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Seasonal abundance of leafhopper, *Amrasca biguttula biguttula* (Ishida) and their relation to weather parameters in cotton

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Abstract
In this study, field trial was conducted to determine the effect of ecological factors on the incidence and development of leafhopper, *Amrasca biguttula biguttula* Ishida of cotton at four different phases of plant protection between October, 2014 and March, 2015 at Agricultural College and Research Institute, Killikulam, Vallanad, Tuticorin district of Tamil Nadu. The overall mean population ranged from 0.90 to 3.79 per three leaves. The contribution of weather parameters to the tune of 47 to 53 per cent on the incidence of leafhopper in SVPR 4 cotton. The pest population was started from first week of November on three weeks old crop and peaked six times (4, 8, 12, 16, 18 and 20 WAS) in unprotected condition; five times during reproductive phase (4, 8, 16, 19 and 22 WAS); four times in vegetative phase protected plants (4, 10, 16 and 21 WAS) followed by three peaks (11, 15 and 20 WAS) on completely protected plants. Among the studied weather factors, only three parameters such as rainfall, evaporation and sunshine hours influenced the population of leafhoppers.

Keywords: Cotton, leafhopper, weather factors, seasonal abundance, correlation and regression analyses

1. Introduction
Cotton, *Gossypium* spp. (Family: Malvaceae) is one of the most commercially important fibre crops in the world. It is a perennial semi-shrub grown as an annual crop in both tropical and warm temperate regions. In addition to textile manufacturing, it produces seeds with a potential multi product base such as hulls, oil, lint and food for animals (Ozyigit *et al.* 2007; Ashfaq *et al*., 2011) [13, 5]. The cotton is not only principal cash crop but also each and every parts of the cotton plant are useful to farmers in one way or the other (Shivanna *et al*., 2009) [25]. Production of cotton is limited by various factors among which scourge by insect pests are of paramount importance. Cotton is damaged by an array of insect pests from sowing to harvest. Among them, sucking pests *viz*., leafhopper, thrips, whitefly, mirid bug, mealybug and dusky cotton bugs causes 22.85 per cent yield reduction (Satpute *et al.* 1990) [20]. Leafhopper, *Amrasca biguttula biguttula* Ishida is of major importance in cotton crop. Leafhoppers occur at all the stages of crop growth and responsible for indirect yield losses. Since, nymphs and adults suck the sap from the leaves which leads to reduction in growth and vigour of the plant. In severe case of infestation, the plants get dried up and die (Madar and Katti, 2010) [10].
Use of chemical control is not only creating health hazards and ecological contamination but also growing the resistance in the insects and disturbing the balance between the forces of destruction and forces of creation in agro-ecosystem (Sorejani, 1998) [27]. High populations of leafhoppers survive every year, despite extensive and intensive application of insecticides. The occurrence and progress of all the insect pests are much dependent upon the environmental factors such as temperature, relative humidity and precipitation (Aheer *et al*., 1994) [2]. Climatic conditions largely influence the pest numbers and activity as well as several predators and parasitoids either directly or indirectly (Arif *et al*., 2006) [4]. For developing weather based pest forewarning system, information regarding population dynamics in relation to prevalent weather parameters is needed. The same meteorological parameters also influence the growth and development of the crop growth. Therefore, a thorough understanding of interaction between the crop growth stage, meteorological parameters and pest dynamics is a pre-requisite for weather based pest forecasting model. Hence, the present study was carried out on location specific seasonal incidence and peak activity of leafhopper on cotton and its relation with weather factors which is of great significance in formulating efficient pest management tactics.

Material and Methods

The present study was carried out at Agricultural College and Research Institute, Killikulam, Vallanad, Tuticorin district of Tamil Nadu between fortnight of October, 2014 and fortnight of March in 2015. The experiment was laid out in Factorial concept of Randomized Block Design (FRBD) with five replications and four treatments *viz*.

1. Protecting the vegetative phase (spraying on 15 and 30 DAS).
2. Protecting the reproductive phase (spraying on 45, 60, 75, 90 and 105 DAS).
3. Complete protection (fortnightly spraying from 15 DAS).
4. Untreated check.

DAS- Days After Sowing

The plot size for each treatment was 5 x 4 m (20 m^2) plots. The seeds were sown at two per hole with a spacing 60 x 30 cm. The insecticide, dimethoate (Rogor 30 EC) was used at the rate of 0.03 per cent. The data on weather factors *i.e*., Maximum and minimum temperatures, rainfall, sunshine hours, wind velocity, relative humidity and evaporation were taken from Department of Agronomy, AC&RI, Killikulam. The data on leafhopper population were recorded from 1st week of November to 18th March at weekly interval from ten randomly selected plants from each plot. Leafhoppers were counted from three leaves each from top, middle and bottom canopies of the plant (CICR, 2015) [6]. Microsoft Office Excel 2007 was used to conduct the statistical analysis of simple correlation and multiple regression coefficients.

Results and Discussion

Population dynamics of *A. biguttula biguttula*

The present investigation clearly brought out the seriousness of leafhopper throughout the crop growth period of cotton in this tract, especially in flowering phase. Similar results were broughtout from Anitha and Nandihalli (2008) [3] and Arif *et al.* (2006) [4] from their research. The leafhopper incidence appeared from early stage and exceeded economic threshold level (1/leaf) by third week after sowing. Mohankumar (1996) [12] also has documented the occurrence of leafhopper from early vegetative to late harvest stage and reported maximum level during 60 to 70 DAS. The population of *A. biguttula* ranged from 0.90 to 3.79 per three leaves and the overall mean in the present research is 2.12 numbers/ three leaves which was comparable to those of Ashfaq *et al*. (2011) [5], Abro *et al.* (2004) [1] and Solangi *et al.* (2008) [26]. The least population was recorded in the treatment of complete protection (0.90/3 leaves) followed by protection during vegetative phase (1.36/3 leaves). Protection during reproductive phase recorded significantly higher population (2.44/3 leaves) than protection during vegetative phase but lower than untreated check (3.79/3 leaves) (Fig. 1).

Protection during vegetative phase was on a par with complete protection from fifth week after sowing up to 10th week after sowing; thereafter the leafhopper population was either numerically or significantly higher from 19th week after sowing. Protection during vegetative phase had lower population than untreated check up to 18th week, thereafter; they were equal between themselves up to 20th week (Table 1). An increase in population was observed on vegetative phase protected plants thereafter. On untreated plants, the leafhopper population peaked six times (4, 8, 12, 16, 18 and 20 WAS), whereas five peaks were observed during reproductive phase (4, 8, 16, 19 and 22 WAS). On vegetative phase protected plants (4, 10, 16 and 21 WAS), the leafhopper population peaked four times. Leafhopper population had three peaks (11, 15 and 20 WAS) on completely protected plants. Reports of Senapati and Mohanty (1980) [22] support the present findings as the population increase from January up to March. Shivanna *et al*. (2009) [25] also revealed that the leafhopper population was noticed during first and second fortnight of April, first fortnight of May, first fortnight of June, second fortnight of February and first and second fortnight of March, respectively.

Correlation between leafhopper population and meteorological parameters

The leafhopper population on cotton plants protected during vegetative phase (Table 2) had positive association with maximum temperature (0.4719*) and negative association with minimum temperature (-0.4894*), rainfall (-0.5526*) and evaporation (-0.4721*). On reproductive phase protection, leafhopper incidence had positive relation with relative humidity (0.5468*) and negative relation with minimum temperature (-0.4706*), sunshine hours (-0.6627**) and evaporation (-0.7250**). In the plots completely protected during vegetative phase and reproductive phase, leafhopper population had positive binding with maximum temperature (0.5216*) and negative binding with minimum temperature (-0.5948**), rainfall (-0.5526*) and evaporation (-0.5722*). On untreated plants leafhopper population had positive correlation with maximum temperature (0.4982*), whereas negative correlation with minimum temperature (-0.5423*), rainfall (-0.4598*), sunshine hours (-0.4783*) and evaporation (-0.6154**).

Shitole and Patel (2009) [24] reported that leafhopper population increased with maximum temperature which confirms our finding. Similarly, Selvaraj *et al*. (2011) [21] reported that the significant negative association was obtained with maximum temperature and sunshine hours which show partial conformity with the present results. The leaf hopper population had negative relationship with evaporation, rainfall and sunshine hours. This derives support from Dhaka and Pareek (2008) [7], Kaur *et al*. (2009) [8], Prasad *et al*. (2008) [15], Radhika and Reddy (2007) [16], Ramamurthy *et al*. (2000) [18], Rao *et al*. (2001) [19] and Shahid *et al*. (2012) [23].

Regression analyses between leafhopper population and meteorological parameters

The present study reveals that the contribution of weather parameters to the tune of 47 to 53 per cent on the incidence of leafhopper in SVPR 4 cotton (Table 3). Earlier Pandi (1997) [14], Manish (1998) [11], Kavitha (2000) [9] claimed 37 to 47, 22 to 85 and 37 to 93 per cent contribution respectively of weather parameters on the variability in leafhopper population on LRA 5168 cotton.

The influence of rainfall and evaporation on the leafhopper population by 51 per cent (R^2=0.5077) and a unit increase in rainfall and evaporation decreased the leafhopper population by 0.14 and 0.82 number respectively. The rainfall and evaporation influenced the variability in leafhopper population by 47 per cent (R^2 = 0.4667) and a unit increase in rainfall and evaporation decreased the leafhopper population by 0.02 and 0.85 numbers respectively. About 49 per cent (R^2 = 0.4870) of variation in leafhopper population was accounted for the effect of rainfall and evaporation; a unit increase in rainfall and evaporation decreased the leafhopper population by 0.06 and 0.55 numbers respectively.

The contribution of the weather parameters was moderately higher when the plants are under prolonged period of unprotected condition during entire reproductive phase throughout the crop period. Under unprotected conditions crop usually become stunted in growth with poor nourishment for the sucking pests. Probably, under such stress condition, wherein only less nourishment could be received by the sucking pests from the stunted plants, the leafhopper might have been much influenced by the abiotic factors. Kavitha (2000) [9] also have reported influence of more weather parameters on the incidence of leafhopper whenever the insect is unchecked throughout the crop growth or during vegetative / reproductive phase alone. Rainfall and evaporation were the influencing weather parameters under partial or complete protected condition, while sunshine hours and evaporation played decisive role under complete unprotected condition. Similar reports on the effect of rainfall (Manish, 1998; Kavitha, 2000; Rajaram *et al*., 2001) [14, 9, 17] are also available.

From this study it is evident that, the seriousness of leafhopper was found throughout the crop growth period of cotton and weather parameters has contributed about 50 per cent on their incidence. Rainfall and evaporation were the influencing weather parameters under partial or complete protected condition, while rainfall and sunshine hours played decisive role under complete unprotected condition. These studies will warn the farmers about the population fluctuation and will be helpful for devising pre-planned management strategies against this pest.

Table 1: Effect of different levels of plant protection on *A. devastans*

Treatment	**Leafhopper population (No. / 3 leaves)**									
	Week after sowing (WAS)									
	3	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Protection during vegetative phase	0.54 A (0.77) a	1.04 A (1.09) a	0.06 A (1.05) a	0.66 A (1.11) a	0.94 A (0.82) a	0.84 A (1.18) a	0.08 A (1.00) a	1.02 A (1.18) a	0.88 A (0.75) a	1.02 (1.06) a
Protection during reproductive phase	2.64 BCDEF (1.75) b	3.28 EFG (1.93) b	3.08 DEFG (1.89) b	3.24 CDEFG (1.87) b	4.36 FG (2.20) c	5.04 G (2.32) b	3.24 EFG (1.92) b	2.00 ABCDE (1.53) b	2.20 ABCDE (1.54) b	1.80 ABCDE (1.47) b
Complete protection	2.68 E (1.76) b	2.44 E (1.69) b	1.80 CDE (1.46) a	1.84 DE (1.51) a	0.52 ABC (1.00) a	0.52 AB (0.97) a	0.52 ABC (1.00) a	0.52 ABC (1.00) a	2.00 DE (1.57) b	0.36 AB (0.89) a
Untreated check	4.60 CDEFGH (2.14) b	5.00 EFGH (2.28) c	3.88 ABCDEFGH (2.05) c	3.20 BCDEF (1.88) b	3.24 BCDEFG (1.90) b	4.96 FGH (2.31) b	3.08 BCDEF (1.88) b	2.84 ABCDE (1.81) c	3.32 BCDEFG (1.92) b	4.76 DEFGH (2.24) c
Mean	2.51 (1.61) A	2.86 (1.75) B	2.36 (1.61) A	2.26 (1.59) A	2.08 (1.48) A	2.89 (1.70) A	1.85 (1.45) A	1.60 (1.38) A	1.90 (1.44) A	1.90 (1.42) A

Treatment	**Leafhopper population (No. / 3 leaves)**										
	Week after sowing (WAS)										
	13	**14**	**15**	**16**	**17**	**18**	**19**	**20**	**21**	**22**	**Mean**
Protection during vegetative phase	0.94 A (1.16) a	0.84 A (1.15) a	0.08 A (0.76) a	1.02 A (1.22) a	0.88 A (1.12) a	1.02 A (1.22) a	2.80 B (1.81) b	4.36 D (2.19) b	6.12 E (2.49) c	3.48 C (1.97) c	1.36 (1.25) b
Protection during reproductive phase	1.94 ABCDE (1.49) b	1.88 ABCDE (1.49) b	0.98 A (1.21) a	2.54 BCDE (1.69) b	1.50 ABC (1.40) b	1.72 ABCDE (1.48) b	2.08 ABCDE (1.54) b	1.36 AB (1.29) a	1.68 ABCD (1.43) a	2.16 ABCDE (1.59) b	2.44 (1.65) c
Complete protection	0.40 (0.94) a	0.48 ABC (0.99) a	1.28 BCD (1.30) b	0.20 AB (0.83) a	0.24 AB (0.86) a	0.16 A (0.81) a	0.44 AB (0.96) a	0.92 ABCD (1.13) a	0.76 ABC (1.12) a	0.00 A (0.71) a	0.90 (1.12) a
Untreated check	4.40 DEFGH (2.21) c	3.40 BCDEFG (1.91) c	2.12 AB (1.59) b	5.72 GH (2.36) c	5.44 H (2.40) c	5.72 FGH (2.33) c	2.76 ABCD (1.78) b	3.20 BCDEFG (1.89) b	2.40 ABC (1.69) b	1.72 A (1.37) b	3.79 (2.00) d
Mean	1.90 (1.45) A	1.70 (1.38) A	1.10 (1.21) A	2.40 (1.52) A	2.00 (1.45) A	2.20 (1.46) A	2.00 (1.52) A	2.50 (1.63) A	2.70 (1.68) A	1.80 (1.41) A	2.12 (1.51)

Mean of three replications. Figures in parentheses are square root transformed values $(x+0.5)^{½}$. In a column/row, means followed by a common letter are not significantly different at 5 % level (LSD).

	T	P	T x P
Significance	0.01	0.01	0.01
CD (p=0.05)	0.11	0.24	0.49

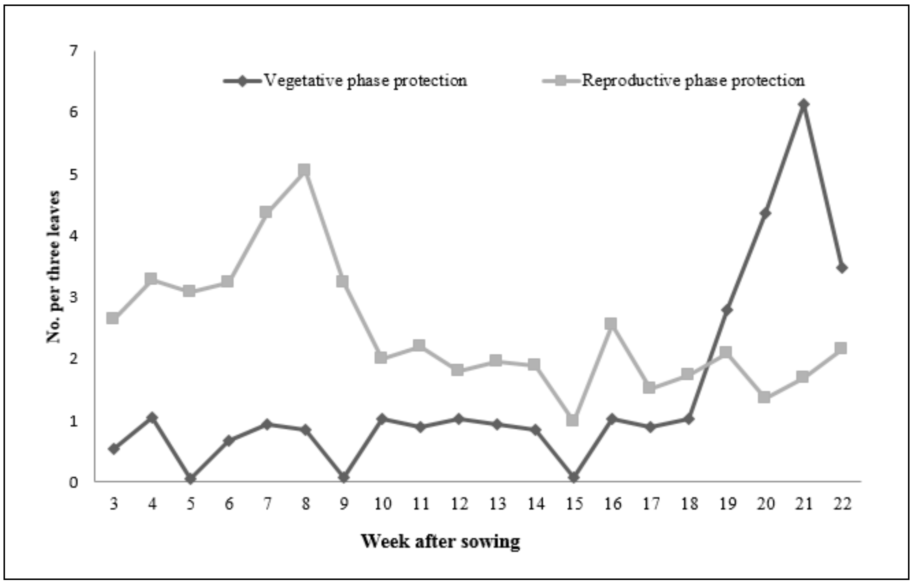
Table 2: Correlation co-efficient between weather parameters and incidence of *A. biguttula biguttula* under different levels of plant protection on cotton

Treatment	Weather Parameters						
	Temperature (ºC)		Rainfall (mm)	Sunshine (hours)	Wind velocity (km/hr)	Relative humidity (%)	Evaporation (mm)
	Maximum	Minimum					
Protection during vegetative phase	0.4719 *	-0.4894 *	-0.5526 *	-0.2673 NS	0.1309 NS	0.3158 NS	-0.4721 *
Protection during reproductive phase	0.3873 NS	-0.4706 *	-0.1903NS	-0.6627 **	-0.1931NS	0.5468 *	-0.7250 **
Complete protection	0.5216 *	-0.5948 **	-0.5526 *	-0.4035 NS	0.1090 NS	0.3713 NS	-0.5722 *
Untreated check	0.4982 *	-0.5423 *	-0.4598 *	-0.4783 *	0.0867 NS	0.3908 NS	-0.6154 **

* - Significant at 5% level ** - Significant at 1% level NS - Non Significant

Table 3: Influence of weather parameters on *A. biguttula biguttula* under different levels of plant protection on cotton

Year	Variable	Mean	Regression Coefficient	Standard error	t stat	Probability	Intercept	R^2 value
Veg. phase protection	Rainfall	13.34	-0.1393	0.0444	-3.136	0.0060	9.4174	0.5077
	Evaporation	4.06	-0.8163	0.3088	-2.643	0.0171		
Rep. phase protection	Rainfall	23.48	-0.0225	0.0101	-2.229	0.0396	7.8215	0.4667
	Evaporation	4.46	-0.8482	0.2289	-3.704	0.0018		
Complete protection	Rainfall	13.34	-0.0565	0.0246	-2.299	0.0345	9.42	0.4870
	Evaporation	4.06	-0.5460	0.1708	-3.197	0.0053		
Untreated check	Rainfall	13.34	-0.0953	0.0285	-3.343	0.0039	6.9679	0.5347
	Sunshine (hours)	5.43	-0.4220	0.1228	-3.437	0.0031		



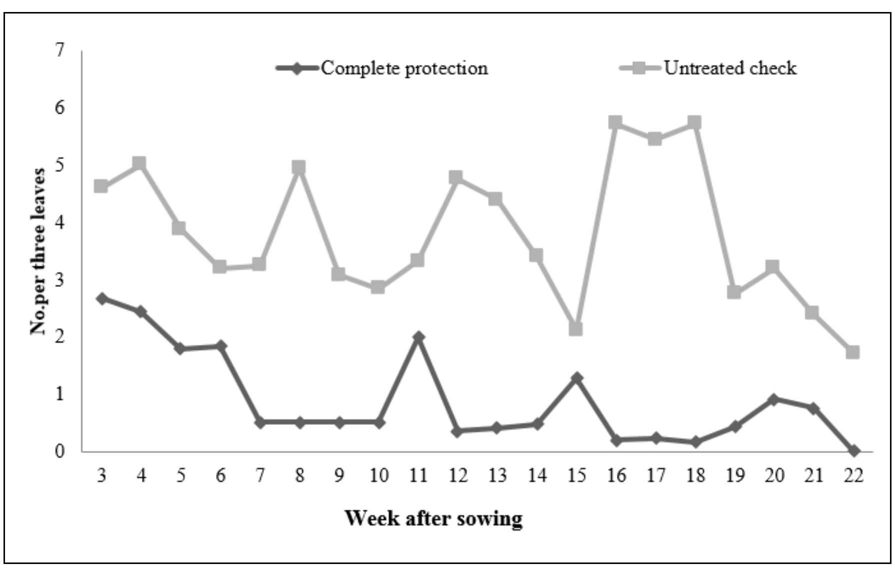


Fig 1: Influence of levels of plant protection on the incidence of leafhopper

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