 per cent of the Indian agricultural, gross domestic product and considerable export earnings [1].

Indian cotton has witnessed dynamic changes right from cultivation of predominantly diploid varieties in the beginnings the cultivation of allotetraploid hirsutum varieties to hybrids and now the transgenic era. In India, all four cultivated species of cotton, viz., *Gossypium hirsutum* L., *G. arboreium* L., *G. herbaceum* L., and *G. barbadense* L. along with intra and inter-specific hybrids are cultivated and grown on commercial scale. The large scale adoption of genetically modified (GM) cotton along with improved production and protection technologies since 2002 made India the second largest exporter of raw cotton. In world, the area under cotton is 292.23 lakh ha with a production of 105.72 million bales of 480 lb and productivity of 788 kg/ha. Whereas, in India, the area under cotton is 105.00 lakh ha with a production of 351 lakh bales of 170 kg and productivity of 568 kg/ha while, in Haryana of India, the area under Cotton is 4.98 lakh ha with a production of 17.00 lakh bales and productivity of 683 kg/ha during 2016-17 [2].

More than 1326 species of insects have been reported in cotton fields worldwide [3]. Insect pests are the major cause of crop losses [4]. Cotton insect pest management has always been an immensely challenging task for entomologists all over the world. *Bt* cotton does not interfere with the activity of sucking insect pests and in turns becoming a burning issue. In the present time, sucking insect pests' *viz*., whitefly (*Bemisia tabaci* Gennadius), leafhopper (*Amrasca biguttula biguttula* Ishida), thrips (*Thrips tabaci* Lindemann) and aphid (*Aphis gossypii* Glover), get the favourable condition for their development and multiplication. The reduction of conventional insecticides on *Bt* cotton is also presumed to have led to an enhanced infestation of sucking insect-pests. Higher dose of nitrogenous fertilizers leading to an increase in the quantum of some amino nitrogen concentrations in the plant system makes it more conducive for the fast development and higher fertility of sucking insect pests [5].

Amongst the sap sucking insect pests damaging this crop, whitefly, *B. tabaci* (Hemiptera: Aleyrodidae), a highly polyphagous insect-pest, has become serious, causing heavy losses during certain years. High population of the pest has the potential to remove significant amounts of phloem sap resulting in the reduction of plant vigour. Damage by this pest is caused in two ways: (a) the vitality of the plant is lowered through the loss of cell sap, and (b) normal photosynthesis is interfering with the growth of sooty mould on the honeydew excreted by the insect. Due to sooty mould growth, the quality and marketability of harvested products are reduces. Honeydew falling on open bolls makes the lint sticky, which creates problems during ginning [6]. The pest is also known to transmit cotton leaf curl virus causing significant yield losses if the infection is in the early stages of crop growth [7].

Due to variation in the agro climatic conditions of different seasons insect show varying trends in their incidence also in nature and extent of damage to the crops. Besides, some known and unknown factors also play a key role in determining the incidence and dominance of a pest. Therefore, the present study was to understand the behaviour of whitefly with the weather parameter of the environment.

2. Materials and Methods

The field experiment was conducted during *kharif* 2014 and 2015 at Cotton Research field area, CCS Haryana Agricultural University, Hisar in unprotected condition with three replicates. The plot has 5 rows of 5 m each for each treatment. The seeds of 23 genotypes were sown at 2 seeds/hill on 18th May, 2014 and 16th May, 2015 by the hand dibbling method. Gap filling was done within 5-7 days after emergence of the crop and thinning was done in 15 days after emergence of the crop, keeping one healthy seedling/hill.

The observations on population of adult whitefly were recorded at weekly intervals from 23 to 41 SMW on three leaves (each from top, middle and bottom) at five randomly selected and tagged plants in each plot throughout the crop period before 9:00 am. The meteorological data obtained from the Department of Agricultural Meteorology. The data were subjected to statistical analysis and correlation coefficient was worked out by using OP STAT (Online) software. Simple correlation was worked out between the population of insect pests and weather parameters by the Karl Pearson's coefficient at 5% level of significance.

3. Results

3.1 Population dynamics of *Bemisia tabaci* on cotton during *kharif* 2014: The adult population of *B. tabaci* was recorded at weekly intervals. The population was nil at 23rd SMW (standard meteorological week) i.e. first week of June and the incidence were commenced from the 24th SMW i.e. second week of June (Fig. 1). Significant differences in the adult population was recorded at 26th SMW with the maximum adult population on Bioseed 6588 BGII (7.11 adults/leaf) and it was statistically on par with SP 7007 BGII (5.78 adults/leaf) while no adult population was observed on PCH 876 BT and significantly superior to other genotypes. Genotype PCH 876 BT was followed by H 1226 (0.78 adults/leaf) and PRCH 333 BGII (1.22 adults/leaf). Increase in the adult population of *B. tabaci* observed from 26th to 34th SMW. At 34th SMW, adult population reached to its peak and it ranged from 56.48 to 135.72 adults/leaf. The maximum adult population of 135.72 adults/leaf was recorded on Western Niroga 151 BGII and it was statistically on par with RCH 653 BGII (128.24 adults/leaf) while, the minimum was on H 1226 (56.48 adults/leaf) and it were statistically on par with NCS 9002 BGII (65.15 adults/leaf), HHH 223 (65.38 adults/leaf), PRCH 333 BGII (69.91 adults/leaf), PCH 876 BT (70.08 adults/leaf) and KDCHH 541 BGII (70.46 adults/leaf). From 34th SMW adult population of *B. tabaci* started declining and reached its minimum at 41th SMW. Genotype Western Niroga 151 BGII was recorded with a maximum adult population of 27.28 adults/leaf while and it were statistically on par with RCH 653 BGII (25.77 adults/leaf) and PCH 877 BGII (23.30 adults/leaf), minimum population was on H 1226 (11.99 adults/leaf) and it were statistically on par with NCS 9002 BGII (13.83 adults/leaf), PCH 876 BT (14.88 adults/leaf) and KDCHH 541 BGII (14.95 adults/leaf). Mean number of adult population was also calculated for all the genotypes and it ranged from 20.15 to 43.46 adults/leaf (Table-1). The maximum adult population was recorded on RCH 653 BGII (43.46 adults/leaf) whereas, the minimum was on H 1226 (20.15 adults/leaf) among the different cotton genotypes.

3.2 Population dynamics of *B. tabaci* on cotton during *kharif* 2015: During *kharif* 2015, the adult population of *B. tabaci* was commenced at 23rd SMW and is presented in Fig. 2. At 23rd SMW, adult population of *B. tabaci* varied significantly among the different genotypes. The maximum adult population was recorded on SP 7010 with 3.15 adults/leaf and it was statistically on par with S 07 H 878 BGII (3.05 adults/leaf) whereas, the minimum on KDCHH 541 BGII and NCS 9002 BGII (0.75 adults/leaf) and it were statistically on par with KSCH 209 BGII (0.82 adults/leaf), PCH 876 BT (0.93 adults/leaf) and HHH 223 (1.36 adults/leaf). Increase in the adult population was recorded in later weeks and reached its peak three weeks earlier, i.e. at 31st SMW as compared to *kharif* 2014 season (Fig. 2). At 31st SMW, the maximum adult population was recorded on Bioseed 6588 BGII (110.82 adults/leaf) and followed by Western Niroga 151 BGII (107.77 adults/leaf) and VICH 310 BTII (105.73 adults/leaf). The minimum adult population was recorded on H 1226 (57.95 adults/leaf) and followed by RCH 314 BGII (64.05 adults/leaf). From 32nd to 37th SMW, adult population of *B. tabaci* decreased gradually while, steep decline in the adult population was observed from 38th to 41th SMW. At 41th SMW, the maximum adult population recorded on KDCHH 541 BGII and Bioseed 6588 BGII (8.11 adults/leaf) and it was statistically on par with PCH 406 BT (6.22 adults/leaf), SP 7007 BGII (6.22 adults/leaf), KSCH 209 BGII (6.56 adults/leaf), Western Niroga 151 BGII (6.78 adults/leaf), PCH 876 BT (7.00 adults/leaf) and RCH 314 BGII (7.11 adults/leaf). The minimum adult population was recorded on KCH 14 K 59 BGII (2.78 adults/leaf) and it was statistically on par with PRCH 333 BGII (3.00 adults/leaf), RCH 653 BGII (3.11 adults/leaf), ANK 3028 BGII (3.22 adults/leaf) S 07 H 878 BGII (3.44 adults/leaf), HHH 223 (3.44 adults/leaf) and GBCH 85 BGII (3.89 adults/leaf). Mean number of adult population was also calculated for all the genotypes and it ranged from 26.16 to 48.67 adults/leaf. The maximum adult population was recorded on Bioseed 6588 BGII (48.67 adults/leaf) whereas, the minimum was on H 1226 (26.16 adults/leaf) among the different cotton genotypes.

3.3 Population dynamics of *B. tabaci* on cotton during both seasons (2014 and 2015): During pooled analysis of two years 2014 and 2015, the activity of the adult population of *B. tabaci* commenced at 23rd SMW and lasted up to 41th

SMW is presented in Fig. 3. Significant difference in adult population was recorded at 25th SMW with maximum adult population recorded on VICH 310 BTII (7.45 adults/leaf) and statistically on par with Bioseed 6588 BGII (6.60 adults/leaf), PRCH 333 BGII (6.68 adults/leaf), KSCH 210 BGII (6.82 adults/leaf), ANK 3028 BGII (6.85 adults/leaf), SP 7171 BGII (6.95 adults/leaf), RCH 314 BGII (7.00 adults/leaf), Western Nigora 151 BGII (7.02 adults/leaf), RCH 653 BGII (7.11 adults/leaf) and SP 7007 BGII (7.33 adults/leaf). The minimum adult population on PCH 876 BT (4.56 adults/leaf) and it was statistically on par with H 1226 (4.85 adults/leaf) and PCH 406 BT (4.95 adults/leaf). The adult population of *B. tabaci* increased in succeeding SMW and reached its peak at 34th SMW (Fig. 3). At 34th SMW, adult population ranged from 50.10 to 114.63 adults/leaf. The maximum adult population was observed on Western Nigora 151 BGII (114.63 adults/leaf) and it was statistically on par with PCH 877 BGII (99.12 adults/leaf) and RCH 653 BGII (102.76 adults/leaf) while, minimum was on H 1226 (50.10 adults/leaf) and it was statistically on par with HHH 223 (57.04 adults/leaf), NCS 9002 BGII (61.43 adults/leaf), PCH 876 BT (62.63 adults/leaf) and GBCH 85 BGII (66.30 adults/leaf). The last observation of the adult population was recorded at 41th SMW and it ranged from 8.66 to 17.03 adults/leaf. The maximum adult population was recorded on Western Nigora 151 BGII (17.03 adults/leaf) and it was statistically on par with RCH 653 BGII (14.44 adults/leaf) and PCH 877 BGII (14.60 adults/leaf) whereas, minimum was on HHH 223 (8.66 adults/leaf) and it was statistically on par with PRCH 333 BGII (8.82 adults/leaf), H 1226 (9.00 adults/leaf), NCS 9002 BGII (9.86 adults/leaf), KSCH 541 BGII (10.29 adults/leaf), GBCH 85 BGII (10.30 adults/leaf) and S 07 H 878 BGII (10.72 adults/leaf). Mean number of adult population was also calculated for all the genotypes and it ranged from 23.15 to 47.83 adults/leaf. The maximum adult population was recorded on Western Nigora 151 BGII (47.83 adults/leaf) whereas, the minimum was on H 1226 (23.15 adults/leaf) among the different cotton genotypes.

3.4 Correlation with the weather parameters and *B. tabaci* during 2014: The correlation between the whitefly population and weather parameters is present in the table-2. The correlation coefficient of adult population with maximum temperature was significantly negative and it was r= -0.598* while significantly positive with morning and evening relative humidity (r= 0.614** and 0.483*).

3.5 Correlation with the weather parameters and *B. tabaci* during 2015: The significant and positive correlation coefficient of adult population with minimum temperature, morning relative humidity and evening relative humidity was r= 0.500*, 0.539* and 0.502*, respectively as presented in the table-2.

3.6 Correlation with the weather parameters and *B. tabaci* during both seasons: During pooled analysis of both the years (2014 and 2015), a similar trend was observed as in *kharif* 2014 as shown in the table-2, significant and negative correlation coefficient between adult population and the maximum temperature was r= -0.562* while, significant and positive with morning and evening relative humidity (r= 0.671** and 0.559*).

Table 1: Average population of whitefly (*Bemisia tabaci*) on American cotton genotypes.

S. No.	Genotypes	Whitefly/leaf		
		2014	2015	Pooled
1	SP 7010	28.32 (5.41)	33.12 (5.84)	30.72 (5.63)
2	PRCH 333 BGII	24.63 (5.06)	42.15 (6.57)	33.39 (5.86)
3	VICH 310 BT II	32.00 (5.74)	44.61 (6.75)	38.30 (6.27)
4	GBCH 85 BG II	27.73 (5.36)	29.87 (5.56)	28.80 (5.46)
5	KSCH 210 BG II	33.08 (5.84)	33.19 (5.85)	33.13 (5.84)
6	S 07 H 878 BG II	30.02 (5.57)	32.33 (5.77)	31.17 (5.67)
7	SP 7007 BGII	33.50 (5.87)	40.01 (6.40)	36.76 (6.14)
8	KSCH 209 BG II	32.59 (5.80)	33.65 (5.89)	33.12 (5.84)
9	KSCH 541 BGII	27.11 (5.30)	41.52 (6.52)	34.32 (5.94)
10	KDCHH 541 BGII	24.88 (5.09)	38.51 (6.29)	31.70 (5.72)
11	PCH 876 BT	24.27 (5.03)	30.95 (5.65)	27.61 (5.35)
12	PCH 406 BT	28.98 (5.48)	30.47 (5.61)	29.73 (5.54)
13	KCH 14 K 59 BG II	37.01 (6.17)	28.52 (5.43)	32.77 (5.81)
14	NCS 9002 BG II	22.88 (4.89)	33.13 (5.84)	28.00 (5.39)
15	PCH 877 BG II	38.53 (6.29)	45.58 (6.82)	42.06 (6.56)
16	WESTERN NIROGA 151 BG II	45.95 (6.85)	49.70 (7.12)	47.83 (6.99)
17	ANK 3028 BG II	32.81 (5.81)	27.66 (5.35)	30.23 (5.59)
18	SP 7171 BG II	33.19 (5.85)	39.73 (6.38)	36.46 (6.12)
19	RCH 653 BG II	43.46 (6.67)	40.98 (6.48)	42.22 (6.57)
20	BIOSEED 6588 BG II	27.68 (5.36)	48.67 (7.05)	38.17 (6.26)
21	RCH 314 BG II	39.95 (6.40)	28.87 (5.47)	34.41 (5.95)
22	HHH 223	23.10 (4.91)	26.25 (5.22)	24.68 (5.07)
23	H 1226	20.15 (4.60)	26.16 (5.21)	23.15 (4.91)
	C.D.	(0.23)	(0.29)	(0.19)
	SE(m)	(0.08)	(0.10)	(0.07)

Figures in parentheses are $\sqrt{X+1}$ transformed values

Table 2: Correlation of whitefly population with weather parameter

Pest	Whitefly		
	2014	**2015**	**Pooled**
Temperature (maximum)	-0.598*	-0.423	-0.562*
Temperature (minimum)	0.033	0.500*	0.234
RH (morning)	0.614**	0.539*	0.671**
RH (evening)	0.483*	0.502*	0.559*
Rainfall	0.076	-0.245	-0.272
Wind Speed	-0.053	0.297	0.067
Sunshine hours	0.075	-0.228	-0.146

*Significant at 5%, **Significant at 1%

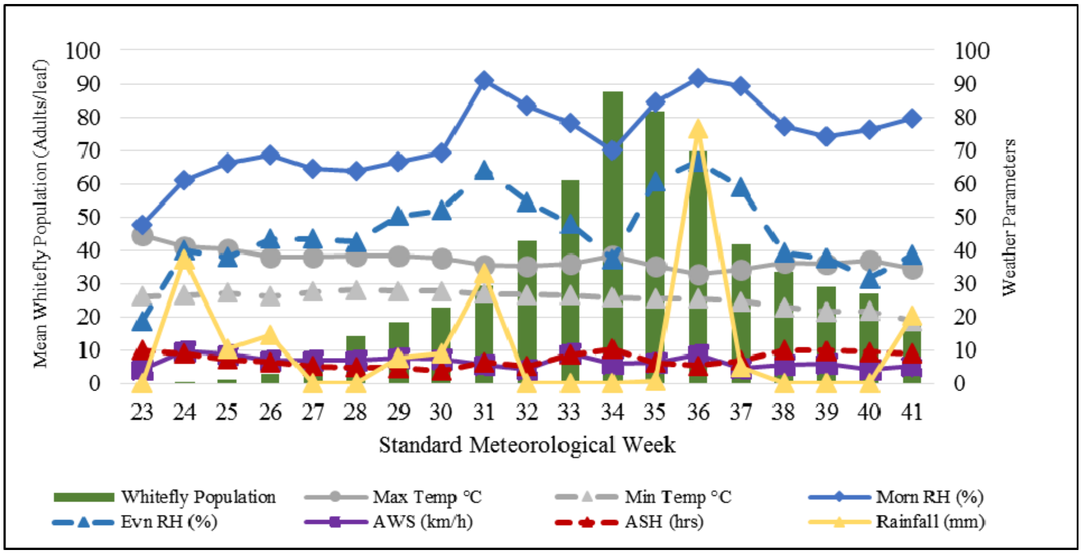

Fig 1: Population dynamic of whitefly in relation to weather parameters 2014

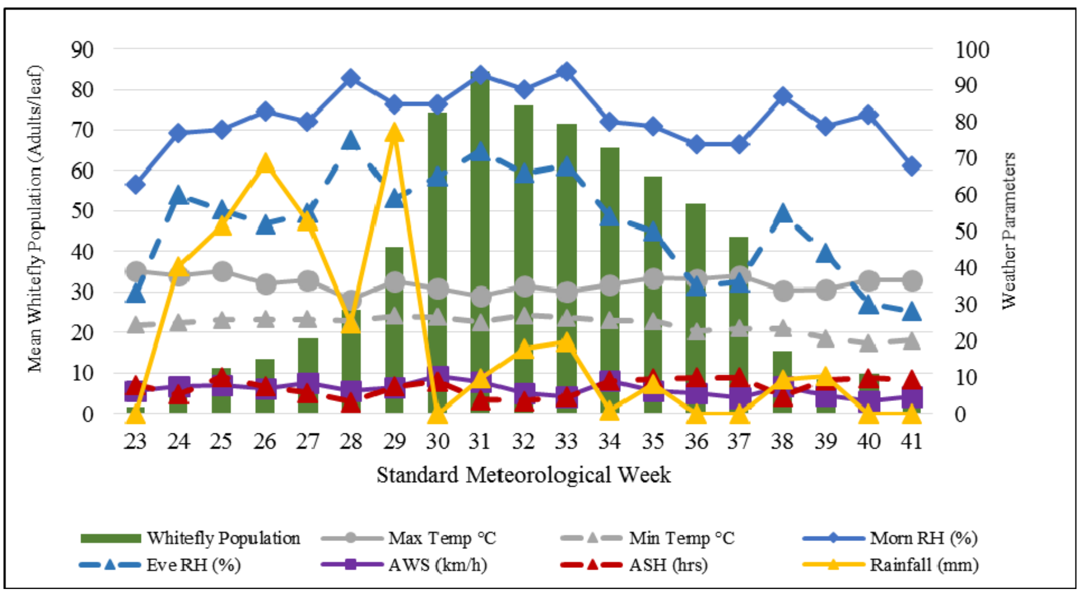

Fig 2: Population dynamic of whitefly in relation to weather parameters 2015

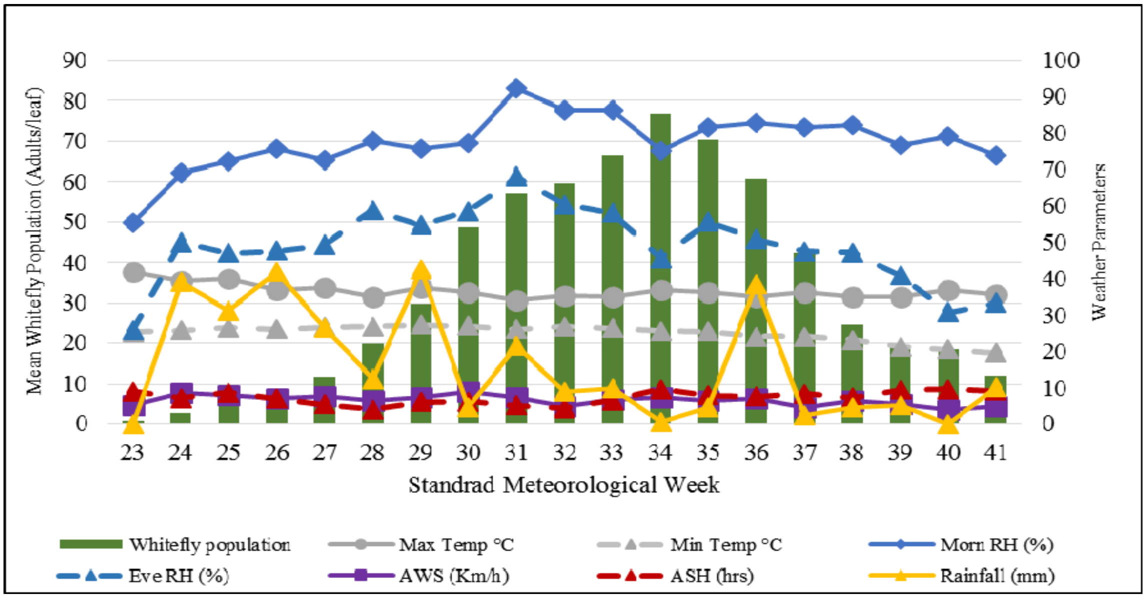

Fig 3: Population dynamic of whitefly in relation to pooled weather parameters

4. Discussion

The results obtained in this study reveal that the commencement of whitefly was found at 24th and 23rd SMW during 2014-15 and 2015-16, respectively and the peak of whitefly population reached on 34th and 31st SMW in 2014-15 and 2015-16 season, respectively. The present findings are in agreement with [8] who found that the incidence of whitefly was observed in the month of June. Similarly, [9] also observed similar findings as reported previous authors that the commencement of whitefly started in the June month and also reported that the peak of whitefly was recorded during 28th SMW at Hisar (Haryana). Accordingly, to [10, 11], the whitefly attained its peaks in month of August and September, they are in-line with present finding. The present study not supported by [12] who reported that whitefly incidence was higher on 31st, 33rd and 37th SMW with the range of 0.9 to 3.9, 0.5 to 3.6 and 0.8 to 4.9 adults/leaf, respectively in Sirsa (Haryana).The present results are at variance with the finding of [13, 4] who reported that the peak period of incidence of whitefly during September-October the differences may be due to the difference in climatic conditions. [14] observed that the incidence of whitefly was low throughout the season with peak (7.58 adults/leaf) incidence in 46th SW. Similarly, the observations on whitefly population revealed that the maximum incidence from April to May, on the second fortnight of April 2008 showed a peak with 29.50 whiteflies/3 leaves [15].

The present study showed that, significant and negative correlation coefficient between adult population and the maximum temperature while, significant and positive with morning and evening relative humidity. The similar negative effect of maximum temperature on whitefly population was also reported by other workers [16-18]. The present results are in line with finding of [9, 19] who computed positive correlation between whitefly incidence and minimum temperature. [20] they reported the significant positive relationship between mean morning relative humidity and whitefly population. The present findings are similar to the findings of [21] who reported that whitefly population to be positively correlated with temperature and rainfall while negative with relative humidity and [22] reported that adult population of whitefly was correlated negatively with relative humidity. Similar results were reported by [23].

5. Conclusion

The present study revealed that whitefly was commenced in first fortnight of June and touched the peak at 34th (56.48 to 135.72 adults/leaf) and 31st SMW (57.95 to 110.82 adults/leaf) during 2014-15 and 2015-16, respectively. It may be concluded that the climatic factors determined seasonal activity and population dynamics of whitefly in cotton. This information generated in the present study would be helpful in developing efficient pest management strategies against insect pests of cotton crop for increased production efficiency, profit, besides safety to the environment.

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