Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2021; 9(1): 1040-1044

Received: 01-11-2020
Accepted: 03-12-2020

ASR Sarma
District Agricultural Advisory and Transfer of Technology Centre, ARS, Peddapuram, East Godavari, Andhra Pradesh, India

J Manjunath
District Agricultural Advisory and Transfer of Technology Centre, ARS, Peddapuram, East Godavari, Andhra Pradesh, India

N Kamakshi
District Agricultural Advisory and Transfer of Technology Centre, ARS, Peddapuram, East Godavari, Andhra Pradesh, India

Corresponding Author:
ASR Sarma
District Agricultural Advisory and Transfer of Technology Centre, ARS, Peddapuram, East Godavari, Andhra Pradesh, India

Seasonal dynamics of insect pests of cotton under high density planting systems (HDPS)

ASR Sarma, J Manjunath and N Kamakshi

Abstract
Experiment conducted during *kharif*, 2017-18 at RARS, Nandyal with variety Suraj for the incidence of sucking pests revealed that on the test variety, the leafhopper population attained with two peaks with the first peak during the 35th standard meteorological week (SMW) with 16.2 leafhoppers /3 leaves and the second peak was observed during 48th SMW with 6.2 leafhoppers/ 3 leaves. Though the incidence of thrips, aphids and whitefly was there, they have not crossed Economic Threshold Level (ETL) during the cropping period. The incidence of *Helicoverpa armigera* and spotted bollworm (*both E. vittella and E. insulana*) in the field and in traps was negligible during the cropping period. The trap catches of *Spodoptera litura* were highest (20.00 moths/ trap/ week) during from 42nd std. week whereas the moth catches of pink bollworm started from 41st. std. week and were above ETL from 47th std. week till harvest of the crop with peak catches during 1st std. week of 2018 (39.00 moths/trap/week). The leafhopper population had significant and positive correlation with minimum temperature and with both relative humidity morning and evening. The moth catches (trap catches) of *Spodoptera litura* had a significant and positive correlation with relative humidity (evening) and rainfall whereas the trap catches of pink bollworm had a significant but negative correlation with minimum temperature and evening relative humidity.

Keywords: cotton, sucking pests, bollworms, abiotic factors, correlation

Introduction
Cotton (*Gossipium* Spp) is commonly known as 'White gold' of India. It is one of the important commercial fiber crop of farmers community and significantly contributes to the national economy. It provides the raw material to allied sectors like ginning, fabric production, textile processing, garment manufacture and their marketing etc. It provides employment about 6 million and contributed 1/3rd of total foreign exchange earning of India [1] In India cotton cultivated on 12.2 million ha area with production of 347.05 lakh bales (170 kg) and productivity of 484 kg lint/ha, however Maharashtra state comes under central which zone occupies an area of 40.95 lakh ha with production of 73.75 lakh bales and productivity of 306 kg lint /ha [2]. After introduction of *Bt* cotton in India from 2002 cultivation of American/ Bt cotton (*Gossypium hirsutum*) started. Transgenic *Bt* cotton (*Cry* 1AC & *Cry* 1AB) is effective against lepidopteron pest (Bollworms), but not against sucking pest complex and thus farmers was getting higher yield of cotton. Ultimately reduced usage of insecticides in *Bt* cottons has led to increased population of sucking insect pests [3]. *Bt* cotton is more vulnerable to the attack of sucking insect pest complex as compared to desi cotton (*Gossypium arborium*) [4]. For the better yield of cotton crop its need to control pest because they damage crop and reduce the yield. The insect pest constitutes one of the major limiting factors and heavy damage caused by insect pests and it has been estimated about 20-25% yield losses [5]. Approximately 162 species of insects and mites reported to be attack on cotton in India and the yield loss in *Gossypium hirsutum* cotton due to sucking pests, bollworms and both has been recorded up to 8.45, 16.55 and 17.35 quintal/ha respectively [6].

Among sucking pests; Aphid, *Aphis gossypii* (Glover), leafhoppers, *Amrasca biguttula biguttula* (Ishida), Thrips, *Thrips tabaci* (Lind.), Whitefly, *Bemisia tabaci* (Genn.) and Mealybug, *Phenococcus solenopsis* (Tinsley) are of major importance and it causes the considerable damage in *Bt* cotton. Jassid is reported to cause 18.78 % decline in cotton yield [7]. Similarly whitefly vector of CLCuV [8] injure to cotton by secreting honeydew and transmitting cotton leaf curl viral diseases that caused normal yield loss in Pakistan up to 38.7% during 1993 [9].

Similarly, in the absence of thrips 56% plants produced 40% more lint than infested plants and young seedlings of cotton were severely infested by thrips [10]. The mealybug had shattered 0.2 million bales (170 kg lint per bale) and 150,000 acres (out of the 8.0 million acres) of cotton area all across Pakistan, chiefly in Punjab and Sindh provinces [11, 12]. Reported 58-73% reduction in seed cotton yield due to mealy bug [13]. Also reported 50% reduction in cotton yield in Gujrat during 2006 due to severe mealybug infestation. According to [14] in India due to mealybug plague nearly 2000 acres of cotton crop were ruined. Now apart from yield losses, the cost of insecticide application only for mealybug has been increased by 250-375 US$ per [15]. For control of insect pests on *Bt* cotton farmers rely on chemical control [16]. 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 (predators, parasitoids and pathogens) in agro-ecosystem [17, 18]. The occurrence and progress of all the insect pests are much dependent upon the customary environmental factors such as temperature, relative humidity and precipitation [19]. The activities of these insect pests are fluctuated under erratic environmental conditions. The knowledge about incidence of pest during the cropping season and its possible dynamics help in designing pest management strategies [20]. To develop the suitable integrated pest management practices close monitoring of insect pest complex of *Bt* cotton is necessary. Thus by keeping in mind the present studies was carried out to investigate the seasonal occurrence and peak activity of sucking insect pest of cotton throughout cotton growing season and its correlation with weather factors. This information of pest surveillance will be useful for devising the suitable pest management strategies for researchers and farmers.

Materials and Methods

Present investigations on the seasonal incidence of sucking pests were recorded on Suraj variety during *kharif*, 2017 at Regional Agricultural Research Station, Acharya N.G. Ranga Agricultural University, Nandyal, Kurnool District, Andhra Pradesh. The crop was grown in a plot size of 1000 m^2 at planting geometry of 60 × 10 cm (high density) and was kept unsprayed throughout the cropping season. All the recommended agronomic practices were followed to raise the crop except for crop protection measures. The population of sucking insect pests was estimated from 10 plants selected randomly and on each plant from 3 fully formed leaves i.e., from the upper, middle and bottom leaves of the plant canopy before 10 AM in the morning at weekly interval, i.e. Standard Meteorological Weeks (SMW) throughout the cropping season.

The data obtained were converted to mean population by using window MS excel functions including the following formulae:

Where Mean (X) = Average/mean population,
N= no. of plants and
Σx = Sum of population of all plants

The pheromone traps were installed @ 4 per acre and the data on trap catches of different bollworms was collected daily and were presented standard week wise average. The data on various meteorological parameters was obtained from Department of Meteorology, RARS, Nandyal. The mean population data obtained from weekly observations were subjected to simple correlation analysis with meteorological parameters, *viz*. maximum and minimum temperature, morning and evening relative humidity and rainfall.

Results and Discussions

The incidence of sucking pests on Suraj variety of cotton under high density planting system and the trap catches of different bollworms along with weather conditions prevailed during the period of study are presented in Table 1 &2.

The leafhoppers have crossed ETL and were peak during 35th, 36th, 39th, 40th, 41st, 47th and 48th std. weeks by recording 16.20, 13.60, 8.40, 9.60, 6.00 and 6.20 leafhoppers / 3 leaves under high density planting system (HDPS). The population of other sucking pests such as thrips, aphids and whiteflies was below ETL during the season. The field incidence of American bollworm, *Spodoptera litura* and *Earias* spp. was almost negligible during the season. However, the incidence of pink bollworm was severe during the season. The trap catches of *Spodoptera litura* were highest (20.00 moths/ trap/ week) during from 42nd std. week whereas the moth catches of pink bollworm started from 41st. std. week and were above ETL from 47th std. week till harvest of the crop with peak catches of 39.0 moths/trap/week during 1st std. week of 2018.. However, the trap catches of remaining bollworms were very less.

The correlation studies between the sucking pest population and the weather parameters under high density planting system in cotton revealed that the leafhopper population had significant and positive correlation with minimum temperature and with both relative humidity morning and evening with correlation coefficient values of r= 0.648, r= 0.464, r= 0.730, respectively whereas the whitefly population did not show any sort of correlation with all the weather parameters tested. The natural enemy population had a significant and negative correlation with maximum temperature (r= -0.424) (Table 3).

The correlation studies between insect pests, natural enemies, moth trap catches and weather parameters indicated that leafhopper population showed a significant and positive correlation with minimum temperature (r = 0.648) and the present findings are also in line with [21] who reported a significant and positive correlation between minimum temperature and leafhoppers population and the present findings are in negation with [22] who reported that leafhopper population showed a significant and positive correlation with maximum temperature. The present investigations are in conformity with [23, 24, 25, 26]. Who also reported a positive correlation between leafhopper population and temperature. However, the present findings of significant and positive correlation between leafhopper population and RH (Mor.) are in agreement with the reports of [27, 28, 29, 30, 31]. Who reported significant and positive correlation between leafhoppers and relative humidity.

The correlation studies between the trap catches of bollworms and weather parameters indicated that American bollworm, Spotted bollworm (both *E. vittella* and *E. insulana*) did not show any sort of correlation with weather parameters whereas the trap catches of *Spodoptera litura* and pink bollworm had a correlation with weather parameters (Table 4).

The moth catches of *Helicoverpa armigera* did not show any sort of correlation with weather parameters in the present study and the results are in negation with the reports of [32] who reported that there was a significant and negative

correlation between moth catches of *H. armigera* and minimum temperature and [33] who reported that the moth catches of *H. armigera* showed a significant and positive correlation with minimum temperature. The moth catches (trap catches) of *Spodoptera litura* had a significant and positive correlation with relative humidity (evening) and rainfall with the coefficient values of r= 0.641 and r= 0.565, respectively whereas the trap catches of pink bollworm had a significant but negative correlation with minimum temperature and evening relative humidity with the coefficient values of r= -0.764 and r= - 0.629, respectively (Table 4).

The pink bollworm trap catches were correlated with weather parameters of the same week, and at 1, 2, 3, 4 and 5 week lag weather parameters and the results indicated that pink bollworm trap catches had a significant and negative correlation only with the minimum temperature whereas the correlation with other weather parameters was found non-significant (Table 5).

Table 1: Population dynamics of sucking pests in relation to weather parameters under HDPS in cotton

Std. week	Sucking pest Population (no. per 3 leaves)		Natural enemies per plant	Temperature		Relative Humidity (%)		Rainfall (mm)
	Leafhoppers	Whiteflies		Max (^{0}C)	Min (^{0}C)	Mor.	Eve.	
35(27th AUG - 2nd Sep, 2017)	16.2	0	0	31.6	24.5	89	66	10.4
36 (3rdto 9th Sep,2017)	13.6	0.3	0.1	33.2	25.1	85.6	65.6	16.2
37(10th to16thSep,2017)	5.6	0.8	0	33.7	24.7	81.4	63.1	58.4
38(17thto 23rd Sep,2017)	5.7	0.1	0.1	31.8	24.0	83.6	61.1	18.2
39(24thto 30th Sep,2017)	8.4	0	0.2	32.4	24.8	88.7	72.6	8.0
40(1st to 7th Oct,2017)	9.6	0.2	0.2	31.5	24.5	90.0	69.1	52.6
41(8th to 14th Oct,2017)	7	0.6	0	30.9	23.9	91.7	70.7	46.6
42(15th to 21st Oct,2017)	2.8	0.2	0	32.9	23.6	88.4	61.7	25.6
43(22nd to 28th Oct,2017)	3.2	0.6	0	33.6	23.5	79.9	50.6	0.0
44(29th Oct to 4th Nov,2017)	2.2	1	0.1	32.3	22.7	74.4	44.3	0.0
45(5th to 11th Nov,2017)	2.5	0.3	0.1	32.1	21.9	86.1	53.1	3.2
46(12th to 18th Nov,2017)	4.3	0.3	0	32.7	23.3	77.3	47.3	0.0
47(19th to 25th Nov,2017)	6	0.2	0	33.3	22.9	85.7	51.0	0.0
48(26thNov to 2nd Dec,2017)	6.2	0.1	0.1	31.5	20.6	82.7	48.1	0.0
49(3rdto 9th Dec,2017)	5	0.3	0.2	31.3	19.4	86.6	47.3	0.0
50(10th to 16th Dec,2017)	4.5	0.1	0	33.0	19.0	83.4	41.1	0.0
51(17th to 23rd Dec,2017)	2.4	0.2	0	30.8	17.0	85.0	40.9	0.0
52(24th to 31st Dec,2017)	2.3	0.5	0.3	30.9	16.4	86.8	39.5	0.0
1 (1st Jan to 7th Jan, 2018)	1.1	0	0.1	31.7	17.8	84.0	37.9	0
2 (8th Jan to 14th Jan, 2018)	1.3	0.4	0	32.2	18.7	81.9	42.6	0
3(15th Jan to 21st Jan, 2018)	2	2.1	0.1	32.7	17.5	82.4	35.3	0
4(22nd Jan to 28th Jan, 2018)	1.7	1.1	0.1	32.0	17.5	82.4	39.9	0

Table 2: Population dynamics of bollworms (trap catches) in relation to weather parameters under HDPS in cotton

Standard week	Trap catches / week					Temperature		Relative Humidity (%)		Rainfall
	H. armigera	Pink Bollworm	*E. insulana*	*E. vittella*	*S. litura*	Max (^{0}C)	Min (^{0}C)	Mor.	Eve.	(mm)
41(8th to 14th Oct,2017)	0.3	8.0	0.3	0.0	9.9	30.9	23.9	91.7	70.7	46.6
42(15th to 21st Oct,2017)	0.4	5.3	0.3	1.0	20.0	32.9	23.6	88.4	61.7	25.6
43(22nd to 28th Oct,2017)	0.0	1.9	0.0	0.0	8.7	33.6	23.5	79.9	50.6	0.0
44(29th Oct to 4th Nov,2017)	1.3	6.6	0.9	0.6	4.1	32.3	22.7	74.4	44.3	0.0
45(5th to 11th Nov,2017)	0.6	7.3	1.7	0.3	1.4	32.1	21.9	86.1	53.1	3.2
46(12th to 18th Nov,2017)	0.3	6.7	2.7	0.0	1.3	32.7	23.3	77.3	47.3	0.0
47(19th to 25th Nov,2017)	0.0	16.9	0.0	0.0	7.4	33.3	22.9	85.7	51.0	0.0
48(26thNov to 2nd Dec,2017)	0.0	20.2	0.7	0.2	8.5	31.5	20.6	82.7	48.1	0.0
49(3rdto 9th Dec,2017)	0.0	19.1	3.1	0.0	5.9	31.3	19.4	86.6	47.3	0.0
50(10th to 16th Dec,2017)	0.0	29.6	2.1	0.0	5.1	33.0	19.0	83.4	41.1	0.0
51(17th to 23rd Dec,2017)	1.0	19.5	0.2	0.3	3.2	30.8	17.0	85.0	40.9	0.0
52(24th to 31st Dec,2017)	0.0	20.2	0.0	0.0	9.2	30.9	16.4	86.8	39.5	0.0
1 (1st Jan to 7th Jan, 2018)	1.3	39.0	0.9	0.0	2.6	31.7	17.8	84.0	37.9	0
2 (8th Jan to 14th Jan, 2018)	0.3	24.3	1.6	0.4	1.3	32.2	18.7	81.9	42.6	0
3(15th Jan to 21st Jan, 2018)	0.4	18.9	0.6	0.4	0.0	32.7	17.5	82.4	35.3	0
4(22nd Jan to 28th Jan, 2018)	0.6	21.0	3.3	0.0	0.0	32.0	17.5	82.4	39.9	0

Table 3: Correlation between incidence of sucking pests and natural enemies and weather parameters

Weather parameters	Leafhoppers	Whiteflies	NE
T- Max (^{0}C)	0.012	0.192	-0.424*
T- Min (^{0}C)	0.648*	-0.289	-0.219
RH -Mor (%)	0.464*	-0.372	0.230
RH -Eve (%)	0.730*	-0.371	-0.027
Rainfall (mm)	0.368	-0.023	-0.077

r-cal (0.05, 20df) = 0.422 r-cal (0.01, 20df) = 0.537

Table 4: Correlation between moth (trap) catches of bollworms and weather parameters

Weather parameter	*H. armigera*	*PBW*	*E. insulana*	*E. vittella*	*S. litura*
T- Max (^{0}C)	-0.210	-0.268	0.001	0.158	0.068
T- Min (^{0}C)	-0.155	-0.764**	-0.162	0.170	0.457
RH -Mor (%)	-0.286	0.108	-0.229	-0.048	0.470
RH -Eve (%)	-0.238	-0.629**	-0.228	0.158	0.641*
Rainfall (mm)	-0.047	-0.370	-0.271	0.202	0.565*

r-cal (0.05, 14df) – 0.497 r-cal (0.01, 14df) – 0.622

Table 5: Pink bollworm incidence (trap catches at existing and previous week weather periods)

	Weather parameters at a period					
Weather parameters	**Same week**	**1 week lag**	**2 weeks lag**	**3 weeks lag**	**4 weeks lag**	**5 weeks lag**
T- Max (^{0}C)	-0.242	-0.205	-0.147	-0.114	-0.090	-0.160
T- Min (^{0}C)	-0.287	-0.497*	-0.566 *	-0.630 **	0.023	-0.731 **
RH -Mor (%)	0.369	0.387	0.244	0.317	0.198	0.168
RH -Eve (%)	0.100	-0.071	-0.238	-0.268	0.139	-0.459
Rainfall (mm)	-0.028	0.013	-0.399	-0.336	-0.207	-0.348

r-cal (0.05, 14df) – 0.497 r-cal (0.01, 14df) – 0.622

Conclusion

From the study it can be concluded that leafhoppers appeared early in the season with their peak populations during 2nd fortnight of August to 2nd fortnight of September and then with one more peak during 2nd fortnight of November. *Spodoptera litura* moth catches were observed throughout the season with their peak during 2nd fortnight of October whereas pink bollworm started appearing from 1st fortnight of October to 2nd fortnight of January, 2018 with peak catches during 1st fortnight of January, 2018. Leafhopper population showed a significant and positive correlation with minimum temperature and morning relative humidity and trap catches of pink bollworm had a significant but negative correlation with minimum temperature and evening relative humidity.

References

1. Mayee CD, Rao MRK. Current cotton production and protection scenarios including G.M. Cotton. Agrolook 2002, 14-20.
2. Anonymous, Central Institute for Cotton Research. Nagpur, Annual Report 2011-12, 78.
3. Krishna Vijesh V, Qaim, Matin. *Bt* cotton and sustainability of pesticide reductions in India. Agril. Systems 2012;107:47-55.
4. Nath P, Chaudhary OP, Sharma PD, Kaushik HD. The studies on the incidence of important insect pests of cotton with special reference to *Gossypium arborium* (Desi) cotton. Indian Journal of Entomology 2000;62:391-395.
5. Butani DK, Jotwani MG. Insects in Vegetables. Periodical Export Book Agency, Delhi 1984, 44-68.
6. Satpute US, Sarnaik DN, Bhalerao PD. Assessment of avoidable field losses in cotton yield due to sucking pests and bollworms. Indian Journal of Plant Protection 1988;16:37-39.
7. Ali A. Physio-chemical factors affecting resistance in cotton against jassid, Amrasca devastans (Dist.) and thrips, Thrips tabaci (Lind.) in Punjab, Pakistan. Ph. D. Thesis., Dept. Entomol., Univ Agric., Faisalabad 1992, 430.
8. Malik AK, Mansoor S, Saeed NA, Asad S, Zafar Y, Stanely J *et al*. Development of CLCV resistance cotton varieties through genetic engineering. A monograph published by Director of Agricultural Information, Punjab, Pakistan 1995, 3.
9. Khan WS, Khan AG. Cotton Situation in Punjab. An overview. Presented at National Seminar on Strategies for Increasing Cotton Production. Agri. House, 21-Agha Khan-III Road, Lahore. April 6-7, 1995.
10. David WAL. Organic phosphorus insecticide for the control of field crop insects. Annual Review of Entomology 1958;11:183-212.
11. ICAC. Mealybug: A new threat to cotton production in Pakistan and India. International Cotton Advisory Committee. ICAC Recorder 2008;26:15-19.
12. Dhawan AK. *Maconellicoccus* sp. Attacking arborium cotton in Panjab. Science and Culture 1980;46:258.
13. Jhala RC, Bharpoda TM. Occurrence in Gujrat and suggestion for action plan to combat the menace of mealybug on cotton. Paper presented in workshop organized by Department of Agriculture and cooperation. Ministry of Agriculture. Krishi Bhawan New Delhi in at NCIPM 2008.
14. Goswami B. Bt cotton devastated by secondarypests. http://www.infochangeindia.org/features 441. jsp (posted on 1 September 2007).
15. Arif MJ, Abbas G, Saeed S. Cotton in danger, p: 4. Dawn, The Internet Edition (http://DAWN.com), March 24th 2007.
16. Nagrare VS, Kranthi S, Biradar VK, Zade NN, Sangode V, Kakde G *et al*. Widespread infestation of the exotic mealybug species *Phenacoccus solenopsis* (Tinsley) (Hemiptera: Pseudococcidae) on cotton in India. Bulletin of Entomological Research 2009;99:537-541.
17. Hamburg HV, Guest PJ. The impact of insecticide arthropods in cotton agro-ecosystem in South Africa. Archives of Environmental Contamination and Toxicology 1997;32(1):63-68.
18. Sorejani M. Current trend in pesticide usage in some Asian countries. Review of Applied Entomology 1998;77:219-234.
19. Aheer GM, Ahmed KJ, Ali A. Role of weather in fluctuating aphid density in wheat crop. Journal of Agricultural Research 1994;32:295-301.
20. Santhosh BM, Patil SB, Udikeri SS, Awaknavar JS, Katageri IS. Impact of *Bt* cotton on pink bollworm, *Pectinophora gossypiella* (Saunders) infestation. Karnataka J Agric. Sci 2009;22(2):322-326.
21. Desai HR, Maisuria IM, Patel CJ, Solanki VY, Bhadsuria S, Kumar V. Incidence of different pests in Bt and non-

Bt cotton hybrids in relation to weather parameters under South Gujarath conditions. National Symposium on Bt cotton: Opportunities and prospects at CICR, Nagpur. November 17 -18, 2009, 126-127.
22. Bhute NK, Bhosle BB, Bhede BV, More DG. Population dynamics of major sucking pests of Bt cotton. Ind. J Entomology 2012;74(3):246-252.
23. Ramesh Babu S, Meghwal ML. Population dynamics and monitoring of sucking pests and bollworms on *Bt* cotton in humid zone of Southern Rajasthan. The Bioscan 2014;9(2):629-632.
24. Shivanna BK, Nagaraja DN, Manjunatha M, Mohan I Naik. Seasonal incidence of sucking pests on transgenic *Bt* cotton and correlation with weather factors. Karnataka J Agric. Sci 2009;22(3 Spl. Issue):666-667.
25. Patel JR. Integrated pest management in cotton hybrid-6. Ph.D. Thesis submitted to Gujarath Agricultural University, Anand 1992.
26. Mohapatra LN. Population dynamics of sucking pests in Hirsutum cotton and influence of weather parameters on its incidence in Western Orissa. J Cot. Res. Dev 2008;22:192-194.
27. Selvaraj S, Adiroubane D, Ramesh V. Population dynamics of leafhopper, *Amrasca devastans* Distant in cotton and its relationship with weather parameters. J Ent 2011;8(5):476-483.
28. Laxman P, Samatha Ch, Sammaiah Ch. Study on infestation of sucking insect pests on Bt cotton and non-*Bt* cotton fields in Warangal- Telangana. International J Adv, Biol. Res 2014;4(2):172-177.
29. Shitole TD, Patel IS. Seasonal abundance of sucking pests and their correlation with weather parameters in cotton crop. Pestology 2009;33:38-40.
30. Kaur P, Singh H, Butter NS. Formulation of weather based criteria rules for the prediction of sucking pests in cotton (*Gossypium hirsutum*) in Punjab. Indian J of Agric. Sci 2009;79:375-380.
31. Prasad NVVSD, Rao NHP, Mahalakshmi MS. Population dynamics of major sucking pests infesting cotton and their relation to weather parameters. J Cot. Res. Dev 2008;22:85-90.
32. Hameed A, Shahzad MS, Ahmad S, Karar H. Forecasting and Modelling of *Helicoverpa armigera* (Hub.) in Relation to Weather Parameter in Multan, Punjab, Pakistan. Pakistan J Zool 2015;47(1):15-20.
33. Yogesh, Rajnish Kumar. Monitoring Helicoverpa armigera through pheromone trap catches under agroclimatic conditions of Eastern U.P. Trends in Biosciences 2014;7(6):434-436.