Journal of

Entomology

ISSN 1812-5670

Academic
Journals Inc.

www.academicjournals.com

Journal of Entomology 8 (5): 476-483, 2011
ISSN 1812-5670 / DOI: 10.3923/je.2011.476.483

Population Dynamics of Leafhopper, *Amrasca devastans* Distant in Cotton and its Relationship with Weather Parameters

[1]S. Selvaraj, [2]D. Adiroubane and [2]V. Ramesh

[1]Department of Entomology, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar-263 145, India

[2]Department of Agricultural Entomology, Pandit Jawaharlal Nehru College of Agricultural and Research Institute, Karaikal-609 603, India

Corresponding Author: S. Selvaraj, Department of Entomology, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar-263 145, Uttarakhand, India Tel: 07895651478

ABSTRACT

In this study, field trials were conducted to determine the effect of ecological factors on the incidence and development of leafhopper, *Amrasca devastans* at five different date of sowing on three varieties of cotton. The pest population was started from third week of February on third weeks old crop and acquired its peak in second week of March on six weeks old crop. Maximum pest population (9.30/3 leaves) was build up at temperature ranged from 21 to 31°C, relative humidity ranges from 82 and 55 percent, zero rainfall, wind velocity 4.5 km h^{-1}, total sunshine hours (9.00 h $week^{-1}$), evaporation (56.10 mm) and dewfall (1.491 mm). The highest incidence of leafhopper population was recorded in MCU 7 followed by SPCH 22 and SVPR 3. Leafhopper population was build up showed a significant and positive correlation with morning and evening relative humidity and rainfall whereas, it was significant and negative association with minimum temperature, wind velocity and dewfall. The determination of effects of different weather factors on population of leafhoppers in cotton was essential for effective pest management. This study will be very helpful not only for forecasting the out breaks of leafhopper population but also in formulating effective pest management strategies.

Key words: Gossypium, *Amrasca devastans*, weather factors, pest management, varieties, correlation

INTRODUCTION

Cotton (*Gossypium* spp.) being the king of natural fiber is grown in 111 countries all along the world. In India, it is cultivated in 8.97 million ha with a production of 21.3 million bales of seed cotton (Anonymous, 2005). Moreover, due to the top most position in Indian agriculture and it is also popularly known as white gold. Cotton fiber is an important raw material to the textile industries and plays a key role in national economy in terms of employment generation and foreign exchange up to 62.3-68.3% (Khan *et al*., 2003). The cotton is not only principal cash crop but also each and every parts of the cotton plant are useful to farmer in one way or the other (Shivanna *et al*., 2009). Unfortunately, cotton is highly vulnerable to insect pests. During growth period, 148 insect pests have been recorded on cotton crop, out of which only 17 species have been recorded as major insect pests of cotton crop (Abbas, 2001). Cotton pests can be primarily divided into sucking pests and bollworms. Among the sucking pests, leafhopper, *Amrasca devastans*

(Dist.) is of major importance in cotton crop. Leafhoppers occur at all the stages of the crop growth and responsible for indirect yield losses. Since, these pests suck the sap from the plants which leads to reduction in growth and vigour of the plants. In severe case of infestation, the plants get dried up and eventually die (Madar and Katti, 2010).

Pesticides continue to play the key role in cotton arthropod pest management. Most of the farmers are marginal and small farmers with poor financial condition and therefore, cannot afford to buy costly pesticides and sprayers. Lot of spurious chemicals is entering into the market which is effective and result in development of insecticide resistance and resurgence of pests. This made cotton cultivation uneconomical resulting in suicide of large number of disappointed farmers in Andra Pradesh and Maharashtra (Saini *et al*., 2010). High populations of leafhoppers survive every year, despite extensive and intensive insecticide application. The incidence and development of these insect pests is very much dependent upon the prevailing physical environmental factors and crop stand. These insects multiply tremendously during the favorable weather conditions and take huge toll (Aheer *et al*., 1994). Climatic conditions largely influence the pest numbers and activity as well as several predators and parasites either directly or indirectly (Arif *et al*., 2006; Chaudhari *et al*., 1999). For developing a weather based pest forewarning system, information regarding population dynamics in relation to prevalent meteorological parameters (temperature, relative humidity, sun shine hours etc.) is needed. Moreover, the same meteorological parameters also influence the growth and development of crop. Therefore, a thorough understanding of interaction between the crop growth stage/meteorological parameters/pest dynamics is a pre requisite for weather based pest forecasting model. Hence, the present study was focused on location specific seasonal occurrence of leafhoppers at different crop growth stages and its relation with weather factors which is of great significance in formulating efficient pest management tactics.

MATERIALS AND METHODS

The field experiment was laid out at Pandit Jawaharlal Nehru College of Agriculture and Research Institute Karaikal during February and July in 2007 (Rice fallow cotton). The experiment was laid out in Factorial concept of Randomized Block Design (FRBD) comprised of 15 treatments (three treatments-varieties/hybrid-MCU 7, SVPR 3 and SPCH 22 and five sub treatments date of sowing-1st, 8th, 15th, 22nd February and 1st March) and designed in RBD. The factorial experiment has two or more factors but level of factors need not be same. Here, the set of three varieties were one factor and the set of five different date of sowing were another factor. Therefore, the fifteen treatment combinations were V1D1 V1D2, V1D3, V1D4, V1D5, V2D1, V2D2, V2D3, V2D3, V2D5, V3D1, V3D2, V3D3, V3D4 and V3D5. These treatment combinations were replicated force. This experiment was conducted with the above treatment combinations allotted to the ultimate experimental units. The plot size for each treatment was 5×4 m (20 m^2) plots. The seeds of varieties MCU 7, SVPR 3 and SPCH 22 were sown at two plants per hole with a spacing 60×30, 60×30 and 120×60 cm, respectively. The interval between each sowing was seven days. The data on abiotic factors i.e., temperatures, relative humidity, wind speed, rainfall, sunshine hours, evaporation and dewfall were taken from Department of Agronomy, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal. The rainfall was calculated by self recorded rain gauge. It can gives as automatic record of rainfall without any bottle reading. The relative humidity can be obtained by hair hygrometer. The properties of human hair to increased the length with increased relative humidity and decrease with decrease the humidity. Increase relative humidity is used the instrument variation in length of human hair cause displacement of hook which is communicated by second arm of the liver to record the changes of graph paper. The circular drum makes one rotation in 24 h or once a week. The instrument is placement in the Stevenson screen in the observatory. The data on leafhopper population were recorded from 16th February to 30th July at weekly interval from following manner. Leafhoppers were counted as adult/nymph per leaf basis. Ten plants were taken from each treatment. The population of insects was counted from upper leaf of first plant, middle leaf of second plant, lower leaf of third plant and so on Arif *et al.* (2006).

Statistical analysis: At the end of season, the data obtained were subjected to proper statistical analysis. The correlations as well as regression between cotton leafhopper population and weather factors were estimated. Leafhoppers population was collected every week from the field. Weather factors were collected from Department of Agronomy (PAJANCOA and RI). Data was analyzed statistically by SPSS simple correlation worked out between population of leafhoppers and weather factors (maximum and minimum temperature, morning and evening relative humidity, sunshine hours, rainfall, evaporation and dewfall). The impact of weather factors on leafhoppers population fluctuation was determined through multiple linear regression models.

The regression equation was obtained:

$$Y_1 = -20.270 + 0.283\,(X_1)$$

where, Y_1 is Leafhopper population and X_1 is Morning relative humidity

RESULTS AND DISCUSSION

Population dynamics of leafhoppers: The incidence of leafhopper was observed during third week of February on third weeks old crop and acquired its peak incidence (9.30/3 leaves) was observed in second week of March on six weeks old crop. The population of leafhoppers was high during initial stage of crop growth with two peak population during 10th (9.30/3 leaves) and 16th (8.20/3 leaves) standard weeks (Table 1). The population of leafhoppers was maximum (9.30/3 leaves) during initial stages of crop growth with maximum temperature ranged from 31 to 33°C and minimum temperature ranged from 21 to 24°C, morning relative humidity 82 to 90 percent and evening relative humidity 55 to 66 percent, wind velocity 4.5 to 5.3 km h^{-1}, sunshine hours 9.00 to 10.00 h and zero rainfall was favourable for multiplication of leafhoppers (Table 1). The present findings are in agreement with those of Prasad *et al.* (2008) and Kaur *et al.* (2009) who reported the maximum and minimum temperature ranged from 30.5 to 32.5°C and 20 to 23.5°C, respectively.

Correlation and regression between meteorological parameters and leafhoppers population: The population of leafhoppers showed significant positive correlation with morning and evening relative humidity and rainfall, while a significant and negative association with minimum temperature, wind velocity and dewfall. Whereas, maximum temperature, sunshine hours and evaporation had a non significant and negative association was recorded with leafhopper population (Table 1). The present findings are in agreement with those of Shitole and Patel (2009), Kaur *et al.* (2009), Prasad *et al.* (2008), Dhaka and Pareek (2008), Ramamurthy *et al.* (2000) and Rao *et al.* (2001) who reported significant positive correlation was found between the leafhopper population and relative humidity and rainfall. Similarly Ammar *et al.* (1986), Kavitha *et al.* (2003),

Table 1: Incidence and correlation matrix of leafhopper, *A. devastans* with weekly mean abiotic factors in cotton

	Weather factors									
	Temperature (°C)		Relative humidity (%)		Wind speed	Bright sunshine	Rainfall	Evaporation	Dewfall	Population of leafhoppers/3
MSW	Max.	Min.	Morning	Evening	(km h^{-1})	(h)	(mm)	(mm)	(mm)	leaves
7	31.70	22.50	95.00	67.00	4.70	7.29	1.25	35.10	1.409	0.22
8	30.20	21.80	85.00	59.00	6.40	6.71	5.00	45.60	0.282	0.33
9	31.70	22.30	95.00	63.00	4.70	5.76	0.00	42.60	1.400	6.22
10	31.00	21.10	82.00	55.00	4.50	9.53	0.00	56.10	1.491	9.30
11	31.30	22.40	89.00	63.00	4.60	10.16	0.00	50.70	1.229	7.91
12	30.20	21.70	95.00	60.00	4.60	9.59	0.00	46.70	1.908	7.42
13	31.90	22.90	94.00	64.00	4.70	9.26	0.00	49.80	1.431	7.66
14	33.10	24.60	94.00	66.00	4.40	8.76	0.00	46.00	1.067	7.64
15	33.30	25.50	92.00	70.00	5.60	6.03	1.50	45.30	0.198	7.35
16	33.70	24.20	90.00	66.00	5.30	7.94	16.25	40.50	0.633	8.20
17	35.20	26.10	92.00	67.00	6.30	9.46	0.00	52.20	0.708	6.59
18	35.10	26.00	89.00	62.00	6.20	9.23	0.00	53.20	0.160	6.73
19	38.80	27.50	83.00	44.00	11.20	8.47	2.50	56.90	0.000	3.15
20	38.80	28.20	77.00	41.00	12.80	8.87	0.00	65.70	0.000	4.53
21	37.70	27.50	85.00	54.00	9.50	8.60	0.00	55.70	0.000	3.89
22	37.00	27.20	81.00	62.00	9.20	8.93	0.00	65.60	0.000	3.73
23	36.90	26.30	91.00	63.00	8.20	9.01	42.75	45.70	0.033	1.89
24	36.00	27.10	80.00	60.00	8.00	7.53	3.00	55.00	0.000	1.55
25	33.70	25.90	80.00	58.00	10.80	8.89	2.00	42.10	0.000	1.24
26	35.70	26.60	75.00	55.00	11.00	8.50	5.00	56.80	0.000	1.64
27	37.10	27.50	72.00	47.00	14.80	7.06	0.00	85.00	0.000	0.83
28	37.30	27.10	78.00	50.00	11.70	8.26	0.00	83.70	0.000	1.00
29	36.20	26.30	76.00	50.00	8.50	7.34	0.00	67.00	0.000	0.66
30	34.10	26.10	85.00	56.00	6.60	8.49	10.00	52.20	0.203	1.00
Correlation Leafhoppers	-0.297	-0.406*	0.690**	0.415*	-0.603**	-0.495	0.175*	-0.308	0.606**	

MSW: Meteorological standard week, Max: Maximum temperature, Min: Minimum temperature, *,**Significant at p = 0.05 and p = 0.01 level, respectively

Singh *et al.* (2004), Aheer *et al.* (2006), Shitole and Patel (2009) and Selvaraj *et al.* (2010) who reported the significant negative association with maximum temperature and sunshine hours. A partial agreement with those of Arif *et al.* (2006) who reported that rainfall and temperature showed a significant and positive correlation with the jassid population, whereas, relative humidity showed a non significant effect. The present findings are in close conformity with those of Purohit *et al.* (2006) and Hegde *et al.* (2004) who reported that increase in jassid population showed a significant positive correlation with minimum temperature and evening relative humidity. The present results are in not agreement with those of Mahmood *et al.* (2002) who reported that minimum and maximum temperature was positively correlated whereas relative humidity and rainfall was negatively correlated with leafhopper population in brinjal. This difference may be due to different ecological condition and difference crop on which the experiment was conducted. The regression revealed that among the various abiotic factors morning relative humidity (X_1) was found to be most influencing factor which contributed (R^2 = 0.4751) 47% variation in leafhopper population. The prediction equation was obtained:

$$Y_1 = -20.270 + 0.283 (X_1)$$

where, Y_1 = Leafhopper population and X_1 = Morning relative humidity

Effect of date of sowing on the incidence of leafhoppers: The incidence of leafhopper population was compared with different dates of sowing. The overall mean incidence of leafhopper population was 5.30/3 leaves for 1st February sowing, 4.93/3 leaves for 8th February sowing, 4.82/3 leaves for 15th February sowing, 4.62/3 leaves for 22nd February sowing and 3.93/3 leaves for 1st March sowing. The incidence of leafhoppers was highest (5.30/3 leaves) in the first sowing (1st February) while the incidence was least (3.93/3 leaves) in last sowing (1st March) in irrespective of varieties (Table 2). A gradual decrease of leafhopper population was observed when the sowing dates were progressed. The present results are not in agreement with those of Butter *et al.* (1992), Singh *et al.* (1978) and Agarwal *et al.* (1979) who reported higher population of cotton jassid on late sown cotton crop. The present results are not in agreement with those of Hassan *et al.* (2003), Oad *et al.* (2002) and Akhtar *et al.* (2002) who reported that seed cotton yield was declined in late sowing crop on different genotypes due to highest occurrence of leafhopper population. This may be due to effect of weather factors prevailing here. This area weather factors

Table 2: Effect of date of sowing on the incidence of leafhopper, *A. devastans* in cotton varieties

Crop stages	Date of sowing				
(DAS)	1st sowing	2nd sowing	3rd sowing	4th sowing	5th sowing
16	0.22	5.11	0.33	5.33	5.11
23	0.33	5.78	6.00	5.33	5.33
30	7.56	14.22	16.78	11.11	6.11
37	9.46	9.00	6.78	9.44	5.47
44	8.57	7.33	6.56	6.11	6.33
51	7.98	7.44	8.22	6.78	8.64
58	8.16	7.89	6.56	7.56	3.56
65	10.44	7.22	7.22	5.22	3.78
72	8.56	8.44	9.00	4.67	2.44
79	8.46	8.00	7.33	4.33	5.28
86	8.44	2.67	8.22	6.00	5.74
93	9.27	3.00	2.78	4.67	5.44
100	5.68	4.11	2.33	4.33	2.99
107	3.44	3.00	1.78	1.78	3.56
114	2.89	1.56	3.11	1.67	3.01
121	2.78	0.44	1.00	1.56	2.44
128	2.11	0.89	0.89	3.56	2.12
135	1.22	1.22	0.56	1.11	1.11
142	0.22	1.00	0.78	1.56	0.23
149	0.22	0.33	0.22	0.33	0.00
Mean	5.30	4.93	4.82	4.62	3.93

DAS: Days after sowing

Table 3: Correlations coefficient between the incidences of leafhopper, *A. devastans* in different varieties of cotton and various weather factors

	Weather factors								
	Temperature (°C)		RH (%)						
Variety	Max.	Min.	Morning	Evening	Wind speed (km h^{-1})	Bright sunshine (h)	Rainfall (mm)	Evaporation (mm)	Dewfall (mm)
MCU 7	-0.494*	-0.578**	0.790**	0.347	-0.737**	0.396	-0.228	-0.314	0.690**
SVPR 3	-0.574**	-0.652**	0.798**	0.378	-0.782**	0.352	-0.212	-0.326	0.734**
SPCH 22	-0.668**	-0.758**	0.767**	0.335	-0.786**	0.255	-0.272	-0.344	0.798**

*,**Significant at p = 0.05 and p = 0.01 level, respectively, Max: Maximum temperature, Min: Minimum temperature, RH: Relative humidity

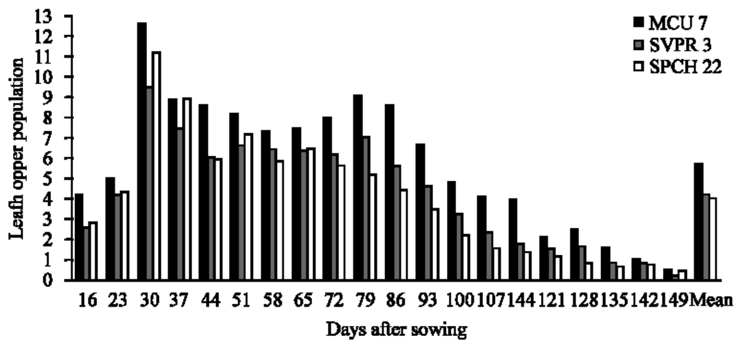

Fig. 1: Effect of different varieties on the incidence of leafhopper, *A. devastans* Dist. in cotton

is favourable for multiplication of pests only in early season of crop. Laterally, this weather factors are slowly affect the pest population. Therefore, weather factors are flexible from area to area and season to season and year to year.

Effect of varieties on the incidence of leafhoppers: The overall mean incidence of leafhopper was recorded in respect of three different varieties was maximum in 30th Days after Sowing (DAS). The highest incidence of leafhopper was recorded in MCU 7 (12.67/3 leaves) followed by SPCH 22 (11.20/3 leaves) and SVPR 3 (9.60/3 leaves). The mean incidence of leafhopper was least in SPCH 22 and maximum in MCU 7 (Fig. 1). The correlation analysis of mean data (Table 3) for all varieties revealed that maximum and minimum temperature and wind velocity showed highly significant negative influence of leafhopper population. Whereas, morning relative humidity and dewfall showed highly significant and have positive influence on the leafhopper population for all varieties, while the association was positive and non significant with other parameters. The present findings are in conformity with those of Aheer *et al*. (2006) and Riaz *et al*. (1987) who reported that maximum temperature affected jassid nymph negatively whereas, relative humidity affected positive and non significant for all genotypes.

The multiple linear regression analysis indicated that the influence of all the weather parameters was high and significant. It was 88.83% (R^2 = 8883) in MCU 7, 63.15% (R^2 = 6315) in SVPR 3 and up to 62.47% (R^2 = 6247) in SPCH 22 on incidence of leafhopper population. The regression equation further indicated that the morning relative humidity had significant positive impact on the population of leafhoppers i.e. for one unit increase in morning relative humidity there will be 0.55, 0.38 and 0.31 units increased leafhoppers population in MCU 7, SVPR 3 and SPCH 22, respectively (Table 4).

Table 4: Multiple linear regression analysis between weather parameters and leafhopper, *A. devastans* in different varieties of cotton

Varieties/hybrid	Regression equation	R^2 value
MCU 7	$= -27.965 + 0.559 (X_1)$	0.8883
SVPR 3	$= -23.787 + 0.383 (X_1)$	0.6315
SPCH 22	$= -17.741 + 0.319 (X_1) + 0.060 (X_2)$	0.6247

X_1: Morning relative humidity, X_2: Minimum temperature

CONCLUSION

It may be concluded that climatic factors determine seasonal activity and population dynamics of leafhoppers in cotton. This information generated in 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.

REFERENCES

Abbas, M.A., 2001. General Agriculture. 2nd Edn., Emporium Publ., Pakistan, pp: 352.

Agarwal, R.A., N.P. Wankhede and K.N. Katiyar, 1979. Impact of agronomic practices on the population of jassids, *Amrasca devastans* (Distant) in cotton. Cotton Fibres Trop., 34: 375-378.

Aheer, G.M., K.J. Ahmad and A. Ali, 1994. Role of weather in fluctuating aphid density in wheat crop. J. Agric. Res., 32: 295-301.

Aheer, G.M., A. Ali and S. Hussain, 2006. Varietal resistance against jassid (*Amrasca devastans* Dist.) in cotton and role of abiotic factors in population fluctuation. J. Agric. Res., 44: 299-305.

Akhtar, M., M.S. Cheema, M. Jamil, S.A. Shahid and M.I. Shahid, 2002. Response of cotton genotypes to time of sowing. Asian J. Plant Sci., 1: 538-539.

Ammar, E.D., S.H. Fouad, M.M. Megahad and G.H. Sewaift, 1986. Population density and vertical distribution of *Empoasca* leafhopper on cotton plants in kafer using two sampling methods. Ann. Agric. Sci., 24: 1655-1664.

Anonymous, 2005. Training manual on DVS test in cotton with resistance to PPV and FR legislation, 2001. All India Coordinated Cotton Improvement Project, CICR, Coimbatore, Tamil Nadu, pp: 134-135.

Arif, M.J., M.D. Gogi, M. Mirza, K. Zia and F. Hafeez, 2006. Impact of plant spacing and abiotic factors on population dynamics of sucking insect pests of cotton. Pak. J. Biol. Sci., 9: 1364-1369.

Butter, N.S., A.S. Brar, J.S. Kular and T.H. Singh, 1992. Effect of agronomic practices on the incidence of key pests of cotton under unsprayed conditions. Indian J. Entomol., 54: 115-123.

Chaudhari, G.B., T.M. Bharpoda, J.J. Patel, K.I. Patel and J.R. Patel, 1999. Effect of weather on activity of cotton bollworms in middle Gujarat. J. Agrometeorol., 1: 137-142.

Dhaka, S.R. and B.L. Pareek, 2008. Weather factors influencing population dynamics of major insect pests of cotton under Arid Agro ecosystem. Indian J. Entomol., 70: 157-163.

Hassan, M., M. Nasrullah, M.Z. Iqbal, T. Muhammad, M. Iqbal and S. Ahmad, 2003. Effect of different sowing dates on cotton (*Gossypium hirsutum* L.) cultivars. Asian J. Plant Sci., 2: 461-463.

Hegde, M., M. Srinivasa, D.P. Biradar, S.S. Udikeri and B.M. Khadi, 2004. Seasonal incidence of key insect pests and their natural enemies on cotton at Siruguppa. Proceeding of the International Symposium on Strategies for sustainable Cotton Production-A global vision, Nov. 23-25, Dharwad, Karnataka, India, pp: 114-115.

Kaur, P., H. Singh and N.S. Butter, 2009. Formulation of weather based criteria rules for the prediction of sucking pests in cotton (*Gossypium hirsutum*) in Punjab. Indian J. Agric. Sci., 79: 375-380.

Kavitha, G., P. Ram and R.K. Saini, 2003. Arthropod predatory fauna and its population dynamics in cotton in Haryana. J. Cotton Res. Dev., 17: 167-171.

Khan, B.S., M. Afzal and M. Afzal Murtaza, 2003. Effect of abiotic factors against the infestation of american bollworm (*Heliothis armigera* Hub.) on different varieties of cotton under unsprayed conditions. J. Biol. Sci., 3: 82-85.

Madar, H. and P. Katti, 2010. Incidence and diversity of leafhoppers on sunflower. Karnataka J. Agric. Sci., 23: 149-150.

Mahmood, T., S.I. Hussain, K.M. Khokar, G. Jeelani and M. Ahmad, 2002. Population dynamics of leafhopper (*Amrasca biguttula biguttula*) on brinjal and effect of abiotic factors on its dynamics. Asian J. Plant Sci., 4: 403-404.

Oad, F.C., G.H. Jamro and J.K. Biswas, 2002. Effect of different sowing dates on seed index, lint and ginning out-turn of various cotton varieties. Asian J. Plant Sci., 1: 316-317.

Prasad, N.V.V.S.D., N.H.P. Rao and M.S. Mahalakshmi, 2008. Population dynamics of major sucking pests infesting cotton and their relation to weather parameters. J. Cotton Res. Dev., 22: 85-90.

Purohit, D., O.P. Ameta and S.S. Sarangdevot, 2006. Seasonal incidence of major insect pests of cotton and their natural enemies. Rajasthan College of Agriculture (MPUAP), Udaipur. Pestology, 30: 24-29.

Ramamurthy, R., V. Rajaram, M. Rajendran and D. Krishnadoss, 2000. Impact of weather parameters on cotton pests. J. Cotton Res. Dev., 14: 193-195.

Rao, G.R., P.P. Rao, P.H. Kumar, C.R.N. Rao and G.B. Madhavi, 2001. Population dynamics and management of Jassid, *Amrasca bigutulla* Ishida on cotton. Proceeding of the National Conference: Plant Protection-New Horizons in the Milennium, Feb. 23-25, Entomological Research Association, Udaipur, pp: 19-19.

Riaz, M., M.A. Chaudhry, A. Ali and L. Khan, 1987. Physio chemical aspects of resistance in cotton to insect pests complex. Sarhad. J. Agric., 3: 491-497.

Saini, T.M., G.M. Patel and M.K. Jat, 2010. Efficacy of farmers innovative plant protection practices against some pests of cotton. Pestology, 34: 46-51.

Selvaraj, S., D. Adiroubane and V. Ramesh, 2010. Population dynamics of important insect pests of bhendi in relation to weather parameters. Pestology, 34: 35-39.

Shitole, T.D. and I.S. Patel, 2009. Seasonal abundance of sucking pests and their correlation with weather parameters in cotton crop. Pestology, 33: 38-40.

Shivanna, B.K., D.N. Nagaraja, M. Manjunatha and M.I. Naik, 2009. Seasonal incidence of sucking pests on transgenic Bt cotton and correlation with weather factors. Karnataka J. Agric. Sci., 22: 666-667.

Singh, J., G.S. Catoria, A.S. Sidhu, K. Singh and A.K. Dhawan, 1978. Effect of time of sowing on incidence of pests and plant characters of hirsutum cotton on variety 320 F. Entomon, 3: 177-180.

Singh, S., R. Niwas, R.K. Saini and M.L. Khichar, 2004. Relationship of micro climatic parameters with population dynamics of leafhopper and whitefly in cotton. Proceeding of the National Symposium on Changing World Order-Cotton Research, Aug. 10-12, Hyderabad, pp: 104-104.