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E Akhila
M.Sc. Student, Dept. of Entomology, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, India

S Upendhar
Dept. of Entomology, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

K Vani Sree
AI & CC, and PJTSAU Press, Rajendranagar, Hyderabad, Telangana, India

B Vidhya Sagar
Dept. of Pathology, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

Corresponding Author:
E Akhila
M.Sc. Student, Dept. of Entomology, College of Agriculture, Rajendranagar, PJTSAU, Hyderabad, Telangana, India

Population dynamics of leafhopper *Amrasca biguttula biguttula* (Ishida) (Homoptera: Cicadellidae) on popular cotton hybrids in Telangana

E Akhila, S Upendhar, K Vani Sree and B Vidhya Sagar

Abstract
The present study aimed at the screening of popular *Bt* cotton hybrids against leafhoppers, *Amrasca biguttula biguttula* (Ishida) incidence at College farm, College of Agriculture, Rajendranagar, Hyderabad during *kharif* 2019-20. Eight transgenic cotton hybrids (Bioseed-7215-2, MH-5343, RCH-668, MRC-7347, PRCH-331, RCH-386, ROHINI-456, RCH-659) were sown and maintained without application of any insecticide till the maturity of the crop. Field data of leafhopper was collected from the occurrence of the pests after seedling emergence to till harvest at weekly intervals. The peak activity of leafhoppers was recorded during the 37th standard week to 44th standard week with a peak population of 10.13/3 leaves/plant in Bioseed-7215-2 and MRC-7347 during the 37th standard week among all the hybrids. While RCH-668 (6.93/3 leaves) showed a minimum leafhopper population build-up. Further, the leafhopper population was correlated with abiotic factors. The maximum temperature had a significant positive response on the leafhopper population. Whereas, minimum temperature, morning relative humidity, evening relative humidity and rainfall also showed positive correlation but non significantly. The regression studies revealed that all the weather parameters together contribute 75 percent **(**$R^2 = 0.75$**)** of the total variation in the leafhopper population.

Keywords: *Bt*-cotton, correlation, leafhopper, weather parameters

1. Introduction
Cotton is the important commercial crop of India. Natural fiber produced by cotton is an important component of the textile industry. It is under commercial cultivation to cater to the domestic consumption and export needs of about 111 countries in the world and hence called "King of fibers" or "White gold". It is popularly known as a friendly fiber because of its versatility, appearance, performance, and above all its natural comfort. India ranks second in global cotton production after china with the adaption of *Bt* transgenic cotton cultivars widely. It is the largest cotton growing country in the world occupying an area of 124.4 lakh ha with production and productivity of 370 lakh bales and 505.4 kg ha^{-1} respectively. In India, Telangana has the largest acreage of 18.97 lakh ha with production and productivity of 55 lakh bales and 492.8 kg ha^{-1}, respectively [1]. Cotton is grown in almost all districts of Telangana state.

Currently, with the popularization of *Bt* cotton, lepidopteran pests such as *Helicoverpa armigera* and *Pectinophora gossypiella* have been successfully controlled [2] & [3]. However, *Bt* toxins are ineffectual against phloem-feeding pests. After the introduction of transgenic cotton in India, sucking pests emerged out as a major constraint in cotton production.

Leafhoppers, *Amrasca devastans*, which inflict the crop from the seedling stage itself and cause phenomenal losses [4]. Among the sucking pests of cotton, the leafhopper, *A. devastans* is an alarming pest throughout the season. It has a broad host range including cotton, okra, brinjal and jute. Both nymph and adult stages cause damage to the plants by sucking the sap from leaves and also transmit different viruses. In spite of repeated use of insecticides, we are witnessing the control failures which might be the signals of insecticide resistance in sucking pests of cotton.

For control of insect pests on *Bt* cotton farmers frequently rely on chemical control [5]. The use of chemical control is not only creating health hazards and ecological contamination but also developing the resistance in the insects and disturbing the balance between the forces of destruction (predators, parasitoids and pathogens) in agro-ecosystem [6, 7]. The occurrence and progress of all the insect pests are much dependent upon the customary environmental factors such as temperature, relative humidity and precipitation [8]. The activities of these insect pests fluctuate under erratic environmental conditions. The knowledge about the incidence of a pest during the cropping season and its possible dynamics help in designing pest management strategies [9]. To develop suitable integrated pest management practices close monitoring of the insect pest complex of *Bt* cotton is necessary. Thus, by keeping the above things in mind the present study was carried out to investigate the seasonal occurrence and peak activity of sucking insect pest of the cotton throughout the cotton growing season and its correlation with weather factors. This information on pest surveillance will be useful for devising suitable pest management strategies for researchers and farmers.

2. Material and Methods

The present investigation was carried out at College farm, College of Agriculture, Rajendranagar, Hyderabad during *kharif* 2019-20 to study the population dynamics of major sucking pests of cotton.

2.1 Method of observations

Eight popular *Bt* cotton hybrids *viz*., Bioseed-7215-2, MH-5343, RCH-668, MRC-7347, PRCH-331, RCH-386, ROHINI-456, RCH-659 were raised in an area of 1000 m^2 to study the seasonal incidence of leafhoppers, *Amrasca biguttula biguttula* (Ishida) by adopting recommended agronomical practices without plant protection during *kharif* 2019-20. The observations were recorded on ten plants/replication randomly and the count was taken early in the morning by visual counting (absolute counting) on three leaves/plant (one each from the top, middle and bottom) using a magnifying lens from the first occurrence of the pest to till the last picking. Meteorological data were collected and analysis was done to arrive at correlation and regression analysis equation between pest incidence and weather parameters.

2.2 Statistical Analysis

The data obtained was analyzed for ANOVA (5% probability level) following a randomized block design by using Microsoft excel software, further subjected to angular transformation. The means were compared by Duncan's Multiple Range Test (DMRT) at P = 0.05. A simple correlation was worked out, between the pest population and weather factors individually, by using a Multiple Linear Regression Equation of Type 1, viz., $Y= a+ b_1X_1+ b_2X_2 + b_3X_3+ b_4X_4$…… where the population of sucking pest was taken as the Response Variables (Y) and the weather factors (X) as independent variables in the equation. Where (a) and (b) are the intercept and regression coefficients respectively.

3 Results and discussion

3.1 Leafhoppers (*Amrasca biguttula biguttula)*

Leafhopper population during *kharif* 2019-20 (Table 1 and figure 1) was recorded throughout the crop period (34^{th} -52^{nd} Std. week) in all the hybrids *viz*., Bioseed-7215-2, MH-5343, RCH-668, MRC-7347, PRCH-331, RCH-386, ROHINI-456 and RCH-659. The overall results revealed that 37^{th} to 44^{th} std. weeks were the most favorable for leafhopper incidence. The leafhopper population crossed ETL during the 37^{th} std. week in all the hybrids.

The peak incidence of leafhopper was recorded during the 37^{th} standard week on all the hybrids. The population fluctuation among the hybrids was ranged between 6.93-10.13 leafhoppers/3 leaves/ plant. The highest population was recorded on Bioseed-7215-2 and MRC-7347 (10.13) followed by MH-5343 (9.93), RCH-659 (9.30), RCH-386 (8.93), Rohini-456 (7.20), PRCH-331 (7.06) and RCH-668 (6.93). Statistically, most of the hybrids are on par with each other. However, RCH-668, PRCH-331 and Rohini-456 differed with other hybrids and among them, they were on par with each other.

The second peak of leafhoppers was recorded during the 39^{th} std. week in almost all the hybrids except Bioseed-7215-2, PRCH-331 (5.13) and Rohini-456. The population fluctuated between 3.83 -7.93 leafhoppers/3 leaves/ plant. The highest population was recorded on RCH-668 (7.93) followed by RCH-386 (6.90), RCH-659 (6.70), MH-5343 (6.23), MRC-7347 (6.13), PRCH-331 (5.13), Rohini-456 (4.70) and Bioseed-7215-2(3.83). Statistically, the hybrids differed significantly among each other.

The correlation studies revealed that a significant positive correlation exists between the jassid population and maximum temperature. The hybrids recorded positive correlation were Bioseed-7215-2(0.549*), MH-5343(0.640**), RCH-668(0.575**), MRC-7347(0.590**), PRCH-331(0.653**), RCH-386(0.532*), ROHINI-456 (0.636**) and RCH-659 (0.581**). Similarly, nonsignificant positive correlation with minimum temperature, morning relative humidity, evening relative humidity and rainfall. Jassid population on Bioseed-7215-2 (0.504*) and MRC-7347 (0.511*) showed a significant positive correlation with rainfall also (Table 2). Further, the regression studies showed that all the weather parameters together contribute 75 percent (R^2 =0.75) of the total variation in the leafhopper population (Table 3).

Present results conform with the findings of Borah [10], Singh *et al.* [11], Dheeraj Purohit *et al.* [12], Sesha Mahalakshmi [13], Lakshmi Soujanya [14], Prasad *et al.* [15], Gosalwad *et al.* [16], Chavan *et al.* [17], Reddy *et al.* [18] and Bhute *et al.* [19] where they reported that the leafhopper population appeared in the 1^{st} week after germination and its population continued to build up throughout the crop growth. Peak activity of leafhoppers registered from mid-September to mid-November on cotton hybrids. Further, the studies conducted on the correlation of weather parameters and influence on leafhopper population by Rao [20], Sewa *et al.* [21], Lakshmi Soujanya [14], Shivanna *et al.* [22], Shitole and Patel [23], Ashfaq *et al.* [24], Neelima [25], Bhute *et al.*[20], Babu and Meghwal [26], Kalkal *et al.* [27], Saleem *et al.* [28] and Harde *et al.* [29] concluded that the leafhopper population showed a positive correlation with all the abiotic factors, while maximum temperature and rainy days were showed a significant positive correlation with the leafhopper population in some instances. The total influence of all the weather factors on the incidence of leafhoppers fluctuated between 55.0-74.00 percent in different cotton hybrids.

Table 1: Leafhopper population incidence in different *Bt*-cotton hybrids during *Kharif* 2019-20

Hybrids	Meteorological standard weeks																		
	34th	35th	36th	37th	38th	39th	40th	41st	42nd	43rd	44th	45th	46th	47th	48th	49th	50th	51st	52nd
Bioseed-7215-2	0.30 (3.00)^{ab}	0.86 (5.30)^{bc}	1.80 (7.70)^{cd}	10.13 (18.56)^{a}	2.50 (8.97)^{c}	3.83 (11.28)^{d}	3.93 (11.43)^{cd}	3.63 (10.95)^{b}	2.73 (9.45)^{c}	4.36 (12.05)^{b}	3.56 (10.64)^{b}	3.56 (10.64)^{ab}	3.23 (10.26)^{bc}	2.76 (9.56)^{b}	1.63 (7.33)^{a}	0.50 (4.00)^{a}	0.66 (4.64)^{b}	0.53 (4.16)^{e}	0.33 (2.64)^{d}
MH-5343	0.50 (3.96)^{a}	0.96 (5.57)^{bc}	2.43 (8.96)^{c}	9.93 (18.37)^{a}	4.40 (12.02)^{ab}	6.23 (14.45)^{abc}	6.33 (14.50)^{a}	3.96 (11.43)^{b}	3.76 (11.11)^{bc}	5.80 (13.63)^{ab}	5.33 (13.26)^{ab}	4.76 (12.59)^{a}	4.10 (11.63)^{a}	4.00 (11.49)^{a}	1.66 (7.32)^{a}	0.53 (4.12)^{a}	0.60 (4.33)^{b}	0.50 (3.91)^{e}	0.90 (5.39)^{ab}
RCH-668	0.43 (3.66)^{a}	2.06 (8.22)^{a}	4.30 (12.01)^{a}	6.93 (15.26)^{b}	5.88 (13.78)^{a}	7.93 (16.26)^{a}	6.46 (14.70)^{a}	5.13 (13.09)^{a}	5.66 (13.76)^{a}	5.30 (13.13)^{ab}	4.06 (11.51)^{b}	3.86 (11.28)^{ab}	4.10 (11.63)^{a}	3.16 (10.24)^{ab}	1.56 (7.12)^{a}	0.43 (3.73)^{a}	0.63 (4.56)^{b}	2.56 (9.20)^{b}	3.40 (5.96)^{a}
MRC-7347	0.26 (2.81)^{ab}	2.10 (8.28)^{a}	2.33 (8.78)^{bc}	10.13 (18.56)^{a}	3.60 (10.83)^{bc}	6.13 (14.33)^{abc}	3.73 (11.10)^{d}	4.00 (11.49)^{b}	3.50 (10.64)^{bc}	4.53 (12.18)^{b}	5.16 (13.06)^{ab}	4.26 (11.92)^{ab}	3.50 (10.78)^{abc}	2.26 (8.53)^{b}	1.56 (7.18)^{a}	0.36 (3.41)^{a}	0.70 (4.69)^{b}	1.06 (5.92)^{d}	1.13 (4.66)^{b}
PRCH-331	0.53 (3.86)^{a}	0.93 (5.49)^{bc}	2.73 (9.47)^{b}	7.06 (15.54)^{b}	3.73 (11.13)^{bc}	5.13 (13.07)^{bcd}	5.36 (13.32)^{ab}	4.73 (12.43)^{ab}	4.50 (12.03)^{ab}	6.40 (14.64)^{ab}	6.46 (14.70)^{a}	4.80 (12.63)^{a}	3.56 (10.86)^{abc}	2.43 (8.94)^{b}	1.86 (7.84)^{a}	0.50 (4.00)^{a}	0.36 (3.46)^{b}	1.00 (5.70)^{d}	0.46 (3.20)^{cd}
RCH-386	0.26 (2.81)^{ab}	0.96 (5.62)^{bc}	2.16 (8.46)^{bcd}	8.93 (17.33)^{a}	2.80 (9.55)^{bc}	6.90 (15.16)^{ab}	4.56 (12.30)^{bcd}	3.90 (11.32)^{b}	3.56 (10.84)^{bc}	5.46 (13.51)^{ab}	4.60 (12.17)^{ab}	4.06 (11.57)^{ab}	3.60 (10.92)^{ab}	3.23 (10.26)^{ab}	2.03 (8.19)^{a}	0.50 (4.00)^{a}	0.6 (4.34)^{b}	3.63 (10.98)^{a}	0.60 (4.33)^{bc}
ROHINI-456	0.13 (1.65)^{b}	0.60 (4.24)^{c}	1.66 (7.32)^{d}	7.20 (15.52)^{b}	3.03 (9.86)^{bc}	4.70 (12.32)^{cd}	5.23 (13.21)^{abc}	3.83 (11.26)^{b}	3.30 (10.40)^{bc}	4.30 (11.88)^{b}	4.50 (12.13)^{ab}	2.70 (9.38)^{b}	2.83 (9.68)^{c}	2.83 (9.68)^{b}	1.60 (7.08)^{a}	0.60 (4.33)^{a}	2.13 (8.36)^{a}	1.63 (7.34)^{c}	1.33 (6.47)^{a}
RCH-659 (Check)	0.36 (3.41)^{ab}	1.36 (6.70)^{ab}	4.26 (11.92)^{a}	9.30 (17.75)^{a}	3.77 (11.05)^{bc}	6.70 (14.96)^{abc}	6.46 (14.65)^{a}	5.66 (13.73)^{a}	5.93 (14.06)^{a}	6.90 (15.22)^{a}	4.66 (12.43)^{ab}	4.00 (11.49)^{ab}	4.16 (11.74)^{a}	3.16 (10.23)^{ab}	1.60 (7.08)^{a}	0.53 (4.12)^{a}	0.43 (3.76)^{b}	0.70 (4.72)^{de}	0.60 (4.33)^{bc}
SEM	0.728	0.535	0.410	0.532	0.870	0.150	0.590	0.509	0.731	0.941	1.021	0.809	0.39	0.599	0.590	0.438	0.465	0.415	0.904
CD (0.05%)	2.208	1.624	1.245	1.614	2.639	0.456	1.790	1.544	2.218	2.85	3.098	2.456	1.189	1.818	1.792	1.330	1.411	1.260	1.279
CD (0.01%)	3.065	2.254	1.729	2.240	3.663	0.633	2.484	2.143	3.078	3.96	4.300	3.409	1.651	2.52	2.487	1.846	1.959	1.749	2.744

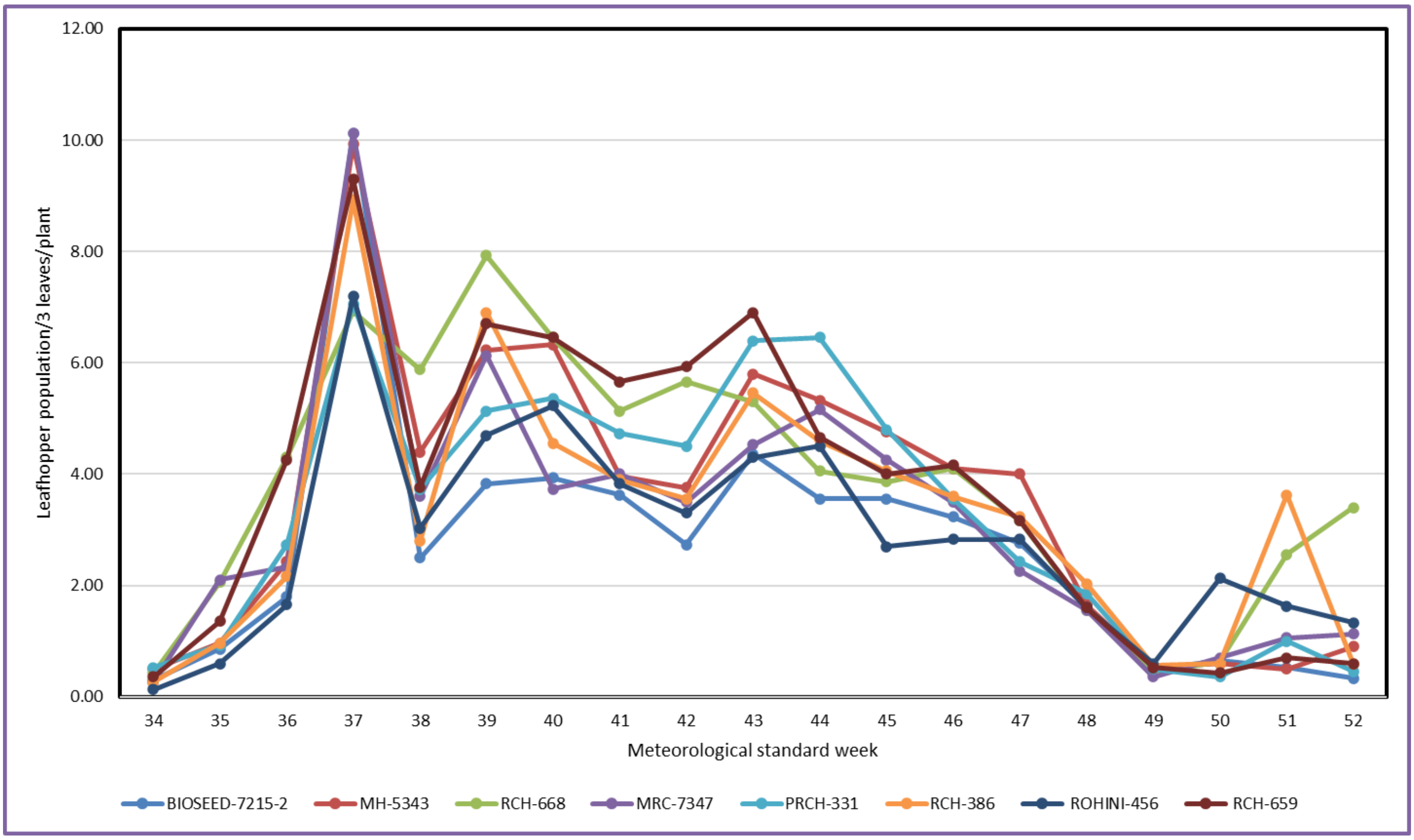

Fig 1: Population dynamics of leafhopper, *Amrasca biguttula biguttula* (Ishida) in different *Bt* cotton hybrids (pooled)

Table 2: Correlation coefficient (r) of leafhopper with weather parameters in different *Bt*- cotton hybrids

Weather parameters / Hybrids	Temperature (°C)		Relative humidity (%)		Rainfall (mm)
	Max.	Min.	Morning	Evening	
Bioseed-7215-2	0.549*	0.146	0.300	0.115	0.504*
MH-5343	0.640**	0.157	0.356	0.139	0.393
RCH-668	0.575**	-0.011	0.415	0.392	0.372
MRC-7347	0.590**	0.178	0.343	0.184	0.511*
PRCH-331	0.653**	0.246	0.386	0.089	0.300
RCH-386	0.532*	0.060	0.373	0.045	0.359
ROHINI-456	0.636**	0.057	0.423	0.066	0.364
RCH-659 (check)	0.581**	0.083	0.378	0.219	0.443

* - Significant at 5% level and **- Significant at 1% level

Table 3: Multiple linear regression analysis between weather parameters and incidence of leafhopper on different *Bt*-cotton hybrids

Name of the hybrid	Regression equation	R^2
Bioseed-7215-2	$Y=-24.91+0.91X_1+0.24X_2-0.00X_3-0.07X_4+0.29X_5$	0.72
MH-5343	$Y=-34.87+1.11X_1+0.25X_2+0.04X_3-0.06X_4+0.25X_5$	0.68
RCH-668	$Y=-23.60+0.76X_1-0.03X_2+0.04X_3+0.01X_4+0.10X_5$	0.50
MRC-7347	$Y=-28.89+0.96X_1+0.28X_2+0.01X_3-0.06X_4+0.29X_5$	0.75
PRCH-331	$Y=-35.43+0.93X_1+0.34X_2+0.09X_3-0.06X_4+0.17X_5$	0.69
RCH-386	$Y=-26.88+0.83X_1+0.15X_2+0.07X_3-0.06X_4+0.20X_5$	0.55
ROHINI-456	$Y=-24.53+0.83X_1+0.15X_2+0.07X_3-0.06X_4+0.20X_5$	0.65
RCH-659 (check)	$Y=-31.53+1.03X_1+0.16X_2+0.04X_3-0.04X_4+0.25X_5$	0.60

Where X1 = Maximum temperature
X2 = Minimum temperature
X3 = Morning relative humidity
X4 = Evening relative humidity
X5 = Rainfall

4. Conclusion

The present study concluded that weather factors determine the seasonal activity and population buildup of insect pest in *Bt* cotton crop. The correlation studies clearly show the importance of weather parameters in predicting the sucking pest incidence and these studies will be helpful to farmers and extension workers for developing efficient pest management strategies to get increased cotton production.

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