The Pharma Innovation Journal 2023; SP-12(12): 17-22

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2023; SP-12(12): 17-22

www.thepharmajournal.com
Received: 19-09-2023
Accepted: 23-10-2023

Saroj Jat
Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

MK Mahla
Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

Deepak Kumar Saini
Division of Plant Pathology, Rajasthan Agricultural Research Institute, Durgapura, Jaipur, SKN Agriculture University, Jobner, Rajasthan, India

S Ramesh Babu
Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

Corresponding Author:
Saroj Jat
Department of Entomology, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur, Rajasthan, India

Population dynamics of major sucking insect pests infesting *Bt.* cotton (*Gossypium hirsutum* L.) and their natural enemies

Saroj Jat, MK Mahla, Deepak Kumar Saini and S Ramesh Babu

Abstract
The experiment on "Population dynamics of major sucking insect pests infesting *Bt.* cotton (*Gossypium hirsutum* L.) and their natural enemies" was carried out at Agronomy Farm, Rajasthan College of Agriculture, Maharana Pratap University of Agriculture and Technology, Udaipur during *kharif*, 2019. The population of aphids reached its peak during the 40th SMW (49.20 aphids/plant). The peak population of jassids (30.25 jassids/plant) and whiteflies (32.40 whiteflies/plant) was recorded during the 34th SMW and 31st SMW, respectively. The peak population of thrips (41.60 thrips/plant) was recorded during the 36th SMW. Whereas, the peak population of mealybugs (26.00 mealybugs/10 cm twig) was recorded during the 37th SMW. The correlation coefficient study reveals that the population of jassids, aphids, whiteflies, thrips and mealybugs was positively correlated with mean temperature, relative humidity and total average rainfall, and the population of these pests was found significantly positive with the relative humidity.

Keywords: Population dynamics, aphids, jassids, thrips, whitefly, mealybugs

Introduction
Cotton (*Gossypium hirsutum*. L.) is one of the most important commercial fibre crops and also have a global significance. Cotton crop has been cultivated in more than 70 countries with a potential of employment generation both in rural and urban sectors. As a commercial commodity, it provides raw material to allied sectors such as ginning, fabric production, textile processing and garment manufacture and their marketing, etc., it generates about six million employment and contribution of 1/3rd of total foreign exchange earning of India (Mayee and Rao, 2002) [11]. It is popularly known as 'White Gold' and 'Friendly Fiber'. The Bt cotton was introduced in India during 2012 and then onwards cultivation of *Bt* cotton (*G. hirsutum*) came into existence in the country. The bollworms like *Helicoverpa armigera* (Hubner) and *Pectinophora gossypiella* (Saunders) which belongs to lepidopteran pests effectively managed by the transgenic *Bt* cotton and it reduces the indiscriminate due of insecticides in *Bt* cotton. However, it is not effective against sucking pests complex (jassids, whiteflies, thrips and aphids) and this aggravates the sucking pests problem along with meal bug infestation on *Bt* cotton (Krishna and Qaim, 2012) [10]. The major sucking pests are aphid, *Aphis gossypii* (Glover), jassids, *Amrasca biguttula biguttula* (Ishida), Thrips, *Thrips tabaci* (Lind.), Whitefly, *Bemisia tabaci* (Genn.) and mealybug, *Phenacoccus solenopsis* (Tinsley) and causing significant damage and economic loss to the *Bt* cotton crop. Jassids are reported to cause an 18.78 percent decline in cotton yield (Ali, 1992) [1]. Similarly, whitefly is acting as a vector for the disease Cotton Leaf Curl Virus (CLCV) and transmitting on *Bt* cotton reported causing in yield losses up to 38.7% (Khan and Khan, 1995) [9]. Due to the introduction of *Bt* cotton, the severity of mealybug infestation was increased and cotton yield was drastically reduced to 50% in cotton in Gujarat as reported by Jhala and Bharpoda, 2008.

Materials and Methods
Layout of experiment
The Cotton variety, Super-2087 was sown at the Agronomy farm of Rajasthan College of Agriculture, Udaipur, Rajasthan. To record the seasonal incidence of insect pests infesting cotton crop, the experiment was laid in uniformly sized plots measuring 3.6 m × 4.5 m replicated three times. The crop was grown under natural conditions without spraying of insecticides and was maintained at a row to row spacing 90 cm and plant to plant 60 cm.

Observations
The observation on the population of sucking pests was recorded on three leaves one each from the top, middle and bottom portion of the 10 tagged cotton plants.

Sampling techniques
The sampling techniques adopted for estimation of population of different insect pests are as given below:

1. **Jassids, thrips and whiteflies:** The population of jassids, thrips and whiteflies were recorded on three leaves, one each from the top, the middle and bottom portion of the 10 tagged untreated cotton plants. The population was estimated by direct visual counting of the population with the help of a magnifying lens**.**
2. **Aphids:** The population of aphids was counted on three leaves chosen from the top, middle and bottom of each plant. With the help of magnifying lens, the aphids present were counted and population was expressed on a per plant basis.
3. **Mealybugs:** The population of mealy bugs was recorded from 10 cm twigs per plant on ten randomly selected and tagged cotton plants in each plot.
4. **Natural enemies:** The associated natural enemies population was recorded by the visual count technique from the ten randomly selected and tagged plants in each plot by counting the number of natural enemies per plant on a whole plant basis.

Statistical analysis
Population data of different insect pests obtained and subjected to statistical analysis to find out the coefficient of correlation with average temperature and relative humidity. The following formula was used for calculating the correlation coefficient.

$$r_{xy} = \frac{\sum XY - \frac{(\sum X)(\sum Y)}{n}}{\sqrt{\left[\sum X^2 - \frac{(\sum X)^2}{n}\right]\left[\sum Y^2 - \frac{(\sum Y)^2}{n}\right]}}$$

Where,
r_{xy} = Simple correlation coefficient
X = Variable *i.e.* abiotic component. (Average temperature and relative humidity rainfall and sunshine hours).
Y = Variable *i.e.* mean number of insect pests.
N= Number of paired observation
The correlation coefficient (r) values were subjected to the test of significance using t-test.

$$t = \frac{r}{\sqrt{1-r^2}} \times \sqrt{n-2}$$

The calculated t-value obtained was compared with tabulated t-value at 5% level of significance.

Results
During the course of investigation on sucking insects of cotton, jassids (*Amrasca biguttula biguttula* Ishida), aphids (*Aphis gossypii* Glover), whiteflies (*Bemisia tabaci* Gennadius), thrips (*Thrips tabaci* Linnman) and mealy bugs (*Phenacoccus solenopsis* Tinsley) were recorded as major sap-sucking pests. Their incidence has been described as under.

Jassids (*Amrasca biguttula biguttula* Ishida)
During the 26th SMW, (standard meteorological week) incidence of jassids was first recorded as 2.05 jassids/plant that touched the peak levels (30.25 jassids/plant) in the 34th SMW. Thereafter, the jassid population decreased gradually in 45th SMW and reached to a minimum level of 0.70 jasids/plant. The mean atmospheric temperature, relative humidity and total rainfall during the peak period of incidence were 26.50 °C, 73.30 percent and 69.60 mm, respectively. The pest insect had a notable positive non-significant correlation (r = 0.109) with temperature and total rainfall (r = 0.426) while with relative humidity the correlation was significantly positive (r = 0.542).

Aphids (*Aphis gossypii* Glover)
The pest attack was first noticed during the 26th SMW (3.40 aphids/plant) and reached the peak (49.20 aphids/plant) in the 40th SMW when the mean atmospheric temperature, relative humidity and total rainfall were 24.40 °C, 78.55% and 66.40 mm, respectively. However, the pest population decreased gradually during 45th SMW and reached the minimum level of 2.00 aphids/plant. The growing aphid population showed a positive significant correlation with relative humidity (r = 0.564); while with mean temperature (r = 0.163) and total rainfall (r = 0.162) the correlation was reported to be positively non-significant.

Whiteflies (*Bemisia tabaci* Gennadius)
During the 26th SMW, whiteflies were first recorded (1.15 whiteflies/plant) thereafter, their population notably increased and touched the peak (32.40whiteflies/plant) in the 31st SMW, when the mean atmospheric temperature was 26.75 °C, relative humidity 83.50% and 15.00 mm total rainfall. During 45th SMW, the population decreased gradually with a minimum of 1.20 whiteflies/plant. The whitefly population reported a positive non-significant correlation with mean temperature (r = 0.127) as well as with total rainfall (r =0.298) while with relative humidity the correlation was significantly positive (r =0.595).

Thrips (*Thrips tabaci* Linnman)
The incidence of thrips was first noticed during the 26th SMW (1.20 thrips/plant) then population increased gradually and reached the maximum level (41.60 thrips/plant) mostly in the 36th SMW. Then the population decreased gradually to a minimum level of 2.40 thrips/plant in the 45th SMW. During the peak period of incidence, the mean atmospheric temperature, relative humidity and total rainfall were 27.10 °C, 88.55% and 85.50 mm, respectively. The pest population exhibited a significant positive correlation with relative humidity (r = 0.645), while with the temperature (r = 0.287) and total rainfall (r = 0.338) it was positively non-significant.

Mealybugs (*Phenacoccus solenopsis* Tinsley)
Mealybugs incidence was first started from 29th SMW (3.00 mealybugs/10 cm twig). Maximum population of mealybugs (26.00 mealybugs/10 cm twig) observed during 37th SMW. Thereafter, mealy bug population decreased gradually and reached to a minimum level of 1.62 mealybugs/10 cm twig. During the peak period of incidence, the mean atmospheric temperature, relative humidity and total rainfall were 26.80 °C, 82.75% and 36.10 mm, respectively. The pest reported positive but non-significant correlation with temperature (r = 0.143) and total rainfall (r = 0.335); while, positively significant correlation with relative humidity (r = 0.704).

Table 1: Seasonal incidence of sucking insect pests of cotton

Standard Meteorological Weeks (SMW)	Abiotic Factors			Seasonal Population (Mean no. /Plant)				
	Mean Temp. (°C)	Mean RH (%)	Total Rainfall (mm)	Jassids	Aphids	Whitefly	Thrips	Mealybug per 10 cm twig
26	28.45	70.85	74.80	2.05	3.40	1.15	1.20	0
27	27.10	76.15	91.00	4.85	10.90	5.20	7.45	0
28	27.90	64.45	o.00	7.35	17.00	10.60	19.65	0
29	28.65	65.95	34.60	12.65	28.60	14.35	23.10	3.00
30	27.80	74.30	12.60	18.85	31.80	24.45	27.90	5.60
31	26.75	83.50	15.00	16.20	34.85	32.40	33.40	9.00
32	25.30	83.00	182.20	14.00	36.50	28.20	28.50	7.80
33	24.60	85.15	153.00	29.25	28.20	26.45	23.45	11.40
34	26.50	73.30	69.60	30.25	39.45	32.25	31.75	17.90
35	25.85	86.35	141.00	25.85	30.00	22.00	40.25	22.00
36	27.10	88.55	85.50	16.35	37.25	21.40	41.60	25.60
37	26.80	82.75	36.10	14.95	42.20	26.25	33.00	26.00
38	26.40	75.05	42.20	14.90	45.40	22.30	27.25	16.00
39	25.60	82.85	14.20	16.80	48.00	20.25	18.30	11.80
40	24.40	78.55	66.40	14.35	49.20	20.30	21.25	9.70
41	23.90	73.85	18.40	15.80	38.80	21.45	19.30	7.20
42	24.05	63.20	0.00	13.20	29.00	19.20	15.80	4.90
43	21.15	59.35	0.00	9.90	13.20	12.15	14.95	3.00
44	23.35	69.05	12.40	1.20	4.00	4.00	11.10	1.78
45	22.90	65.15	0.00	0.70	2.00	1.20	2.40	1.62
Coefficient of correlation (r) for population and Atm. Temp.				0.109	0.163	0.127	0.287	0.143
Coefficient of correlation (r) for population and R. H.				0.542*	0.564*	0.595*	0.645*	0.704*
Coefficient of correlation (r) for population and total rainfall				0.426	0.162	0.298	0.338	0.335

*= significant at 5% level of significance

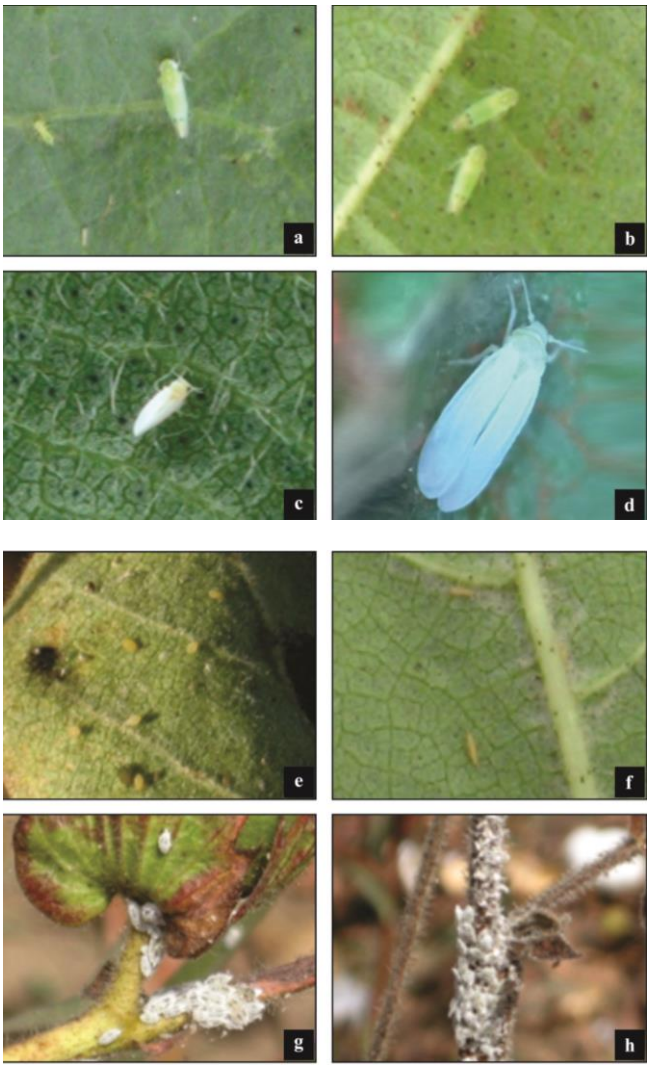

Plate 1: Insect pests recorded in *Bt*. Cotton ecosystem during *Kharif*, 2019 (a & b) Jassids, (c & d) Whiteflies, (e) Aphids, (f) Thrips, (g & h) mealybugs.

Population dynamics of major natural enemies on *Bt.* Cotton

Coccinellids

The coccinellid population was first observed during the 29th SMW (0.40 coccinellids/plant) and the population reached to the highest level (1.80 coccinellids/plant) during the 39th SMW then the population decreased gradually up to zero till 44th SMW. The mean atmospheric temperature, relative humidity and total rainfall during the peak population were recorded as 25.60 °C, 82.85% and 14.20 mm, respectively. The coccinellid population showed positive but non-significant correlation with temperature (r = 0.080) and total rainfall (r = 0.205); while, positively significant correlation with relative humidity (r = 0.691).

Chrysoperla

The occurrence of *Chrysoperla* in the crop was started during the 28th SMW (0.30 chrysoperla/plant) and increased to its peak (1.70 chrysoperls/plant) in 40th SMW when the recorded mean temperature, relative humidity and total rainfall were 24.40 °C, 78.55% and 66.40 mm, respectively. The population was recorded almost zero during the 45th SMW. The population of *Chrysoperla* exhibited negatively non-significant correlation with temperature (r = -0.079) and total rainfall (r = -0.190); while, positively non-significant correlation with relative humidity (r = 0.263).

Spider

The appearance of spiders was first noticed during the 30th SMW (0.30 spiders/plant) with peak in 36th SMW (1.90 spiders/plant). The population of spiders decreased gradually and no spider was recorded in the 44th SMW. The mean atmospheric temperature, relative humidity and total rainfall during the peak population were 27.10 °C, 88.55% and 85.50 mm, respectively.

Table 2: Population dynamics of natural enemies in *Bt* cotton

Standard	Abiotic Factors			Natural Enemies Population (mean no. /plant)		
Meteorological Weeks (SMW)	Mean Temp. (°C)	Mean RH (%)	Total Rainfall (mm)	Coccinellids	Chrysoperla	Spider
26	28.45	70.85	74.80	0	0	0
27	27.10	76.15	91.00	0	0	0
28	27.90	64.45	0.00	0	0.30	0
29	28.65	65.95	34.60	0.40	0.20	0
30	27.80	74.30	12.60	0.70	0.30	0.20
31	26.75	83.50	15.00	0.80	0.40	0.40
32	25.30	83.00	182.20	0.90	0.10	0.20
33	24.60	85.15	153.00	0.80	0.20	1.00
34	26.50	73.30	69.60	0.90	0.30	1.30
35	25.85	86.35	141.00	1.00	0.10	1.60
36	27.10	88.55	85.50	1.30	0.50	1.90
37	26.80	82.75	36.10	1.50	0.70	1.80
38	26.40	75.05	42.20	1.50	1.00	0.90
39	25.60	82.85	14.20	1.80	1.20	0.80
40	24.40	78.55	66.40	1.60	1.70	0.40
41	23.90	73.85	18.40	1.20	0.80	0.30
42	24.05	63.20	0.00	0.30	0.40	0.10
43	21.15	59.35	0.00	0.10	0.20	0.10
44	23.35	69.05	12.40	0	0.10	0
45	22.90	65.15	0.00	0	0	0
Coefficient of correlation (r) for population and Atm. Temp.				0.080	-0.079	0.168
Coefficient of correlation (r) for population and R. H.				0.691*	0.263	0.699*
Coefficient of correlation (r) for population and total rainfall				0.205	-0.190	0.363

*= significant at 5% level of significance

Discussion

Among different sap-sucking pests in cotton, studies conducted on the seasonal incidence revealed that *Amrasca biguttula biguttula*, *Aphis gossypii*, *Bemisia tabaci*, *Thrips tabaci*, and *Phenacoccus solenopsis* were occurring regularly and caused considerable economic damage to the crop under prevailing climatic conditions of Udaipur (Rajasthan).

Jassids (*Amrasca biguttula biguttula* Ishida)

Jassids incidence was observed throughout the cropping season on *Bt* cotton and peak population (30.25 jassids/plant) was reported during the 34th SMW. The pest had a positive non-significant correlation with temperature as well as with total rainfall. While, with relative humidity, the correlation was significantly positive. The results obtained in the present study are in close agreement with the earlier reports of Dhaka and Pareek (2008) [5] who reported the incidence of jassids first from the last week of June (26th SMW) and reached its peak (90 jassids/30 leaves) in August. This finding is in close conformity with the findings of Bishnoi *et al*. (1996) [3] who reported that temperature ranging from 27.0 to 34.0 °C with 52 to 82 percent relative humidity was the most suitable condition for jassids. Whereas, Ramesh Babu and Meghwal (2014) [13] revealed that the temperature, relative humidity and rainy days significant positively correlated with the populations of jassids. The present findings are also in accordance with that of Ramandeep *et al.* (2017) [14] the results revealed that the peak population of jassids (7.05 jassids/plant) was noted in the third week of August.

Aphids (*Aphis gossypii* Glover)

During *Kharif*, 2019 aphid infestation was noticed in the 26th SMW (in June) and continued up to 45th SMW (in November). The pest population increased to the maximum level with a mean of 49.20 aphids/plant during the 40th SMW (in October). After reaching the peak level, the population

declined gradually up to 2.00 aphids/plant in 45th SMW. The population exhibited a positive significant correlation with relative humidity; while with mean temperature and total rainfall the correlation was positively non-significant. Similar results were also reported by Shitole and Patel (2009) [15] who observed that the incidence of aphid was maximum (7.0/3 leaves) during the last week of August *i.e.* 35th SMW on cotton *cv*. Hy-10. Soujanya *et al.* (2010) [17] recorded the peak incidence from 39th SMW to 46th SMW which supported the present investigation. Ramesh Babu and Meghwal (2014) [13] observed that the highest incidence of aphids was observed during the 45-48th (SMW) where the dry conditions have prevailed. Similarly, the peak incidence of aphid (75.40-86.45 aphids/3 leaves) was recorded during 35 and 37th (SMW) by Bhute *et al*., 2012 [2]. Correlation analysis revealed that the rainfall, rainy days, relative humidity had a significant negative correlation with aphids population.

Whiteflies (*Bemisia tabaci* Gennadius)

Bemisia tabaci attacked the crop during the 26th SMW (1.15 whiteflies/plant) and reached to peak (32.40 whiteflies/plant) in the 31st SMW. Thereafter, the population showed a decline gradually and reached 1.20 white flies/plant during the first week of November. The whitefly population exhibited a positively non-significant correlation with mean temperature as well as with total rainfall; while, with relative humidity, the correlation was significantly positive. The present findings are in close conformity with the findings of Purohit *et al.* (2006) [12] who reported that whitefly appearance during the first week of July and its peak in the second week of August (12/3 leaves) in cotton cultivar GH-8.

Thrips (*Thrips tabaci* Linnman)

Thrips were first noticed in the 26th SMW (1.20 thrips/plant) that increased gradually and reached the peak (41.60 thrips/plant) in the 36th SMW. Thereafter, the population decreased gradually and reached a minimum level of 2.40 thrips/plant in the 45th SMW. The population exhibited a positive correlation with mean temperature, relative humidity as well as with the total rainfall. The results obtained in the present investigation are similar to the results of Gupta *et al.*, (1997), who reported maximum numbers of thrips (*T. tabaci*) on cotton cultivars H-4, H-6, JKH- 1, DCH-32 and AHH-468 during the second fortnight of August. The major activity of thrips was during the 35th to 40th SMW and reached its peak level (110.10 thrips/3 leaves) during 40th SMW and it exhibited a positive correlation with atmospheric temperature and relative humidity (Prasad *et al.* 2010; Sitaramaraju *et al.* 2010, Soujanya *et al.* 2010 and Bhute *et al.* 2012) [16, 17, 2].

Mealybugs (*Phenacoccus solenopsis* Tinsley)

The incidence of mealybugs was started from 29th SMW (3.00 mealybugs/10 cm twig). The maximum population of mealybugs (26.00 mealybugs/10 cm twig) was noticed during the 37th SMW. Thereafter, the population declined gradually and reached a minimum number of 1.62 mealy bugs/10 cm twig. The pest showed positive but non-significant correlation with temperature and total rainfall while the positively significant correlation with relative humidity. The results obtained in the present investigation are in close agreement with the earlier reports of Boda and Ilyas (2017) [4] they recorded the mealy bug infestation on *Bt* cotton during 33rd SMW with peak population (12.40 mealy bugs/3 shoots) and the infestation continued up to 50th SMW. Hanchinal *et al.* (2009) [7] reported the mealybug infestation appearance in September and gradually increased as crop growth advanced. The Population was 0.50 /10cm apical shoot in the38th meteorological week and progressively increased throughout the season. Ramesh Babu and Meghwal (2014) [13] observed that the peak incidence of mealy bug (42.40 mealy bugs/2.5 cm shoot length) in 49 to 51st SMW. Maximum and minimum temperatures showed a significant positive correlation with the mealybug population.

Conclusion

Based on the experimentation, it could be concluded that among different sap-sucking pests of cotton *Amrasca biguttula biguttula*, *Aphis gossypii*, *Bemisia tabaci*, *Thrips tabaci*, and *Phenacoccus solenopsis* were occurring regularly and caused considerable economic damage under favourable climatic conditions.

References

1. 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, Department of Entomology, University Agriculture, Faisalabad; c1992. p. 430.
2. Bhute NK, Bhosle BB, Bhede BV, More DG. Seasonal incidence of major sucking insect pests of Bt cotton and their natural enemies in Marathwada region. Journal of Cotton Research and Development. 2012;26:238-242.
3. Bishnoi OP, Singh M, Rao VUM, Nivas R, Sharma PD. Population dynamics of cotton pests in relation to weather parameters. Indian Journal of Entomology. 1996;58:103-107.
4. Boda V, Ilyas M. Population dynamics of sucking Pests of Bt cotton and their correlation with abiotic factors. Bulletin of Environment, Pharmacology and Life Sciences. 2017;6:167-171.
5. Dhaka SR, Pareek BL. Weather factors influencing population dynamics of major insect pests of cotton under semi-arid agro-ecosystem. Indian Journal of Entomology. 2008;70:157-163.
6. Gupta MP, Sharma S, Shrivastava SK. Population buildup of some sap-sucking insect on cotton in M.P. Journal of Insect Science. 1997;10:53-56.
7. Hanchinal SG, Patil BV, Bheemanna M, Hosamani AC, Sharanabasappa. Incidence of mealy bug on cotton in Tungbhadra project area In: Proc. Dr. Leslie C. ColemanMemorial Nation. Ssymp. Pl. Prot. Dec 4-6, 2008, Univ. of Agric. Sci. GKVK, Bangalore; c2009.
8. Jhala RC, Bharpoda TM. Occurrence in Gujrat and suggestion for action plan to combat the menace of mealy bug on cotton. Department of Agriculture and cooperation, Ministry of Agriculture; c2008. p. 1-8.
9. Khan WS, Khan AG. An overview; Presented at national seminar on strategies for increasing cotton production. Agri. House, 21- Agha Khan-III Road, Lahore; c1995 April 6-7.
10. Krishna VV, Qaim M. Btcotton and sustainability of pesticide reductions in India. Agriculture Systems. 2012;107:47-55.
11. Mayee CD, Rao MRK. Likely impact of Bt cotton cultivation on production and utilization in India. National Seminar on Bt cotton in India at UAS, Dharward; c2002.
12. Purohit D, Ameta DP, Sarangdevot SS. Seasonal

incidence of major insect pests of cotton and their natural enemies. Pestology. 2006;30:24-29.
13. Babu RS, Meghwal ML. Population dynamics and monitoring of sucking pests and bollworms on Bt. Cotton in humid zone of southern Rajasthan. The Bioscan. 2014;9:629-632.
14. Ramandeep S, Dangi NL, Swaminathan R, Mahla MK. Seasonal incidence of major sucking insect pests and their natural enemies in farms caped cotton. Indian Journal of Applied Entomology. 2017;31:104-111.
15. Shitole TD, Patel IS. Seasonal incidence of sucking pests and their correlation with weather parameters in cotton crop. Pestology. 2009;33:38-40.
16. Sitaramaraju S, Prasad NVVSD, Krishnaiah PV. Seasonal incidence of sucking insect pests on Btcotton in relation to weather parameters. Annals of Plant Protection Science. 2010;18:49-52.
17. Soujanya PL, Prasad NVVSD, Krishnaiah PV. Population dynamics of sucking pests and their relation to weather parameters in Bt, stacked Bt and non Bt hybrids. Trends in Biosciences. 2010;29:2035-2039.