



SEASONAL INCIDENCE OF MAJOR SAP SUCKING INSECT PESTS AND THEIR NATURAL ENEMIES IN FARMSCAPED COTTON

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ABSTRACT

During the crop season, in sole cotton the abiotic factors of the environment, the mean atmospheric temperature happened to show significant positive correlation with the major sap sucking insect pests of cotton except red cotton bug. The total rainfall and sunshine evinced a significant negative and significant positive correlation with the jassids population of cotton during 2016. The mean population of major sap sucking insect pests showed a significant positive correlation with the mean atmospheric temperature except thrips and red cotton bug on cotton cultivated with cowpea farmscaping. When cotton cultivated with marigold farmscaping, the mean population of major sap sucking insect pests showed a significant positive correlation with the mean atmospheric temperature except whiteflies and red cotton bug.

Key words: Insect pests, cotton, farmscaping, sucking pest and seasonal incidence

INTRODUCTION

Cotton (*Gossypium hirsutum* L.), a friendly fiber grown in 111 countries, is an important commercial crop in the Indian subcontinent. India continues to maintain the largest area under cotton and is the second largest producer of cotton next to China with 34 per cent of world's area and 21 per cent of world's production. Cotton is prone to insect pest infestation at all the stages of crop growth and about 1326 pests have been reported to damage the crop (Agrawal, 1978). In India, of the 162 insect pests that are known to infest the crop, only a dozen are major and half of them are key production constraints that cause losses to the extent of 30-80 per cent. The sucking pests and bollworms on an average caused 52.1 per cent loss of seed cotton yield (Dhawan *et al.*, 1988). The cotton crop in the Southern Rajasthan is attacked by large number of insect pest right from sowing to the picking. Of which, the aphids (*Aphis gossypii* Glover), jassids (*Amarsca bigutulla bigutulla* Ishida), whitefly (*Bemisia tabaci* Genna.), thrips (*Thrips tabaci* Lindeman), red Cotton bug (*Dysdercus cingulatus* Fab.), dusky cotton bug (*Oxycarenus laetus* Kirby), leaf roller (*Sylepta derogata* Fab.), semilooper (*Tarache notabilis* Walker and *Anomis flava* Fab.), spotted bollworm (*Earias insulana* Fab.), american bollworm (*Helicoverpa armigera* Hubner) and pink bollworm (*Pectinophora gossypiella* Saund.) and tobacco caterpillar (*Spodoptera litura* Fab.) are important insect pests which cause considerable losses in cotton. More than 50 per cent of the total pesticides consumption in the country is used on cotton crop. This occupies only 5

per cent of the total cultivated area. The indiscriminate and excessive use of insecticides resulted in the development of resistance to insecticides in insects and the resurgence of insect pests (Dhawan, 1998).

The changing cropping pattern, monoculture, intensive cultivation of high yielding varieties, non adoption of summer ploughing, negligence of crop rotation and other cultural practices have aggravated the pest problems and their management has become difficult. At the same time, indiscriminate use of synthetic insecticides has negatively affected the environment, besides, leading to pest resistance to insecticides and pest resurgence. In recent years, bio-ecological pest management, farmscaping in particular, has gained worldwide attention. Various forms of farmscaping have been used to increase the activity of beneficial insects in the form of permanent hedgerows or temporary insectary strips in the vegetable fields (Chaney, 2004). Farmscaping refers to intentionally introducing flowering plants into agricultural ecosystems with a view to increase pollen and nectar resources required by most natural enemies of insect pests. Several species of natural enemies, including aphidophagous hoverflies (Diptera: Syrphidae) and parasitic hymenoptera depend on pollen and nectar for reproductive success and longevity (Jervis, 1986).

MATERIAL AND METHODS

The experiment was conducted in the Department of Entomology, Rajasthan College of Agriculture, MPUAT, Udaipur, during *kharif* 2016.

Preparation of nursery for seedling of marigold:

The seeds of early flowering marigold variety Pusa Narangi were sown in well prepared, raised nursery beds. The usual floriculture operations were followed while raising the seedlings. The nursery was raised in the last week of June, 2016.

The trial was laid out in plots measuring 3.6 m x 4.5 m in Randomized Block Design containing 6 treatments as detailed later with four replications of each; thus in all, there was 24 plots. The row to row and plant to plant spacing for cotton was 90 cm x 90 cm, respectively. Sowing of Orbit variety of cotton was done in the last week of June; while, cowpea, mature seedlings of marigold was sown/ transplanted as the farmscape crop in the last week of July, 2016. The farmscape crops were sown in between two rows of standing cotton crop.

Observations

- The population of leafhoppers, aphids, whiteflies and thrips were recorded from three leaves one each from top, middle and bottom of the canopies at 7 days interval on 5 randomly selected plants in each replicate.
- The observations on natural enemies were recorded on same tagged plants.
- Weekly data on temperature, relative humidity, total rainfall and sunshine hours was recorded and simple correlations were worked out between the pest population and abiotic factors of the environment.
- All the observations were taken during early hours of the day from 7 to 9 am.

Formula for simple correlation:

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

Where,

r_{xy} = Simple correlation coefficient

X = Variable *i.e.* abiotic component

(Average temperature, relative humidity, rainfall and sunshine hours)

Y = Variable *i.e.* mean number of pest population

n = Number of paired observations

The correlation coefficient (r) values were subjected to the test of significance using t-test:

$$t = \frac{r}{\sqrt{1-r^2}} \times \sqrt{n-2} \sim t_{n-2} \text{ d. f.}$$

The calculated t-value obtained were compared with tabulated t-value at 1% and 5% level of significance.

Sole cotton

From the Table 1, it can be observed that on sole cotton, the incidence of major sap sucking insect pests (aphid, thrips, whiteflies and jassids) were noted in the first week of August, while infestation of red cotton bug and dusky cotton bug was observed in third week of August and last week of October, respectively. The peak population for aphid (111.70), thrips (20.00) and whiteflies (8.00) mean per plant reached in the last week of September; whereas, the peak population of jassids (7.05), red cotton bug (16.00) and ducky cotton bug (8.30) was noted in the third week of August, last week of October and first week of November respectively. Among the abiotic factors of the environment, the mean atmospheric temperature happened to show significant positive correlation with the major sap sucking insect pests of cotton except red cotton bug. The coefficient of correlation values computed were as follows: aphid ($r=0.659$), thrips ($r=0.669$), whiteflies ($r=0.607$), jassids ($r=0.626$) and ducky cotton bug ($r=0.994$). The total rainfall ($r=-0.582$) and sunshine ($r=0.640$) evinced a significant negative and significant positive correlation with the jassids population of cotton during 2016.

The occurrence of associated natural enemies (spiders and coccinellids) was noted in the first week of August that continued up to first week of November. The peak population of spiders (8.00) and coccinellids (6.00) was noted in the first week of October and last week of September, respectively. Among the abiotic factors of the environment, the mean atmospheric temperature happened to show significant positive correlation with the population of spiders ($r=0.677$) and coccinellids ($r=0.749$), but was non-significant with relative humidity, rainfall and sunshine. The mean population of coccinellids ($r= 0.818$) showed significant positive correlation with aphid population, whereas, mean population of spiders was non-significant with red cotton bug population.

Cotton + Cowpea

The results in Table 2 show that the incidence of major sap sucking insect pests on cotton, cultivated with cowpea farmscaping, was observed as follows: aphid, thrips, whiteflies and jassids in the first week of August, while the population of red cotton bug and ducky cotton bug was observed in third week of September and last week of October respectively. The peak population of aphid (90.40), thrips (21.30), whiteflies (4.00), jassids (5.90), red cotton bug (12.20) and ducky cotton bug

(6.45) reached in the last week of September, third week of August, second week of September, third week of September, last week of October and first week of November respectively. The mean population of major sap sucking insect pests showed a significant positive correlation with the mean atmospheric temperature except thrips and red cotton bug. The correlation coefficient values computed for the pests were as follows: aphid ($r=0.704$), whiteflies ($r=0.566$), jassids ($r=0.614$) and dusky cotton bug ($r=0.996$). The total rainfall evinced a significant negative correlation with the jassids ($r=-0.676$) population on cotton cultivated with cowpea farmscaping during 2016.

The data have been presented in Table (2) indicating that occurrence of associated natural enemies (spiders and coccinellids) was noted in the first week of August that continued up to first week of November. The peak population of spiders (2.10) and coccinellids (5.95) was noted in the first week of September and third week of September respectively, in cotton cultivated under cowpea farmscaping. Among the abiotic factors of the environment, the mean atmospheric temperature happened to show significant positive correlation with the population of spiders ($r=0.554$) and the coccinellids ($r=0.536$), but was non-significant with relative humidity, total rainfall and sunshine. The mean population of spiders ($r=-0.718$) showed significant negative correlation with red cotton bug population under cowpea farmscaping whereas, mean population of coccinellids was non-significant with aphid population.

Cotton + Marigold

The incidence of major sap sucking insect pests on cotton, cultivated with marigold farmscaping (Table 3), was observed as follows: aphid, thrips, whiteflies and jassids in the first week of August, while the population of red cotton bug in third week of September and ducky cotton bug was observed in last week of October. The peak population of aphid (95.90) and thrips (25.00) reached in the last week of September. While, the peak population of whiteflies (5.25), jassids (6.00), red cotton bug (12.25) and ducky cotton bug (6.35) reached in the third week of August, third week of September, last week of October and first week of November respectively. The mean population of major sap sucking insect pests showed a significant positive correlation with the mean atmospheric temperature except whiteflies and red cotton bug. The correlation coefficient values computed for the pests were as follows: aphid ($r=0.695$), thrips ($r=0.618$), jassids ($r=0.592$) and dusky cotton bug ($r=0.984$) population on cotton cultivated with marigold farmscaping during 2016.

Occurrence of associated natural enemies (spiders and coccinellids) was noted in the first week of August

that continued up to first week of November. The peak population of spiders (2.25) and coccinellids (5.00) was noted in the second week of September in cotton cultivated under marigold farmscaping. Among the abiotic factors of the environment, the mean relative humidity showed a significant positive correlation with the population of coccinellids ($r=0.591$), but was non-significant with mean atmospheric temperature, total rainfall and sunshine. The mean population of spiders and coccinellids was shown non-significant with red cotton bug and aphid population under marigold farmscaping.

The abundance of the resulting pest populations naturally varied strongly between one particular case and the next. These populations were influenced by a variety of factors, amongst which were those which affected the behaviors of the pests and their natural enemies (Gurr *et al.*, 2004; Irwin *et al.*, 2000). In intercropping, the modification of the microenvironment and differences in the nutrient uptake by the intercrops may influence plant infestation and the development and movement of insect pests (Rao and Reddy, 1999; Choudhary and Laroia, 2001). Lower aphid population was noted on cotton + cowpea (Vieira and Santos, 1983; Natarajan and Sheshadri, 1988) than sole cotton. Balasubramanyam *et al.*, (1998) who reported that intercropping system had low infestation of sucking pests such as whiteflies, leafhoppers, aphids and thrips over sole cotton. Simwat (1994) also opined that there was a decrease in sucking pests when cotton intercropped with cowpea, black gram and greengram.

The present findings are in accordance with that of Kataria *et al.*, 2017 the results revealed that peak population of whitefly was recorded in last fortnight of September in 2013 (98.60 whitefly adult per 3 leaves), 2014(101.00 whitefly adult per 3 leaves) and 2016 (38.42 whitefly adult per 3 leaves) whereas it shifted towards early season *i.e.* from July to August during 2015 (Range=28.00-123.60 whitefly adults per 3 leaves). Leaf hopper peak infestation was observed in first fortnight of July during 2015 (4.20 leafhopper per 3 leaves) and 2016 (4.60 leafhopper per 3 leaves). Simple correlations studies revealed that during 2013 and 2014, the whitefly population was negatively correlated with temperature, relative humidity and rainfall. During 2015, population of whitefly showed a significant positive correlation with minimum temperature ($r=0.657$) and evening humidity ($r=0.833$) whereas during 2016, it was negatively correlated with rainfall and non-significant positive correlation with all other factors. Leaf hopper had a non-significant positive correlation with all the three weather variables during 2015 whereas negative correlation with temperature during 2016 and positive correlation with all other weather variables. Phulse and

Table 1. Linear relationship between population abundance of major sap sucking insect pests and their natural enemies in sole cotton during *kharif*, 2016

Date of observation	Mean/plant											
	Mean Atm. Temp (°C)	Mean RH (%)	Total rainfall (mm)	Sunshine (hrs.)	Aphid	Thrips	Whitefly	Jassids	RCB	DCB	Spiders	Coccinellids
06 Aug.	25.59	87.50	124.20	3.50	3.25	1.50	0.30	3.00	-	-	0.30	1.20
13 Aug.	25.14	92.00	104.50	3.60	8.85	5.15	1.50	1.00	-	-	0.50	1.80
20Aug.	26.53	74.57	0.60	44.30	12.05	6.20	3.60	7.05	-	-	1.10	2.00
27 Aug.	25.40	85.00	61.20	8.30	17.55	1.15	1.50	1.50	-	-	1.65	2.30
03 Sept.	26.99	80.29	14.40	27.30	41.90	5.60	2.25	2.30	-	-	1.75	3.25
10 Sept.	26.05	68.21	0.00	51.60	91.15	10.60	5.90	4.75	0.00	-	1.90	3.40
17 Sept.	26.76	63.71	0.00	56.70	106.20	15.00	4.35	6.00	8.50	-	1.45	3.30
24 Sept.	28.93	64.57	3.40	40.00	111.70	20.00	8.00	5.70	10.55	-	6.00	6.00
01Oct.	28.67	58.36	0.00	56.50	78.55	8.00	2.50	6.25	9.60	-	8.00	4.00
08 Oct.	28.04	73.21	50.00	23.10	40.65	6.25	2.00	3.95	10.90	-	0.30	1.15
15 Oct.	25.80	64.50	12.40	56.50	29.05	0.55	1.50	4.25	11.90	0.00	0.20	0.70
22 Oct.	25.44	51.86	0.00	52.60	23.75	0.25	0.50	1.55	13.10	0.00	0.30	0.20
29 Oct.	23.24	54.64	0.00	61.60	11.35	-	0.30	-	16.00	6.00	0.10	0.15
05 Nove.	21.96	51.86	0.00	57.60	6.90	-	-	-	10.55	8.30	0.05	0.10
Seasonal mean	26.04	69.31	26.48	38.80	41.64	6.69	2.63	3.94	10.12	3.58	1.69	2.11
Coefficient of correlation (r) b/w insect pests & NE's and mean Atm. Temp.			0.659*	0.669*	0.607*	0.626*	-0.245	-0.994*	0.677*	0.749*		
Coefficient of correlation (r) b/w insect pests & NE's and mean RH			-0.256	-0.266	-0.136	-0.462	-0.487	-0.504	-0.161	0.150		
Coefficient of correlation (r) b/w insect pests & NE's and Total Rainfall			-0.454	-0.411	-0.428	-0.582*	0.108	-0.563	-0.284	-0.180		
Coefficient of correlation (r) b/w insect pests & NE's and sunshine			0.352	0.327	0.252	0.640*	0.084	0.670	0.170	-0.040		
Coefficient of correlation (r) b/w aphid and coccinellids												0.818*
Coefficient of correlation (r) b/w RCB and Spiders												-0.206

* Significant at 5% level of significance, Legend: RCB = Red Cotton Bug, DCB=Dusky Cotton Bug

Table 2. Linear relationship between population abundance of major sap sucking insect pests and their natural enemies in cotton + cowpea during *kharif*, 2016

Date of observation	Mean/plant											
	Mean Atm. Temp (°C)	Mean RH (%)	Total rainfall (mm)	Sunshine (hrs.)	Aphid	Thrips	Whitefly	Jassids	RCB	DCB	Spiders	Coccinellids
06 Aug.	25.59	87.50	124.20	3.50	1.75	1.30	0.50	1.50	-	-	0.60	2.85
13 Aug.	25.14	92.00	104.50	3.60	6.45	13.65	1.25	1.00	-	-	0.80	3.20
20 Aug.	26.53	74.57	0.60	44.30	9.75	21.30	2.50	5.00	-	-	1.70	4.00
27 Aug.	25.40	85.00	61.20	8.30	12.20	15.25	0.75	3.50	-	-	2.05	4.25
03 Sept.	26.99	80.29	14.40	27.30	25.85	11.25	2.00	3.70	-	-	2.10	5.00
10 Sept.	26.05	68.21	0.00	51.60	51.55	11.35	4.00	5.00	0.00	-	2.00	5.00
17 Sept.	26.76	63.71	0.00	56.70	63.15	8.80	3.25	5.90	5.10	-	2.05	5.95
24 Sept.	28.93	64.57	3.40	40.00	90.40	7.85	3.20	5.10	8.20	-	2.00	4.00
01 Oct.	28.67	58.36	0.00	56.50	55.65	2.95	1.80	4.90	8.00	-	1.05	2.80
08 Oct.	28.04	73.21	50.00	23.10	29.85	0.70	1.65	3.50	8.85	-	0.80	2.10
15 Oct.	25.80	64.50	12.40	56.50	15.55	0.30	1.10	3.30	8.40	0.00	0.60	1.90
22 Oct.	25.44	51.86	0.00	52.60	14.70	0.25	0.35	1.10	9.55	0.00	0.40	1.10
29 Oct.	23.24	54.64	0.00	61.60	8.90	-	0.20	-	12.20	4.40	0.30	0.75
05 Nove.	21.96	51.86	0.00	57.60	5.40	-	-	-	8.35	6.45	0.15	0.35
Seasonal mean	26.04	69.31	26.48	38.80	27.94	7.91	1.73	3.63	7.63	2.71	1.19	3.09
Coefficient of correlation (r) b/w insect pests & NE's and mean Atm. Temp.					0.704*	-0.178	0.566*	0.614*	-0.217	-0.996*	0.554*	0.536*
Coefficient of correlation (r) b/w insect pests & NE's and mean RH					-0.255	0.448	-0.060	-0.363	-0.475	-0.507	0.346	0.481
Coefficient of correlation (r) b/w insect pests & NE's and Total Rainfall					-0.430	-0.051	-0.425	-0.676*	0.162	-0.558	-0.170	0.021
Coefficient of correlation (r) b/w insect pests & NE's and sunshine					0.305	-0.193	0.276	0.568	0.010	0.647	-0.143	-0.239
Coefficient of correlation (r) b/w aphid and coccinellids								0.5109				
Coefficient of correlation (r) b/w RCB and Spiders								-0.718*				

*Significant at 5% level of significance, Legend: RCB = Red Cotton Bug, DCB=Dusky Cotton Bug

Table 3. Linear relationship between population abundance of major sap sucking insect pests and their natural enemies in cotton + marigold during *khariif*, 2016

Date of observation	Mean/plant											
	Mean Atm. Temp (°C)	Mean RH (%)	Total rainfall (mm)	Sunshine (hrs.)	Aphid	Thrips	Whitefly	Jassids	RCB	DCB	Spiders	Coccinellids
06 Aug.	25.59	87.50	124.20	3.50	2.25	1.25	0.50	1.50	-	-	0.50	2.55
13 Aug.	25.14	92.00	104.50	3.60	6.85	14.05	0.75	2.00	-	-	0.65	3.00
20 Aug.	26.53	74.57	0.60	44.30	9.95	15.00	5.25	3.75	-	-	1.20	3.10
27 Aug.	25.40	85.00	61.20	8.30	13.25	9.00	1.75	2.75	-	-	0.75	3.80
03 Sept.	26.99	80.29	14.40	27.30	30.50	16.00	3.75	2.60	-	-	1.25	4.05
10 Sept.	26.05	68.21	0.00	51.60	64.10	11.20	4.40	5.85	0.00	-	2.25	5.00
17 Sept.	26.76	63.71	0.00	56.70	74.00	15.00	3.55	6.00	5.15	-	1.55	4.35
24 Sept.	28.93	64.57	3.40	40.00	95.90	25.00	3.45	5.20	8.25	-	0.90	2.65
01 Oct.	28.67	58.36	0.00	56.50	61.35	14.00	2.20	4.95	8.50	-	0.75	1.85
08 Oct.	28.04	73.21	50.00	23.10	34.55	8.00	1.75	3.80	9.05	-	0.50	1.65
15 Oct.	25.80	64.50	12.40	56.50	18.70	4.00	1.00	3.35	8.40	0.00	0.40	1.20
22 Oct.	25.44	51.86	0.00	52.60	15.35	0.05	0.40	1.15	9.95	0.00	0.35	0.25
29 Oct.	23.24	54.64	0.00	61.60	9.15	-	0.25	-	12.25	5.25	0.25	0.40
05 Nove.	21.96	51.86	0.00	57.60	5.50	-	-	-	9.10	6.35	0.10	0.20
Seasonal mean	26.04	69.31	26.48	38.80	31.53	11.05	2.23	3.58	7.85	2.90	0.81	2.43
Coefficient of correlation (r) b/w insect pests & NE's and mean Atm. Temp.					0.695*	0.618*	0.500	0.592*	-0.237	-0.984*	0.402	0.406
Coefficient of correlation (r) b/w insect pests & NE's and mean RH					-0.245	0.027	0.038	-0.405	-0.511	-0.495	0.206	0.591*
Coefficient of correlation (r) b/w insect pests & NE's and Total Rainfall					-0.433	-0.334	-0.472	-0.588*	0.148	-0.572	-0.233	0.149
Coefficient of correlation (r) b/w insect pests & NE's and sunshine					0.314	0.109	0.217	0.579*	0.021	0.722	0.070	-0.346
Coefficient of correlation (r) b/w aphid and coccinellids									0.416			
Coefficient of correlation (r) b/w RCB and Spiders									-0.567			

* Significant at 5% level of significance. Legend: RCB = Red Cotton Bug, DCB=Dusky Cotton Bug

Udikeri (2014) recorded highest incidence of thrips, leafhoppers and whiteflies was recorded on MRC 7918 BG-II (17.3, 5.7 and 0.31/ 3 leaves respectively) followed by MRC 6918 non-Bt, RCH-2 BG-II and RCH-2 non Bt .The lowest incidence was noticed on DDhC-11. In contrast to above pests the highest incidence of aphids was recorded on DDhC-11 (23.4/ 3 leaves) followed by 20.9 on MRC-7918BG-II.The lowest of 17.8 aphids / 3 leaves was recorded on RCH-2 Non-Bt. The highest seasonal mean of predatory coccinellids recorded was 2.6/plant on RCH-2 non Bt followed by RCH-2 Bt (1.6/plant). In MRC-7918, MRC-6918 non-Bt and DDhC-11, the mean seasonal abundance was 1.5/pl. The highest seasonal abundance of spider was on MRC-7918 BG-II (1.1/plant) followed by MRC 6918 Non- Bt, RCH-2 BG-II, RCH-2 non-Bt and DDhC-11 with 0.9/plant. The *Bt cry* toxins either as single gene or as stacked format could not influence the sucking pest incidence and their predators. Roomi *et al.* (2016) the incidence of sucking insect pests on seven varieties of genetically /non genetically modified cotton. Sucking insect pests (whitefly, leafhopper and thrips) remained active throughout the crop season with little differences among them. Whitefly was active from 24th to 41st standard meteorological weeks (SMW *i.e.* June to October, 2014) while leafhopper from 25th to 41st and thrips from 25th to 40th (SMW). Whitefly and leafhoppers population were negatively correlated with maximum temperature, minimum temperature, average wind speed and rainfall and positively correlated with RH morning, RH evening and sunshine hours. While thrips population showed positive correlation with temperature and negative with sunshine hours.

Among sucking insect pests, the incidence of a leafhopper [*Amrasca biguttula biguttula* (Ishida)] and a whitefly [*Bemisia tabaci* (Gennadius)] remained active through the cropping season in varying population density. Thrips [*Thrips tabaci* (Lindemann)] population was only observed in early stages of the crop growth. The leafhopper population attained its peak during 2nd half of July and was maximum (9.2 nymphs/3 leaves) in the year 2008. The population of whitefly adults was maximum (14.8 adults/3 leaves) in 2007 and it acquired its peak during end of July and again in end of September to early October. The incidence of thrips was maximum in June. The population of the *A. biguttula* showed significant positive correlation with minimum temperature ($r=0.636$; $p=0.003$), mean temperature ($r=0.475$; $p=0.034$), evening relative humidity ($r=0.618$; $p=0.004$) and rainfall ($r=0.556$; $p=0.011$). The correlation of *B. tabaci* population with minimum temperature was significantly positive ($r=0.454$; $p=0.044$). The multiple regression analysis revealed that all the weather parameters collectively accounted for

variability in the *A. biguttula* and *B. tabaci* population with R_2 values ranging from 0.67–0.80 and 0.50–0.69, respectively, during different years (Shera *et al.*, 2013).

The occurrence of associated natural enemies in sole cotton (spiders and coccinellids) was noted in the first week of August that continued up to first week of November. The peak population of spiders and coccinellids was noted in the first week of October and last week of September, respectively. Among the abiotic factors of the environment, the mean atmospheric temperature happened to show significant positive correlation with the population of spiders and coccinellids. The mean population of coccinellids showed significant positive correlation with aphid population. The peak population of spiders and coccinellids was noted in the first week of September and third week of September respectively, in cotton cultivated under cowpea farmscaping. Among the abiotic factors of the environment, the mean atmospheric temperature happened to show significant positive correlation with the population of spiders and the coccinellids. The mean population of spiders showed significant negative correlation with red cotton bug population under cowpea farmscaping. The peak population of spiders and coccinellids was noted in the second week of September in cotton cultivated under marigold farmscaping. Among the abiotic factors of the environment, the mean relative humidity showed a significant positive correlation with the population of coccinellids. Earlier workers reported that the three major predatory insects were recorded *viz.* ladybird beetle, *Coccinella septempunctata* (Linnaeus); green lacewing, *Chrysopa* spp. (Stephens) and spider, *Dictyna* sp. (Linnaeus) under unprotected condition. Densities of natural enemies peaked from 37th to 46th meteorological week. The highest density of 2.60 *C. septempunctata* per plant on 41st MW, 1.30 *Chrysopa* spp. per plant in 43rd MW and 1.20 *Dictyna* sp. per plant in 45th MW were recorded. The natural enemies completely disappeared after mid-November. Simple correlation analysis revealed that maximum temperature showed significant positive effect on all the predatory insects. The minimum temperature showed negative effect on spider population and non significant effect on ladybird beetle and green lacewing bug population.

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