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# PEST SUCCESSION AND SEASONAL INCIDENCE OF INSECT PESTS IN OKRA *VIS-A-VIS* WEATHER PARAMETERS

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**Abstract:** *Regular monitoring of the local insect pests and their natural enemies under field conditions is pertinent for timely forecast and prevention of any outbreak of epidemics and for suggesting the suitable pest management programme. The interaction between pests and climatic factors help in developing the models for early predictions that help in forecast of pest incidence in any area. Ten and eight insect pests consistently attacked the okra crop in the Aligarh region during 2013 and 2014 cropping seasons, respectively. The arrival of major and minor insect pests at Aligarh varied on the crop. In case of Earias vitella it was last week of May and 2$^{nd}$ June in 2013 and 2014, respectively. For Dysdercus cingulatus it was first week of August (2013) and last week of July (2014). On the contrary, for Mylabris pustulata it was 10$^{th}$ June 2013 and 16$^{th}$ June 2014 and for Phenacoccus solenopsis it was 1$^{st}$ July and 16$^{th}$ June in 2013 and 2014, respectively. All the four insect pests responded differently towards the abiotic factors (temperature, humidity, rainfall) studied in both years. E. vitella showed significant positive correlation with minimum temperature during the year 2014 only while it had non-significant positive correlation in 2013. While in case of D. cingulatus, P. solenopsis and M. pustulata minimum temperature had no effect. On the contrary, maximum temperature had adverse effect on all the four insect pests during both the years except E. vitella where maximum temperature had non-significant (2013) and negatively non-significant (2014) effect. Rainfall also had negatively non-significant role in D. cingulatus (2013) and significantly positive role in M. pustulata in 2014. On the contrary, relative humidity played significant positive role in the studied insects in both years except the D. cingulatus in 2013.*

**Keywords:** *Abiotic factors; Correlation; Pest succession; Population dynamics*

**Introduction:** India is the second largest producer of vegetables next to China accounting for about 10 per cent of the total production. Among the vegetable crops, Okra (*Abelmoschus esculentus* L. Moench) is an economically important vegetable grown especially in tropical and sub-tropical regions. It has occupied a prominent position in India among the export oriented vegetables because of its high nutritive value, palatability and good post harvest life. It has enormous potential as one of the foreign exchange earner crops and accounts for a major share in the production globally [1].

Insect pest infestation is one of the most limiting factors for accelerating the yield potential of many vegetables including okra.Various pests have been reported [2-5] to attack this crop at different stages of growth. While identified nine insect species as serious pests of this crop worldwide [6]. On the contrary [7] okra crop is ravaged by as many as 45 species of insect pests throughout its growth period. Among these, cotton jassid, *Amrasca devastans*; red cotton bug, *Dysdercus cingulatus* and shoot and fruit borer, *Earias vitella* are quite serious and major restraining factors in its cultivation. These infest the crop throughout vegetative as well as reproductive period causing significant reduction in yield [8]. Besides these, other important pests recorded on okra at various stages of growth include cotton aphid, *Aphis gossypii* [9]; whitefly, *Bemisia tabaci* [10]; mite, *Tetranychus telarius* [11]; blister beetle, *Mylabris pustulata* [12] and leafroller, *Syllepta derogata* [13].

Forecasting pest incidence requires systematically collected field and lab data over a long period of time. However, going through the sudden changes in environmental factors specially the temperature, rainfall, humidity and also keeping the topography in mind, it has become desirable to make short term quantitative studies to predict timely forecasting because of better weather predictions available since the infestation of a pest within a season is primarily influenced by the changes in these factors. It is well established that environmental variability and unpredictable resources are of paramount importance in insect population dynamics [14-19].

The interaction between pests and climatic factors help in developing the models for early predictions that help in forecast of pest incidence in any area. The pest incidence and damage varies from year to year in addition to its crop and location specific nature due to variation in prevailing environmental conditions. Therefore, regular monitoring of the local insect pests and their natural enemies under field conditions is pertinent for timely forecast and prevention of any outbreak of epidemics and for suggesting the suitable pest management programme. Keeping in view the above facts, present studies to study pest succession and seasonal incidence of insect pests in okra *vis-a-vis* weather parameters.

## Materials and Methods

**1.1. Pest Succession:** Weekly observations on the sequence of appearance and population build up of different insect pests were recorded on 50 randomly selected plants in each plot in the expeimental field of Faculty of Agricultural Sciences, Aligarh Muslim University, Aligarh. Observations on insect population were recorded from 15 days after sowing. The species were identified from the collection of Department of Plant Protection, Aligarh Muslim University, Aligarh.

**1.2. Studies on Seasonal Incidence of Insect Pests in Relation to Weather Parameters:** The experiment was laid down in Randomized Block Design. All the recommended agronomic practices were followed to raise the crop, except plant protection measures which enabled the build-up of pests and their natural enemies in pesticide free environment. Population dynamics of various insect pests was recorded during the summer season of 2013 and 2014.

**1.2.1. Shoot and Fruit Borer, *E. vitella*:** The shoot and fruit borer larval density was recorded by counting all the larvae in 5 randomly selected fruits/plot. The observation was carried out at weekly intervals. Larvae were either present inside the fruit or crawled on the fruits.

**1.2.2. Cotton Mealybug, *P. solenopsis*:** Nymphs and adults of this pest were recorded on 10 cm apical shoot length at weekly interval from 30 randomly selected plants.

**1.2.3. Red Cotton Bug, *D. cingulatus*:** Abundance of this sucking pest was estimated once a week by direct counting of nymphs and adults on 30 randomly selected plants.

**1.2.4. Blister Beetle, *M. pustulata*:** Weekly records on the number of adults per plant on 30 randomly selected plants were made.

1.3. **Statistical Analysis:** The weekly mean data on the pest population and weather parameters were subjected to Pearson´s Correlation analysis by using the language programme "SPSS 13.0" unless stated otherwise.

## Results and Discussion

**2.1. Pest Succession in Okra:** Ten and eight insect pests consistently attacked the okra crop in the Aligarh region during 2013 and 2014 cropping seasons, respectively (Table 1 and 2). These were grouped as major, minor and occasional, based on their abundance. Those insects which occurred in good number for considerable period of time and hence found to be causing appreciable damage were designated as major pests while those which appeared for a short period of time in fairly low number were considered as minor and those casually recorded were designated as occasional pests. The insect pests attacked leaves, stems, shoots, flowers and pods. Some of the species damaged the crop through biting and chewing activities while others injured the crop by piercing and sucking sap from the attacked parts.

**Table 1: Insect pest complex of okra during 2013 cropping season**

| Common name | Scientific name | Family | Order | Crop growth stage | Abundance |
|---|---|---|---|---|---|
| Shoot and fruit borer | *Earias vitella* | Noctuidae | Lepidoptera | Fruiting | Major |
| Cotton mealybug | *Phenacoccus solenopsis* | Pseudococcidae | Hemiptera | Flowering- initiation fruiting | Major |
| Blister beetle | *Mylabris pustulata* | Meloidae | Coleoptera | Flowering- initiation fruiting | Major |
| Red cotton bug | *Dysdercus cingulatus* | Pyrrhocoridae | Hemiptera | Peak vegetative | Minor |
| Cotton aphid | *Aphis gossypii* | Aphididae | Hemiptera | Fruiting | Occasional |
| Cotton jassid | *Amrasca biguttula biguttula* | Cicadellidae | Hemiptera | Fruiting | Occasional |
| Wolf spider | *Lycosa* spp. | Lycosidae | Araneae | Fruiting | Occasional |
| Ants | Unknownspp. | - | Hymenoptera | Flowering-initiation fruiting | Occasional |
| Tobacco caterpillar | *Spodoptera litura* | Noctuidae | Lepidoptera | Fruiting | Occasional |
| Serpentine leaf miner | *Liriomyza trifolii* | Agromyzidae | Diptera | Peak vegetative | Occasional |

Insects falling under major category included shoot and fruit borer, *E. vitella* (Fabricius); Cotton mealy bug, *P. solenopsis* (Tinsley) and blister beetle, *M. pustulata* (Thunbergo). Those falling under minor category included red cotton bug, *D. cingulatus* (Fabricius). Cotton aphid, *A. gossypii* (Glover); cotton jassid, *A. biguttula biguttula* (Ishida); spider, *Lycosa* spp. (Latreille); ants, Unknown spp.; Tobbacco caterpillar, *S. litura* (Fabricius) and serpentine leaf miner, *Liriomyza trifolii* (Burgess) were occasional pests. Spiders were found predatory on *E. vitella* while ants were found in the field during peak time of mealybug infestation.

**Table 2: Insect pest complex of okra during 2014 cropping season**

| Common name | Scientific name | Family | Order | Crop growth stage | Abundance |
|---|---|---|---|---|---|
| Shoot and fruit borer | *Earias vitella* | Noctuidae | Lepidoptera | Fruiting | Major |
| Cotton mealybug | *Phenacoccus solenopsis* | Pseudococcidae | Hemiptera | Flowering- initiation fruiting | Major |
| Blister beetle | *Mylabris pustulata* | Meloidae | Coleoptera | Flowering- initiation fruiting | Major |
| Red cotton bug | *Dysdercus cingulatus* | Pyrrhocoridae | Hemiptera | Peak vegetative | Minor |
| Cotton aphid | *Aphis gossypii* | Aphididae | Hemiptera | Fruiting | Occasional |
| Cotton jassid | *Amrasca biguttula biguttula* | Cicadellidae | Hemiptera | Fruiting | Occasional |
| Wolf spider | *Lycosa* spp. | Lycosidae | Araneae | Fruiting | Occasional |
| Ants | Unknownspp. | - | Hymenoptera | Flowering-initiation fruting | Occasional |

**2.2. Shoot and Fruit Borer, *E. vitella*:** Data on the population build up of shoot and fruit borer larvae in the year 2013 is presented in table 3. The incidence of the pest commenced on 27$^{th}$ May. Later it increased and attained the peak on 8$^{th}$July with the peak population of 0.78 larvae per five picked fruits/plot. The corresponding means of maximum temperature, minimum temperature and humidity at the maximum population of the pest recorded were 33.50$^{o}$C, 27.02$^{o}$C and 75.35%, respectively with 1.80 mm rainfall. Subsequently the population started to decline and remained on crop till 12$^{th}$ August. Maximum infestation of the pest was recorded in July whereas later half of August and September remained pest free.

**Table 3: Population of shoot and fruit borer, *E. vitella* in okra during cropping season of 2013 under different weather factors**

| Date | Maximum temperature (°C) | Minimum temperature (°C) | Humidity (%) | Rainfall (mm) | Number of larvae /5 picked fruits |
|---|---|---|---|---|---|
| 6-May | 33.94 | 19.90 | 37.00 | 0.00 | 0.00 |
| 13-May | 40.37 | 24.90 | 39.70 | 26.20 | 0.00 |
| 20-May | 40.60 | 25.20 | 29.30 | 0.00 | 0.00 |
| 27-May | 42.77 | 31.20 | 41.30 | 0.00 | 0.10 |
| 3-Jun | 39.60 | 33.14 | 52.78 | 0.00 | 0.26 |
| 10-Jun | 40.70 | 29.70 | 68.20 | 4.40 | 0.34 |
| 17-Jun | 33.17 | 18.90 | 64.85 | 94.60 | 0.46 |
| 24-Jun | 35.48 | 27.40 | 75.78 | 0.00 | 0.62 |
| 1-Jul | 40.60 | 24.90 | 77.50 | 25.20 | 0.67 |
| 8-Jul | 33.50 | 27.02 | 75.35 | 1.80 | 0.78 |
| 15-Jul | 34.11 | 26.30 | 82.50 | 42.20 | 0.72 |
| 22-Jul | 31.40 | 26.28 | 75.40 | 73.20 | 0.61 |

| | | | | | |
|---|---|---|---|---|---|
| 29-Jul | 34.20 | 26.60 | 73.00 | 105.80 | 0.52 |
| 5-Aug | 33.85 | 26.88 | 72.00 | 0.00 | 0.32 |
| 12-Aug | 31.00 | 25.70 | 84.78 | 48.60 | 0.24 |
| 19-Aug | 33.08 | 31.00 | 88.50 | 52.80 | 0.00 |
| 26-Aug | 34.20 | 26.00 | 75.90 | 5.40 | 0.00 |
| 2-Sept | 31.80 | 24.70 | 79.85 | 73.60 | 0.00 |
| 9-Sept | 34.20 | 24.80 | 76.00 | 0.40 | 0.00 |
| 16-Sept | 34.20 | 25.80 | 66.07 | 0.00 | 0.00 |
| 23-Sept | 33.37 | 24.77 | 68.71 | 9.60 | 0.00 |

However, during 2014, the pest population commenced from 9th June, and was delayed upto 20 days during this year (Table 4). Highest population of the pest was noticed in the last week of July with the peak population of 0.72 larvae per five picked fruits/plot. The corresponding means of maximum temperature, minimum temperature and humidity when the maximum population of the pest was recorded were 33.74°C, 30.38°C and 86.28%, respectively with 6.6 mm rainfall. Thereafter, the borer population started to decline and ceased to occur in the second week of September which again differed with earlier observation of 2013 when no incidence of pest was recorded in the month of September. This year also infestation was maximum in the month of July.

**Table 4: Population of shoot and fruit borer, *E. vitella* in okra during cropping season of 2014 under different weather factors**

| Date | Maximum temperature (°C) | Minimum temperature (°C) | Humidity (%) | Rainfall (mm) | Number of larvae /5 picked fruits |
|---|---|---|---|---|---|
| 5-May | 40.40 | 25.32 | 36.00 | 0.00 | 0.00 |
| 12-May | 38.80 | 24.88 | 42.20 | 3.40 | 0.00 |
| 19-May | 37.55 | 23.42 | 43.70 | 0.00 | 0.00 |
| 26-May | 40.40 | 29.42 | 40.07 | 0.00 | 0.00 |
| 2-Jun | 41.30 | 27.60 | 45.50 | 6.20 | 0.00 |
| 9-Jun | 44.90 | 28.90 | 39.64 | 2.20 | 0.18 |
| 16-Jun | 40.80 | 31.08 | 52.20 | 0.00 | 0.24 |
| 23-Jun | 39.80 | 28.68 | 57.14 | 0.00 | 0.42 |
| 30 – Jun | 38.70 | 27.28 | 52.64 | 37.60 | 0.48 |
| 7-Jul | 31.40 | 27.11 | 66.20 | 16.20 | 0.58 |
| 14-Jul | 33.60 | 33.40 | 56.50 | 3.20 | 0.62 |
| 21-Jul | 33.37 | 27.11 | 82.64 | 19.00 | 0.66 |
| 28-Jul | 33.74 | 30.38 | 86.28 | 6.60 | 0.72 |
| 4-Aug | 34.70 | 31.60 | 80.60 | 73.60 | 0.64 |
| 11-Aug | 32.20 | 26.05 | 86.07 | 13.20 | 0.48 |
| 18-Aug | 35.00 | 26.40 | 70.60 | 4.00 | 0.24 |
| 25-Aug | 37.97 | 27.62 | 72.40 | 59.00 | 0.12 |
| 1-Sept | 35.30 | 27.60 | 71.90 | 0.00 | 0.1 |
| 8-Sept | 32.34 | 25.40 | 70.40 | 0.00 | 00.0 |
| 15-Sept | 34.76 | 26.53 | 69.20 | 0.00 | 0.00 |
| 22-Sept | 31.67 | 26.40 | 72.70 | 0.00 | 0.00 |

**2.2.1. Correlation Studies:** Pearson's correlation coefficients were worked out between weather parameters and pest population of the borer for both the cropping seasons. It is evident from the table 11 (a) that the maximum temperature, minimum temperature and rainfall showed a non significant positive correlation with the population in the year 2013 (r = 0.138, r = 0.030 and r = 0.153) whereas during the cropping season of 2014, the maximum temperature showed a negative non significant correlation (r = -0.386), minimum temperature and relative humidity showed a significant positive correlation (r = 0.551, r = 0.529) while rainfall also exhibited a positive non significant correlation (r = 0.405).

**2.3. Cotton mealybug, *P. solenopsis*:** During the year 2013, the pest incidence started in the second week of July and reached its peak in the same week on 8th July with a population of 38.82 bugs/plant as shown in the table 5. The corresponding means of maximum temperature, minimum temperature and humidityat the maximum population of the pest were 33.50°C, 27.02°C and 75.35%, respectively with a total rainfall of 1.80 mm. Beyond that the population showed a decreasing trend. The population increased again in the second week of September and showed another peak on 16th September with a population of 37.06 bugs/plant. The corresponding means of maximum temperature, minimum temperature and humidityat the maximum population of the pest were 34.20°C, 25.80°C and 66.07%, respectively. No rainfall was recorded in this week.

**Table 5: Population of cotton mealybug, *P. solenopsis* in okra during cropping season of 2013 under different weather factors**

| Date | Maximum temperature (°C) | Minimum temperature (°C) | Humidity (%) | Rainfall(mm) | Number of bugs/plant |
|---|---|---|---|---|---|
| 6-May | 33.94 | 19.90 | 37.00 | 0.00 | 0.00 |
| 13-May | 40.37 | 24.90 | 39.70 | 26.20 | 0.00 |
| 20-May | 40.60 | 25.20 | 29.30 | 0.00 | 0.00 |
| 27-May | 42.77 | 31.20 | 41.30 | 0.00 | 0.00 |
| 3-Jun | 39.60 | 33.14 | 52.78 | 0.00 | 0.00 |
| 10-Jun | 40.70 | 29.70 | 68.20 | 4.40 | 0.00 |
| 17-Jun | 33.17 | 18.90 | 64.85 | 94.60 | 0.00 |
| 24 – Jun | 35.48 | 27.40 | 75.78 | 0.00 | 0.00 |
| 1-Jul | 40.60 | 24.90 | 77.50 | 25.20 | 0.00 |
| 8-Jul | 33.50 | 27.02 | 75.35 | 1.80 | 38.82 |
| 15-Jul | 34.11 | 26.30 | 82.50 | 42.20 | 36.02 |
| 22-Jul | 31.40 | 26.28 | 75.40 | 73.20 | 36.54 |
| 29-Jul | 34.20 | 26.60 | 73.00 | 105.8 | 29.04 |
| 5-Aug | 33.85 | 26.88 | 72.00 | 0.00 | 29.08 |
| 12-Aug | 31.00 | 25.70 | 84.78 | 48.60 | 31.71 |
| 19-Aug | 31.00 | 33.08 | 88.50 | 52.80 | 31.06 |
| 26-Aug | 34.20 | 26.00 | 75.90 | 5.40 | 31.16 |
| 2-Sept | 31.80 | 24.70 | 79.85 | 73.60 | 29.12 |
| 9-Sept | 34.20 | 24.80 | 76.00 | 0.40 | 35.68 |
| 16-Sept | 34.20 | 25.80 | 66.07 | 0.00 | 37.06 |
| 23-Sept | 33.37 | 24.77 | 68.71 | 9.60 | 33.60 |

However, during the year 2014, the pest incidence started much earlier in the beginning of third week of June as is evident from the table 6. It showed a speedy increase every week and highest population was recorded on 8th September with 72.04 bugs/plant. The corresponding means of maximum temperature, minimum temperature and humidityat the maximum population of the pest were 32.34°C, 25.40°C and 70.40%, respectively. No rainfall was noted in this week. The pest remained on the crop in considerable number (33.37 bugs/plant for the year 2013 and 63.52 bugs/plant for the year 2014) till final harvesting.

**Table 6: Population of cotton mealybug, *P. solenopsis* in okra during cropping season of 2014 under different weather factors**

| Date | Maximum temperature (°C) | Minimum temperature (°C) | Humidity (%) | Rainfall (mm) | Number of bugs/plant |
|---|---|---|---|---|---|
| 5 – May | 40.40 | 25.32 | 36.00 | 0.00 | 0.00 |
| 12 – May | 38.80 | 24.88 | 42.20 | 3.40 | 0.00 |
| 19 – May | 37.55 | 23.42 | 43.70 | 0.00 | 0.00 |
| 26 – May | 40.40 | 29.42 | 40.07 | 0.00 | 0.00 |
| 2 – Jun | 41.30 | 27.60 | 45.50 | 6.20 | 0.00 |
| 9 – Jun | 44.90 | 28.9 | 39.64 | 2.20 | 0.00 |
| 16 – Jun | 40.80 | 31.08 | 52.20 | 0.00 | 0.00 |
| 23 – Jun | 39.80 | 28.68 | 57.14 | 0.00 | 41.12 |
| 30 – Jun | 38.70 | 27.28 | 52.64 | 37.60 | 46.00 |
| 7 – Jul | 31.40 | 27.11 | 66.20 | 16.20 | 47.80 |
| 14 – Jul | 33.60 | 33.40 | 56.50 | 3.20 | 49.36 |
| 21 – Jul | 33.37 | 27.11 | 82.64 | 19.00 | 49.56 |
| 28 – Jul | 33.74 | 30.38 | 86.28 | 6.60 | 45.38 |
| 4 – Aug | 34.70 | 31.60 | 80.60 | 73.60 | 46.56 |
| 11 – Aug | 32.20 | 26.05 | 86.07 | 13.20 | 50.60 |
| 18 – Aug | 35.00 | 26.40 | 70.60 | 4.00 | 53.20 |
| 25 – Aug | 37.97 | 27.62 | 72.40 | 59.00 | 58.12 |
| 1 – Sept | 35.30 | 27.60 | 71.90 | 0.00 | 64.56 |
| 8 – Sept | 32.34 | 25.40 | 70.40 | 0.00 | 72.04 |
| 15 – Sept | 34.76 | 26.53 | 69.20 | 0.00 | 67.12 |
| 22 – Sept | 31.67 | 26.40 | 72.70 | 0.00 | 63.52 |

**2.3.1. Correlation Studies:** The pest population showed a significant negative correlation with maximum temperature for both the cropping seasons of 2013 and 2014 as is evident from the table 11 (b) (r = -0.743, r = -0.780). Minimum temperature and rainfall showed a non significant positive correlationwhereas relative humidity showed a significant positive relation for both the years with r values of 0.041, 0.207 and 0.659 for the year 2013 and 0.031, 0.257 and 0.814 respectively, for the year 2014.

**2.4. Red Cotton Bug, *D. cingulatusI:*** During the year 2013, the activity of red cotton bug initiated in the first week of August as is evident from the table 7. The pest population increased till the last week of August and then showed a retreating tendency but amplified again in the following week and reached its peak on 23rd September when the crop was in its final stage of maturity with a total population of 1.04 bugs/plant. The corresponding means of maximum temperature, minimum temperature and humidityat the maximum population of the pest were 33.7$^{o}$C, 24.77$^{o}$C and 68.71%, respectively with a total rainfall of 9.60 mm.

**Table 7: Population of red cotton bug, *D. cingulatus* in okra during cropping season of 2013 under different weather factors**

| Date | Maximum temperature (°C) | Minimum temperature (°C) | Humidity (%) | Rainfall (mm) | Number of bugs/plant |
|---|---|---|---|---|---|
| 6-May | 33.94 | 19.90 | 37.00 | 0.00 | 0.00 |
| 13-May | 40.37 | 24.90 | 39.70 | 26.20 | 0.00 |
| 20-May | 40.60 | 25.20 | 29.30 | 0.00 | 0.00 |
| 27-May | 42.77 | 31.20 | 41.30 | 0.00 | 0.00 |
| 3-Jun | 39.60 | 33.14 | 52.78 | 0.00 | 0.00 |
| 10-Jun | 40.70 | 29.70 | 68.20 | 4.40 | 0.00 |
| 17-Jun | 33.17 | 18.90 | 64.85 | 94.60 | 0.00 |
| 24-Jun | 35.48 | 27.40 | 75.78 | 0.00 | 0.00 |
| 1-Jul | 40.60 | 24.90 | 77.50 | 25.20 | 0.00 |
| 8-Jul | 33.50 | 27.02 | 75.35 | 1.80 | 0.00 |
| 15-Jul | 34.11 | 26.30 | 82.50 | 42.20 | 0.00 |
| 22-Jul | 31.40 | 26.28 | 75.40 | 73.20 | 0.00 |
| 29-Jul | 34.20 | 26.60 | 73.00 | 105.80 | 0.00 |
| 5-Aug | 33.85 | 26.88 | 72.00 | 0.00 | 0.64 |
| 12-Aug | 31.00 | 25.70 | 84.78 | 48.60 | 0.72 |
| 19-Aug | 33.08 | 31.00 | 88.50 | 52.80 | 0.72 |
| 26-Aug | 34.20 | 26.00 | 75.90 | 5.40 | 0.72 |
| 2-Sept | 31.80 | 24.70 | 79.85 | 73.60 | 0.64 |
| 9-Sept | 34.20 | 24.80 | 76.00 | 0.40 | 0.76 |
| 16-Sept | 34.20 | 25.80 | 66.07 | 0.00 | 0.74 |
| 23-Sept | 33.37 | 24.77 | 68.71 | 9.60 | 1.04 |

During the year 2014, the activity of the pest started in the last week of July,a little earlier than the preceding year as shown in the table 8. It showed a speedy decline in the consecutive weeks and further amplified in the last week of August and reached its peak on 22nd September with 1.22 bugs/plant on the pattern same as for the cropping season of 2013. The corresponding means of maximum temperature, minimum temperature and humidityat the maximum population of the pest were 31.67$^{o}$C, 26.40$^{o}$C and 72.70%, respectively. However, no rainfall was recorded during this week.

**Table 8: Population of red cotton bug, *D. cingulatus* in okra during cropping season of 2014 under different weather factors**

| Date | Maximum temperature (°C) | Minimum temperature (°C) | Humidity (%) | Rainfall (mm) | Number of bugs/plant |
|---|---|---|---|---|---|
| 5-May | 40.40 | 25.32 | 36.00 | 0.00 | 0.00 |
| 12-May | 38.80 | 24.88 | 42.20 | 3.40 | 0.00 |
| 19-May | 37.55 | 23.42 | 43.70 | 0.00 | 0.00 |
| 26-May | 40.40 | 29.42 | 40.07 | 0.00 | 0.00 |
| 2-Jun | 41.30 | 27.60 | 45.50 | 6.20 | 0.00 |
| 9-Jun | 44.90 | 28.90 | 39.64 | 2.20 | 0.00 |
| 16-Jun | 40.80 | 31.08 | 52.20 | 0.00 | 0.00 |
| 23-Jun | 39.80 | 28.68 | 57.14 | 0.00 | 0.00 |
| 30-Jun | 38.70 | 27.28 | 52.64 | 37.60 | 0.00 |
| 7-Jul | 31.40 | 27.11 | 66.20 | 16.20 | 0.00 |

| | | | | | |
|---|---|---|---|---|---|
| 14-Jul | 33.60 | 33.40 | 56.50 | 3.20 | 0.00 |
| 21-Jul | 33.37 | 27.11 | 82.64 | 19.00 | 0.00 |
| 28-Jul | 33.74 | 30.38 | 86.28 | 6.60 | 0.82 |
| 4-Aug | 34.70 | 31.60 | 80.60 | 73.60 | 0.70 |
| 11-Aug | 32.20 | 26.05 | 86.07 | 13.20 | 0.78 |
| 18-Aug | 35.00 | 26.4 | 70.60 | 4.00 | 0.72 |
| 25-Aug | 37.97 | 27.62 | 72.40 | 59.00 | 0.86 |
| 1-Sept | 35.30 | 27.60 | 71.90 | 0.00 | 0.94 |
| 8-Sept | 32.34 | 25.40 | 70.40 | 0.00 | 1.18 |
| 15-Sept | 34.76 | 26.53 | 69.20 | 0.00 | 1.18 |
| 22-Sept | 31.67 | 26.40 | 72.70 | 0.00 | 1.22 |

**2.4.1. Correlation Studies:** Data pertaining to the Pearson's correlation is presented in table 11(c). The minimum temperature and relative humidity showed a positive non significant correlation (r = 0.009 and r = 0.429) while maximum temperature showed a significant negative correlation (r = -0.522) and rainfall showed a non significant negative correlation (r= -0.100) for the year 2013.

A significant negative and positive correlation was found with maximum temperature (r = -0.579) and relative humidity (r = 0.687), respectively for the year 2014. Minimum temperature and rainfall showed a non significant negative and positive correlation, respectively (r = -0.140, r = 0.115).

**2.5. Blister Beetle, *M. pustulata*:** Data with respect to beetle count is presented in the table 9. During the cropping season of 2013, the beetles commenced to emerge in the field on 17th June. The population showed a speedy increase in the consecutive weeks and reached its peak on 26th August with a population of 1.34 beetles/plant. The corresponding means of maximum temperature, minimum temperature and humidityat the maximum population of the pest were 34.20°C, 26.00°C and 75.90%, respectively with a total rainfall of 5.40 mm. Beyond this week, the beetle population started to decline but remained (1 beetle/plant) at the time of harvesting.

**Table 9: Population of blister beetle, *M. pustulata* in okra during cropping season of 2013 under different weather factors**

| Date | Maximum temperature (°C) | Minimum temperature (°C) | Humidity (%) | Rainfall (mm) | Number of beetles/plant |
|---|---|---|---|---|---|
| 6 - May | 33.94 | 19.90 | 37.00 | 0.00 | 0.00 |
| 13 - May | 40.37 | 24.90 | 39.70 | 26.20 | 0.00 |
| 20 - May | 40.60 | 25.20 | 29.30 | 0.00 | 0.00 |
| 27 - May | 42.77 | 31.20 | 41.30 | 0.00 | 0.00 |
| 3 - Jun | 39.60 | 33.14 | 52.78 | 0.00 | 0.00 |
| 10 - Jun | 40.70 | 29.70 | 68.20 | 4.40 | 0.00 |
| 17 - Jun | 33.17 | 18.90 | 64.85 | 94.60 | 0.20 |
| 24 – Jun | 35.48 | 27.40 | 75.78 | 0.00 | 0.48 |
| 1 - Jul | 40.60 | 24.90 | 77.50 | 25.20 | 0.62 |
| 8 - Jul | 33.50 | 27.02 | 75.35 | 1.80 | 0.74 |
| 15 - Jul | 34.11 | 26.30 | 82.50 | 42.20 | 0.94 |
| 22 - Jul | 31.40 | 26.28 | 75.40 | 73.20 | 0.94 |
| 29 - Jul | 34.20 | 26.60 | 73.00 | 105.80 | 1.02 |
| 5 - Aug | 33.85 | 26.88 | 72.00 | 0.00 | 1.10 |
| 12-Aug | 31.00 | 25.70 | 84.78 | 48.60 | 1.08 |
| 19 - Aug | 31.00 | 33.08 | 88.50 | 52.80 | 1.26 |
| 26 - Aug | 34.20 | 26.00 | 75.90 | 5.40 | 1.34 |
| 2 - Sept | 31.80 | 24.70 | 79.85 | 73.60 | 1.14 |
| 9 - Sept | 34.20 | 24.80 | 76.00 | 0.40 | 1.22 |
| 16 - Sept | 34.20 | 25.80 | 66.07 | 0.00 | 1.08 |
| 23 - Sept | 33.37 | 24.77 | 68.71 | 9.60 | 1.00 |

In the year 2014, the beetles first appeared on the crop in the third week of June as shown in the table 10. The population of the beetles increased rapidly in the following weeks and reached its peak on 11th August with a population of 1.56 beetles/plant. The corresponding means of maximum temperature, minimum temperature and humidityat the maximum population of the pest were 32.20°C, 26.05°C and 86.07%, respectively with a total rainfall of 13.20 mm. Beyond this week, the population started to fall gradually and reached a low of 0.6 beetles/plant on 22nd September at the time of final harvest of the crop.

**Table 10: Population of blister beetle, *M. pustulata* in okra during cropping season of 2014 under different weather factors**

| Date | Maximum temperature (°C) | Minimum temperature (°C) | Humidity (%) | Rainfall (mm) | Number of beetles/plant |
|---|---|---|---|---|---|
| 5-May | 40.40 | 25.32 | 36.00 | 0.00 | 0.00 |
| 12-May | 38.80 | 24.88 | 42.20 | 3.40 | 0.00 |
| 19-May | 37.55 | 23.42 | 43.70 | 0.00 | 0.00 |
| 26-May | 40.40 | 29.42 | 40.07 | 0.00 | 0.00 |
| 2-Jun | 41.30 | 27.60 | 45.50 | 6.20 | 0.00 |
| 9-Jun | 44.90 | 28.90 | 39.64 | 2.20 | 0.00 |
| 16-Jun | 40.80 | 31.08 | 52.20 | 0.00 | 0.00 |
| 23-Jun | 39.80 | 28.68 | 57.14 | 0.00 | 0.44 |
| 30-Jun | 38.70 | 27.28 | 52.64 | 37.60 | 0.72 |
| 7-Jul | 31.40 | 27.11 | 66.20 | 16.20 | 0.84 |
| 14-Jul | 33.60 | 33.40 | 56.50 | 3.20 | 0.98 |
| 21-Jul | 33.37 | 27.11 | 82.64 | 19.00 | 1.22 |
| 28-Jul | 33.74 | 30.38 | 86.28 | 6.60 | 1.32 |
| 4-Aug | 34.70 | 31.60 | 80.6 | 73.60 | 1.40 |
| 11-Aug | 32.20 | 26.05 | 86.07 | 13.20 | 1.56 |
| 18-Aug | 35.00 | 26.40 | 70.60 | 4.00 | 1.20 |
| 25-Aug | 37.97 | 27.62 | 72.40 | 59.00 | 1.04 |
| 1-Sept | 35.30 | 27.60 | 71.90 | 0.00 | 0.84 |
| 8-Sept | 32.34 | 25.40 | 70.40 | 0.00 | 0.74 |
| 15-Sept | 34.76 | 26.53 | 69.20 | 0.00 | 0.70 |
| 22-Sept | 31.67 | 26.40 | 72.70 | 0.00 | 0.60 |

**2.5.1. Correlation Studies:** Data pertaining to the Pearson's correlation of beetle population and weather parameters for the years 2013 and 2014 is given in the table 11(d). A significant negative correlation and significant positive correlation of population was seen with maximum temperature (r = -0.740, r = -0.750) and relative humidity(r = 0.799, r = 0.917) respectively, for both the years. Minimum temperature showed a non significant positive correlation (r = 0.023, r = 0.214) for both the years whereas, rainfall exhibited a non significant positive and a significant positive correlation for the years 2013 and 2014, respectively (r = 0.261, r = 0.486).

**Table 11 (a) : Correlations of (a) *E. vitella* (b) *P. solenopsis* (c) *D. cingulatus* (d) *M. pustulata*population with climatic factors during the cropping seasons of 2013 and 2014**

| Abiotic factors (Climatic) | (a) *E. vitella* population (No. of larvae/5 fruits/plot) | |
|---|---|---|
| | **2013** | **2014** |
| Maximum temperature | 0.138ns | -0.386ns |
| Minimum temperature | 0.030ns | 0.551** |
| Relative humidity | 0.79** | 0.529* |
| Rainfall | 0.153ns | 0.405ns |
| **Abiotic factors (Climatic)** | **(b) *P. solenopsis* population (No. of bugs/plant)** | |
| | **2013** | **2014** |
| Maximum temperature | -0.743** | -0.780** |
| Minimum temperature | 0.041ns | 0.031ns |
| Relative humidity | 0.659** | 0.814** |
| Rainfall | 0.207ns | 0.257ns |
| **Abiotic factors (Climatic)** | **(c) *D. cingulatus* population (No. of bugs/plant)** | |
| | **2013** | **2014** |
| Maximum temperature | -0.522* | -0.579** |
| Minimum temperature | 0.009ns | -0.140ns |
| Relative humidity | 0.429ns | 0.687** |
| Rainfall | -0.100ns | 0.115ns |
| **Abiotic factors (Climatic)** | **(d) *M. pustulata* population (No. of beetles/plant)** | |
| | **2013** | **2014** |
| Maximum temperature | -0.740** | -0.750** |
| Minimum temperature | 0.023ns | 0.214ns |
| Relative humidity | 0.799** | 0.917** |
| Rainfall | 0.261ns | 0.486* |

** denotes correlation is significant at the 0.05 level (2-tailed); ** denotes correlation is significant at the 0.01 level (2-tailed)*

## Discussion and Conclusion

One of the important objectives of the entomologists is to monitor the insect activity through regular surveys. The knowledge about insect activity gained through these surveys is indispensible since the pest management system cannot operate without accurate estimates of pests and natural enemies or without reliable assessment of plant damage and its effect on yield. Indiscriminate use of chemical pesticides without taking into account the economic damage to the crops has caused a number of problems like pest resistance, pest resurgence, toxicity and environmental pollution, etc. Thus, the major objective of pest surveillance is to monitor the pest number and their status in the crop regularly in order to decide when to undertake control measures. Conducting regular monitoring gives the best chance of spotting a new pest soon after its arrival which paves way for further work on bio-ecology and management in the crop in question.

Although, the major and the minor pests remained consistent during the study period there were changes in the appearance of the occasional pests. These observations were in conformity with the results [20-21]. Tobacco caterpillar, *S. litura* and serpentine leaf miner, *L. trifolii* appeared in 2013 but not in 2014 which may be attributed to the differences in the abiotic factors of the two study years. Besides, alteration in the nutrient level of soil affects the concentration of nutrients in the host plant which in turn influence the pests that are feeding on the plants.

It may be pointed out that some species are favoured by altered conditions, whereas others may disappear. Sap sucking insects become more abundant but lepidopterous, detritivores and predators, become less abundant following canopy opening disturbances in forests [22-23].

The arrival of four insect pests on okra at Aligarh also varied. It may be attributed to the phenology of the host plant. It may be pointed out that the plants depend on environmental factors for their growth and development, the insect feed upon them may be affected by climate not only directly but also through their host plant. Thus, there is a relationship between seasonal development of an insect and its food plant [24]. It may be inferred that every organism particularly the insects respond to every deviation from normal environmental conditions. In the current scenario of climate change and global warming it is of utmost importance that every dimension about insect ecology is re-researched and every single year's population dynamics of the pest taken into account rather than the past data for appropriate insect pest management.

These observations may be supported by a classic report published as "Insect and Climate", [23] where it was stated that " It would be a mistake to believe that meteorological conditions can effect only those insects which are exposed to direct action of the atmosphere, since the conditions of the temperature, humidity, etc in the soil or inside a tree trunk, or in any other habitat, are closely dependent on the intensity of solar heat, on the amount of precipitation, on the humidity and evaporating power of air, infact on the whole complex of phenomenon covered by the word climate". It was further stated that "an insect living under natural conditions is never exposed to one isolated climatic factor, but to the continually changing combinations of several. While it is necessary to investigate the influence of each factor separately, it would be wrong to assume that the response of an insect to the combined action of several factors will represent merely a sum of the response of each factor involved. Indeed we must first satisfy ourselves whether this is true, or not, by studying experimentally all the more usual combinations of factors [24].

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