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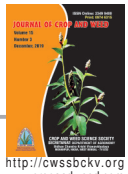

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# Seasonal abundance of different insect pests and predatory coccinellids in association with weather factors on bitter gourd, *Momordica charantia* L.

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## ABSTRACT

*Seasonal incidence of important insect pests of bitter gourd along with natural enemies was studied during the spring-summer seasons (2016 and 2017) at RRSS, Sekhampur and 'C' Block Farm, Kalyani, West Bengal. Maximum activity of Diaphania indica was observed during April while the population of Aulacophora foveicollis, Henosepilachna septima, Bemisia tabaci and predatory coccinellids was recorded maximum during the months of April, May and June at Sekhampur and Kalyani in 2016 and 2017, respectively. Trap catches of Bactrocera cucurbitae was found maximum which varied in different weeks during February to June at both the locations in 2016 and 2017. At Sekhampur and Kalyani, maximum temperature and evening relative humidity had significant positive and significant negative correlation with the larval incidence of cucumber moth, whereas rainfall and morning relative humidity were significant and negatively correlated at Kalyani. At Sekhampur, minimum temperature, rainfall and relative humidity (morning and evening) were significant and positively correlated with red pumpkin beetle and epilachna beetle incidence, whereas at Kalyani, minimum temperature, rainfall and evening relative humidity had significant positive correlation with red pumpkin beetle, while maximum and minimum temperature were significant and positively correlated with epilachna beetle. At both locations, correlation between whitefly population and temperature (maximum and minimum) was found significantly positive while morning relative humidity showed significant negative relation at Kalyani. Temperature (maximum and minimum) and rainfall had significant positive relationship with fruit flies at Sekhampur, whereas correlation with minimum temperature, rainfall and evening relative humidity was recorded positively significant at Kalyani. Incidence of predatory coccinellids was positive and significantly correlated with temperature (maximum and minimum) at both locations but at Sekhampur, rainfall and morning relative humidity were also exhibited significant positive association.*

***Keywords*:** Abiotic factors, bitter gourd, correlation, insect pests, seasonal incidence

Among the major cucurbitaceous vegetables, bitter gourd is cultivated throughout India as well as in West Bengal and is grown in almost every season in a year (Dhaliwal, 2017; Nath *et al*., 2017). Due to its extensive cultivation pattern in different seasons, the crop is suffered to infest by a wide range of insect pests during various phases of growth starting right from its germination to harvesting stage. Bitter gourd, like other cucurbits, is also prone to attack by fruit fly, whitefly, red pumpkin beetle, aphids, epilachna beetle, semilooper and are of major concern causing serious damage (Lekshmi *et al*., 2014; Jha, 2008; Behera *et al*., 2010; Kumar and Nadarajan, 2008; Ghule and Jha, 2012). To develop sustainable pest management strategies, study of population dynamics of insect species is essential to forecast and interpret their response to environmental factors (weather patterns) which are "fluctuating daily, seasonally or as a consequence of long-term effect of global climate change" (Denholm *et al*., 2001). The present study was aimed to get a preliminary idea about the seasonal incidence pattern of important insect pests and natural enemies associated with bitter gourd crop in relation to various weather parameters at two agro-climatic regions of West Bengal which would be useful in the proper planning of suitable and timely pest interventions.

## MATERIALS AND METHODS

Supervised field experimentations were conducted at 'C' Block Farm, Bidhan Chandra Krishi Viswavidyalaya (BCKV), Kalyani, Nadia, and at the Regional Research Sub Station (RRSS), BCKV, Sekhampur, Birbhum during 2016 and 2017 (spring-summer season). 'C' Block Farm, Kalyani is situated under Gangetic-Alluvial agro-climatic zone known for its typical summer season which is characteristically hot and humid and the RRSS, Sekhampur is located in the Red and Laterite agro-climatic zone with dry sub-humid and subtropical climate. Three replications were used in the field experiments, which were carried out in a Randomized Block Design (RBD). Bitter gourd

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cultivar 'Pusa Do Mausami' was used for the filed experimentations and the seeds were obtained from IARI (Indian Agricultural Research Institute), Pusa, New Delhi. Seeds were sown on raised beds with a plot size of 6 m × 1.3 m with a spacing of 120 cm × 50 cm between rows and plants, respectively. For raising the crop, recommended agronomic package of practices without chemical interventions were adopted.

Observations on the appearance of important herbivorous insects and natural enemies *viz*. cucumber moth, red pumpkin beetle, epilachna beetle, whitefly, fruit fly and ladybird beetle were recorded at weekly interval after the crop germination and continued until the final crop harvest during spring summer season of the years 2016 and 2017 at both the locations. In the experimental field there was a total of 30 plots and each plot had two rows of 6 m each in length accommodating a total of 24 plants. Thus, 24 plants in each plot (n = 720) were considered as sample plant for observing and counting the population of insect pests and natural enemies. The number of insect pests and natural enemies present on the creepers were recorded simply by counting of insects in the morning hours. The larvae of cucumber moth were counted in each plant and expressed as number of larvae plant$^{-1}$. In case of red pumpkin beetle, epilachna beetle and ladybird beetle, only the adult population were considered for recording the insect count. For fruit fly, monitoring of male fruit fly population was done by installation of cue lure traps @ 10 traps ha$^{-1}$ in the fields after one week of crop sowing. The population of fruit fly was counted as number of fruit flies trap$^{-1}$ and recorded at weekly intervals in every standard week for both 2016 and 2017, respectively. Population of whitefly were recorded on randomly selected ten leaves per plot by counting both the nymphs and adults and expressed as number of whiteflies leaf$^{-1}$. To study the effect of meteorological parameters on the occurrence of observed insect species in bitter gourd, the data on various weather factors (maximum and minimum temperature, rainfall, morning relative humidity, evening relative humidity and bright sunshine) during the cropping periods were obtained from the Department of Agricultural Meteorology and Physics, Bidhan Chandra Krishi Viswavidyalaya and correlated with the population of insect pests and natural enemies.

## RESULTS AND DISCUSSION

The insect species those appeared during the course of study at both locations were recorded at the particular stage of the crop as per Standard Meteorological Week (SMW) during both the years. Among the observed insect species in 2016 and 2017, population of cucumber moth, red pumpkin beetle, epilachna beetle, whitefly and predatory coccinellids was recorded low at both the locations during spring-summer seasons compared to the population of fruit fly (Table 1). However, the incidence of all the observed insect species was found slightly higher at Kalyani as compared to Sekhampur during the experiment in both years. The seasonal incidence of each individual insect species and the influence of various weather factors on them are discussed under the following heads.

### *Cucumber moth (Diaphania indica Saunders)*

The incidence of cucumber moth was commenced during first and second week of March at Sekhampur and Kalyani, respectively (Table 2 and 3). At Sekhampur, gradual increment in the population of *D. indica* was noticed after its first appearance and reached its peak of 0.92 and 0.12 larvae plant$^{-1}$ during fourth week of April (17$^{th}$ SMW) and first week of June (23$^{th}$ SMW), respectively (Table 2) whereas at Kalyani, peak incidence (0.45 larvae plant$^{-1}$) was noticed during third week of April (16$^{th}$ SMW) (Table 3). Saha *et al*. (2018) noticed quite low incidence of pumpkin caterpillar (*D. indica*) throughout the crop growing season and recorded highest larval population during April (last week) to May (last week). The pest showed positively significant correlation with maximum temperature at Sekhampur (r = 0.656**) and Kalyani (r = 0.791**) while significantly negative association was observed with rainfall (r = -0.501*), morning (r = -0.576**) and evening relative humidity (r = -0.527*) at Kalyani (Table 4 and 5). At Sekhampur, evening relative humidity also had significant negative correlation (r = -0.650**) with the pest incidence. Rest of the weather factors had non-significant correlation at both locations. Halder *et al*. (2017) reported that larval incidence of cucumber moth showed positive significant relationship with maximum and minimum temperature whereas rainfall, maximum relative humidity and minimum relative humidity had negative correlation with the pest population.

### *Red pumpkin beetle (Aulacophora foveicollis Lucas)*

Incidence of red pumpkin beetle was first noticed during first week of March (10$^{th}$ SMW) at Sekhampur, while at Kalyani, the beetles were first appeared in the fourth week of March (13$^{th}$ SMW) (Table 2 and 3). At Sekhampur, peak population of the adult beetles was recorded during 15$^{th}$ SMW *i.e*., second week of April (0.06 beetles plant$^{-1}$), 20$^{th}$ SMW i.e., third week of May (0.07 beetles plant$^{-1}$) and during 26$^{th}$ SMW *i.e*., fourth week of June (0.12 beetles plant$^{-1}$) (Table 2). At

**Table 1: List of major insect pests and natural enemies observed in bitter gourd during spring summer seasons of 2016 and 2017 at Sekhampur and Kalyani**

| Sl. No. | Common name | Scientific name | Order | Family | Feeding habit |
|---|---|---|---|---|---|
| | | **A. Insect pests** | | | |
| 1. | Cucumber moth | *Diaphania indica* (Saunders) | Lepidoptera | Pyralidae | Mainly foliage feeder but also found feeding on tender fruits |
| 2. | Red pumpkin beetle | *Aulacophora foveicollis* (Lucas) | Coleoptera | Chrysomelidae | Feed on leaves and flowers |
| 3. | Epilachna beetle | *Henosepilachna septima* (Dieke) | Coleoptera | Coccinellidae | Mainly foliage feeder |
| 4. | Whitefly | *Bemisia tabaci* (Gennadius) | Hemiptera | Aleyrodidae | Sap sucking from foliage |
| 5. | Fruit fly | *Bactrocera cucurbitae* (Coquillett) | Diptera | Tephritidae | Feed on fruits |
| | | **B. Natural enemies** | | | |
| 1. | Ladybird beetle | *Coccinella septempunctata* (Linnaeus) *C. transversalis* (Fabricius) *Brumoides suturalis* (Fabricius) *Cheilomenes sexmaculata* (Fabricius) *Micraspis discolor* (Fabricius) *Harmonia axyridis* (Pallas) | Coleoptera | Coccinellidae | Grubs and adults prey on aphids, whitefly and other sucking insects |

Kalyani, the beetles reached its first peak during 15$^{th}$ SMW i.e., second week of April (0.07 beetles plant$^{-1}$) and second peak during 21$^{st}$ SMW *i.e*., fourth week of May (0.26 beetles plant$^{-1}$) (Table 3). Lekshmi *et al*. (2014) reported red pumpkin beetle as a minor pest infesting bitter gourd and peak population was recorded during March. Ghule *et al*. (2015) found highest beetle population in the month of March and May on ridge gourd. At Sekhampur and Kalyani, the beetle incidence exhibited significant positive correlation with minimum temperature (r = 0.663** and r = 0.599**), rainfall (r = 0.549* and r = 0.600**) and evening relative humidity (r = 0.460* and r = 0.492*), respectively while morning relative humidity exhibited significant positive correlation (r = 0.464*) with beetle population only at Sekhampur (Table 4 and 5). Ghule *et al*. (2015) reported that correlation between red pumpkin beetle population and temperature (maximum and minimum) and rainfall was found significantly positive, whereas maximum relative humidity was non-significant and negatively associated and minimum relative humidity was significant and negatively correlated with the beetle incidence.

***Epilachna beetle (Henosepilachna septima Dieke)***

Occurrence of epilachna beetles was started from third week (12$^{th}$ SMW) and second week (11$^{th}$ SMW) of March at Sekhampur and Kalyani, respectively with trace population (Table 2 and 3). At Sekhampur, the maximum activity of the epilachna beetles was noticed during the months of May and June when the crop was at its flowering and fruiting stage where it reached its peak population of 0.12 beetles plant$^{-1}$ in the third (25$^{th}$ SMW) and fourth (26$^{th}$ SMW) week of June (Table 2). At Kalyani (Table 3), the beetles were found active throughout the growing season and the peak incidence (0.67 beetles plant$^{-1}$ and 0.38 beetles plant$^{-1}$) was noticed during 20$^{th}$ SMW (third week of May) and 25$^{th}$ SMW (third week of June), respectively. Barma and Jha (2013) reported peak incidence of epilachna beetle during the months of March, April, May and July which corroborate the present findings. At Sekhampur, beetle population was significant and positively correlated with minimum temperature (r = 0.618**), rainfall (r = 0.575**), morning relative humidity (r = 0.681**) and evening relative humidity (r = 0.646**)

**Table 2: Seasonal incidence of important insect pests and natural enemies in bitter gourd at RRSS, BCKV, Sekhampur, West Bengal during spring-summer season of 2016 and 2017 (mean data of two years)**

| Stage of the crop | Month | SMW | Cucumber moth plant$^{-1}$ | Red pumpkin beetle plant$^{-1}$ | Epilachna beetle plant$^{-1}$ | White fly leaf$^{-1}$ | Fruit fly Trap$^{-1}$ Week$^{-1}$ | Coccinellids plant$^{-1}$ | T. Mx (°C) | T. Mn (°C) | Rainfall (mm) | MRH (%) | ERH (%) | BSS (hours day$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre-germination | February | 8 (III) | 0.00 | 0.00 | 0.00 | 0.00 | 7.17 | 0.00 | 32.4 | 17.5 | 0.0 | 66.6 | 52.2 | 7.2 |
| | | 9 (IV) | 0.00 | 0.00 | 0.00 | 0.00 | 8.67 | 0.00 | 32.6 | 17.2 | 0.4 | 67.6 | 55.9 | 7.5 |
| Germination | March | 10 (I) | 0.09 | 0.01 | 0.00 | 0.00 | 8.34 | 0.00 | 32.8 | 19.6 | 0.4 | 69.5 | 62.1 | 6.1 |
| Seedling | | 11 (II) | 0.25 | 0.01 | 0.00 | 0.00 | 9.67 | 0.03 | 32.8 | 17.3 | 0.0 | 61.0 | 48.2 | 8.0 |
| Vegetative to | | 12 (III) | 0.33 | 0.02 | 0.01 | 0.09 | 11.83 | 0.08 | 35.2 | 20.0 | 0.1 | 65.4 | 50.0 | 7.8 |
| pre-flowering | | 13 (IV) | 0.38 | 0.01 | 0.00 | 0.16 | 15.83 | 0.09 | 31.0 | 20.6 | 1.5 | 63.1 | 47.8 | 5.7 |
| Pre-flowering | April | 14 (I) | 0.71 | 0.05 | 0.01 | 0.18 | 19.67 | 0.16 | 37.1 | 24.5 | 0.7 | 70.5 | 54.6 | 5.1 |
| Flowering to | | 15 (II) | 0.85 | 0.06 | 0.01 | 0.21 | 22.84 | 0.28 | 39.7 | 23.9 | 0.0 | 54.7 | 35.8 | 9.3 |
| fruiting (harvesting) | | 16 (III) | 0.88 | 0.01 | 0.02 | 0.15 | 22.00 | 0.22 | 38.2 | 25.7 | 0.0 | 70.6 | 56.8 | 6.7 |
| | | 17 (IV) | 0.92 | 0.01 | 0.02 | 0.19 | 25.50 | 0.27 | 40.3 | 25.8 | 1.2 | 70.2 | 42.3 | 7.9 |
| Flowering and | May | 18 (I) | 0.71 | 0.02 | 0.01 | 0.15 | 22.83 | 0.28 | 37.8 | 24.0 | 1.6 | 71.2 | 52.7 | 5.9 |
| fruiting (harvesting) | | 19 (II) | 0.59 | 0.06 | 0.02 | 0.12 | 24.33 | 0.27 | 37.5 | 23.9 | 2.3 | 67.7 | 54.0 | 8.5 |
| | | 20 (III) | 0.25 | 0.07 | 0.03 | 0.08 | 24.17 | 0.30 | 35.7 | 24.4 | 3.6 | 72.6 | 60.4 | 7.3 |
| | | 21 (IV) | 0.13 | 0.06 | 0.05 | 0.11 | 24.67 | 0.34 | 36.5 | 25.7 | 2.3 | 73.2 | 59.3 | 6.5 |
| | | 22 (V) | 0.11 | 0.04 | 0.05 | 0.08 | 22.33 | 0.35 | 37.2 | 25.2 | 4.0 | 74.8 | 61.2 | 7.5 |
| Flowering and | June | 23 (I) | 0.12 | 0.07 | 0.07 | 0.09 | 22.67 | 0.38 | 36.2 | 25.2 | 1.0 | 74.5 | 64.1 | 7.2 |
| fruiting (harvesting) | | 24 (II) | 0.05 | 0.08 | 0.08 | 0.10 | 23.84 | 0.36 | 35.4 | 23.6 | 8.8 | 74.1 | 63.6 | 6.1 |
| | | 25 (III) | 0.05 | 0.09 | 0.12 | 0.11 | 25.00 | 0.24 | 35.1 | 25.4 | 3.2 | 75.5 | 69.3 | 5.0 |
| | | 26 (IV) | 0.03 | 0.12 | 0.12 | 0.12 | 24.50 | 0.22 | 37.2 | 26.7 | 2.3 | 75.6 | 60.6 | 7.3 |

SMW= Standard Meteorological Week; T. Mx= Maximum temperature; T. Mn= Minimum temperature; MRH= Morning relative humidity; ERH= Evening relative humidity; BSS= Bright sunshine

**Table 3: Seasonal incidence of important insect pests and natural enemies in bitter gourd at 'C' Block Farm, BCKV, Kalyani, West Bengal during spring-summer season of 2016 and 2017 (mean data of two years)**

| Stage of the crop | Month | SMW | Cucumber moth plant$^{-1}$ | Red pumpkin beetle plant$^{-1}$ | Epilachna beetle plant$^{-1}$ | White fly leaf$^{-1}$ | Fruit fly Trap$^{-1}$ Week$^{-1}$ | Coccinellids plant$^{-1}$ | T. Mx (°C) | T. Mn (°C) | Rainfall (mm) | MRH (%) | ERH (%) | BSS (hours day$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Pre-germination | February | 8 (III) | 0.00 | 0.00 | 0.00 | 0.00 | 13.50 | 0.00 | 32.8 | 19.3 | 5.6 | 89.3 | 44.7 | 6.2 |
| | | 9 (IV) | 0.00 | 0.00 | 0.00 | 0.00 | 14.00 | 0.00 | 32.6 | 18.4 | 16.7 | 94.1 | 53.2 | 7.9 |
| Germination | March | 10 (I) | 0.00 | 0.00 | 0.00 | 0.00 | 16.00 | 0.00 | 32.6 | 20.6 | 0.3 | 93.2 | 55.0 | 5.7 |
| Seedling | | 11 (II) | 0.12 | 0.00 | 0.05 | 0.05 | 15.84 | 0.00 | 33.2 | 18.7 | 0.0 | 87.6 | 38.1 | 8.4 |
| Vegetative to | | 12 (III) | 0.19 | 0.00 | 0.11 | 0.15 | 18.67 | 0.17 | 34.5 | 21.9 | 8.4 | 91.8 | 44.5 | 7.9 |
| pre-flowering | | 13 (IV) | 0.25 | 0.05 | 0.33 | 0.23 | 22.00 | 0.32 | 35.1 | 24.8 | 2.2 | 92.7 | 53.2 | 6.9 |
| Pre-flowering | April | 14 (I) | 0.29 | 0.06 | 0.37 | 0.38 | 22.67 | 0.42 | 36.4 | 26.3 | 0.0 | 91.2 | 54.7 | 5.9 |
| Flowering to | | 15 (II) | 0.43 | 0.07 | 0.43 | 0.44 | 23.00 | 0.49 | 39.5 | 25.9 | 0.0 | 90.3 | 37.6 | 9.2 |
| fruiting (harvesting) | | 16 (III) | 0.45 | 0.06 | 0.45 | 0.43 | 28.00 | 0.51 | 37.2 | 26.5 | 0.0 | 85.9 | 54.5 | 7.0 |
| | | 17 (IV) | 0.38 | 0.05 | 0.53 | 0.34 | 32.67 | 0.55 | 38.7 | 26.7 | 0.6 | 89.1 | 50.3 | 8.1 |
| Flowering and | May | 18 (I) | 0.22 | 0.08 | 0.65 | 0.34 | 32.67 | 0.42 | 36.9 | 25.0 | 10.6 | 87.6 | 52.8 | 8.4 |
| fruiting (harvesting) | | 19 (II) | 0.12 | 0.11 | 0.66 | 0.23 | 35.50 | 0.50 | 36.3 | 25.4 | 39.3 | 90.5 | 56.2 | 8.7 |
| | | 20 (III) | 0.09 | 0.16 | 0.67 | 0.20 | 39.00 | 0.55 | 35.0 | 24.6 | 35.8 | 91.6 | 65.2 | 6.9 |
| | | 21 (IV) | 0.05 | 0.26 | 0.66 | 0.21 | 37.00 | 0.37 | 36.0 | 26.4 | 10.3 | 88.7 | 58.7 | 8.3 |
| | | 22 (V) | 0.04 | 0.24 | 0.43 | 0.19 | 35.00 | 0.41 | 35.5 | 25.2 | 42.0 | 93.2 | 65.0 | 7.4 |
| Flowering and | June | 23 (I) | 0.00 | 0.14 | 0.43 | 0.11 | 40.83 | 0.47 | 35.9 | 27.3 | 17.7 | 91.4 | 64.3 | 7.8 |
| fruiting (harvesting) | | 24 (II) | 0.00 | 0.11 | 0.35 | 0.09 | 44.67 | 0.41 | 34.0 | 26.3 | 23.2 | 94.0 | 75.4 | 3.7 |
| | | 25 (III) | 0.00 | 0.09 | 0.38 | 0.09 | 50.00 | 0.34 | 34.1 | 26.7 | 25.1 | 93.9 | 77.7 | 5.0 |
| | | 26 (IV) | 0.00 | 0.08 | 0.34 | 0.09 | 55.17 | 0.54 | 33.9 | 27.1 | 12.0 | 94.4 | 77.6 | 6.8 |

SMW= Standard Meteorological Week; T. Mx= Maximum temperature; T. Mn= Minimum temperature; MRH= Morning relative humidity; ERH= Evening relative humidity; BSS= Bright sunshine

**Table 4: Pooled correlation (*r*) between observed insect species and meteorological parameters during spring-summer seasons of 2016 and 2017 at RRSS, BCKV, Sekhampur**

| Meteorological parameters | Cucumber moth | Red pumpkin beetle | Epilachna beetle | White fly | Fruit fly | Predatory coccinellids |
|---|---|---|---|---|---|---|
| Maximum temperature | 0.656** | 0.350 | 0.225 | 0.720** | 0.763** | 0.699** |
| Minimum temperature | 0.338 | 0.663** | 0.618** | 0.705** | 0.948** | 0.857** |
| Rainfall | -0.331 | 0.549* | 0.575** | 0.067 | 0.501* | 0.580** |
| Morning relative humidity | -0.375 | 0.464* | 0.681** | -0.060 | 0.454 | 0.469* |
| Evening relative humidity | -0.650** | 0.460* | 0.646** | -0.374 | 0.173 | 0.239 |
| Bright sunshine | 0.194 | -0.075 | -0.247 | -0.045 | -0.045 | 0.039 |

*Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level

**Table 5: Pooled correlation (*r*) between observed insect species and meteorological parameters during spring-summer seasons of 2016 and 2017 at 'C' Block Farm, BCKV, Kalyani**

| Meteorological parameters | Cucumber moth | Red pumpkin beetle | Epilachna beetle | White fly | Fruit fly | Predatory coccinellids |
|---|---|---|---|---|---|---|
| Maximum temperature | 0.791** | 0.303 | 0.698** | 0.921** | 0.163 | 0.735** |
| Minimum temperature | 0.288 | 0.599** | 0.788** | 0.592** | 0.770** | 0.921** |
| Rainfall | -0.501* | 0.600** | 0.396 | -0.211 | 0.519* | 0.295 |
| Morning relative humidity | -0.576** | 0.041 | -0.270 | -0.515* | 0.287 | -0.087 |
| Evening relative humidity | -0.527* | 0.492* | 0.312 | -0.247 | 0.853** | 0.419 |
| Bright sunshine | 0.383 | 0.076 | 0.252 | 0.360 | -0.254 | 0.102 |

*Correlation is significant at the 0.05 level; **Correlation is significant at the 0.01 level

during both the years (Table 4), while at Kalyani, only maximum temperature (r = 0.698**) and minimum temperature (r = 0.788**) were significant and positively correlated with beetle incidence (Table 5). Banerjee *et al.* (2003) observed highest epilachna beetle incidence in bitter gourd crop associated with temperature (maximum and minimum) and relative humidity (maximum and minimum) which are in line with the present study.

***White fly (Bemisia tabaci Gennadius)***

Population of whitefly appeared during third week (12$^{th}$ SMW) and second week (11$^{th}$ SMW) of March at Sekhampur and Kalyani, respectively and found active throughout the crop growing period (Table 2 and 3). At Sekhampur, the incidence of whitefly reached its peak four times during second week of April (15$^{th}$ SMW) with a mean population of 0.21 whiteflies leaf$^{-1}$ at flowering to fruiting stage of the bitter gourd crop (Table 2). Thereafter, the subsequent peaks were observed during fourth weeks of April (17$^{th}$ SMW), May (21$^{st}$ SMW) and June (26$^{th}$ SMW) exhibiting 0.19, 0.11 and 0.12 whiteflies leaf$^{-1}$, respectively. At Kalyani (Table 3), peak incidence of whiteflies was noticed during second week of April (15$^{th}$ SMW) and fourth week of May (21$^{st}$ SMW) with mean population of 0.44 and 0.21 whiteflies leaf$^{-1}$, respectively. Relationship of whitefly incidence with abiotic factors revealed that maximum temperature (r = 0.720** and r = 0.921**) and minimum temperature (r = 0.705** and r = 0.592**) were significant and positively correlated at Sekhampur and Kalyani, respectively (Table 4 and 5). However, morning relative humidity had significant negative association (r = -0.515*) with whitefly population at Kalyani (Table 5). Saha *et al*. (2018) recorded peak whitefly incidence infesting bitter gourd during May (last week) to June (second week). They also implicated that temperature (maximum and minimum) were significant and positively associated with *B. tabaci* population whereas rainfall and relative humidity (maximum and minimum) were negatively correlated which are in conformity with the present investigation.

***Melon fruit fly (Bactrocera cucurbitae Coquillett)***

Monitoring of melon fruit flies using cue lure baited parapheromone traps indicated that activity of adult flies initiated after the installation of the traps and at both locations, initial population was observed in the third week of February (8$^{th}$ SMW) during spring-summer seasons of 2016 and 2017 (Table 2 and 3). At Sekhampur (Table 2), maximum trap catches (22.84, 25.50, 24.67 and 25.00 flies trap$^{-1}$) were recorded during second and fourth week of April (15$^{th}$ and 17$^{th}$ SMW), fourth week of May (21$^{st}$ SMW) and third week of June (25$^{th}$ SMW), respectively. At Kalyani

(Table 3), three peaks (16.00, 39.00 and 55.17 flies trap$^{-1}$) in trap catches were observed during first week of March (10$^{th}$ SMW), third week of May (20$^{th}$ SMW) and fourth week of June (26$^{th}$ SMW), respectively. The results are supported by Pareek and Kavadia (1986) and Barma and Jha (2011 and 2013) who also reported peak incidence of melon fruit fly during May to June on various cucurbits including bitter gourd. At Sekhampur (Table 4), captured population of male fruit flies exhibited significant positive correlation with maximum temperature (r = 0.763**), minimum temperature (r = 0.948**) and rainfall (r = 0.501*). At Kalyani (Table 5), minimum temperature (r = 0.770**), rainfall (r = 0.519*) and evening relative humidity (r = 0.853**) had significant positive association with the fruit fly population. Barma and Jha (2011) observed a significant positive relation between fruit fly incidence and temperature (maximum and minimum), evening relative humidity and soil temperature, respectively.

***Predatory coccinellids***

Among the observed natural enemies, six species of predatory coccinnelids *viz. Coccinella septempunctata*, *C. transversalis*, *Brumoides suturalis*, *Cheilomenes sexmaculata*, *Micraspis discolor* and *Harmonia axyridis* were found predominant at both the locations in 2016 and 2017 during spring-summer seasons. Rekha *et al*. (2009) reported that certain vegetables including bitter gourd were observed with high species diversity of predatory coccinellid beetles (9 species) out of which only three species *viz. Coccinella transversalis*, *Menochilus sexmaculatus* and *Brumoides suturalis* were very common. The activity of ladybird beetles was found throughout the crop growing period after its appearance during second to third week of March (11$^{th}$ – 12$^{th}$ SMW) at both the locations (Table 2 and 3). At Sekhampur, peak activity of ladybird beetles coincided with 15$^{th}$ SMW *i.e*., during second week of April (0.28 coccinellids plant$^{-1}$), 18$^{th}$ SMW *i.e*., during first week of May (0.28 coccinellids plant$^{-1}$) and 23$^{rd}$ SMW *i.e*., during first week of June (0.38 coccinellids plant$^{-1}$), respectively (Table 2). At Kalyani, incidence of ladybird beetles attained four peaks (0.55, 0.55, 0.47 and 0.54 coccinellids plant$^{-1}$) during fourth week of April (17$^{th}$ SMW), third week of May (20$^{th}$ SMW) and first and fourth week of June (23$^{rd}$ and 26$^{th}$ SMW), respectively (Table 3). Lekshmi *et al*. (2014) found ladybird beetles were active from March (third week) to May (fourth week) and exhibited highest incidence during last week of March on bitter gourd. Saha *et al*. (2018) had reported two species of coccinellid beetles *viz. C. septempunctata* and *M. sexmaculata* when they studied the incidence of insect pest of cucumber in relation to weather factors in Eastern Bihar. The activity of the coccinellids was found throughout the growing period from during March to June and recorded peak population during first week of May to first week of June (16$^{th}$, 18$^{th}$ and 21$^{st}$ SMW) which are in general agreement with the results of the present investigation. Relationship of ladybird beetle population with weather parameters showed significant positive correlation with maximum temperature (r = 0.699**), minimum temperature (r = 0.857**), rainfall (r = 0.580**) and morning relative humidity (r = 0.469*) at Sekhampur (Table 4), whereas at Kalyani (Table 5), only the former two abiotic factors were significant and positively correlated (r = 0.735** and r = 0.921**, respectively). These findings are also supported by Meena and Shashi (2014) who reported that incidence of coccinellids was correlated positively with temperature (both maximum and minimum) and relative humidity and had significant effect.

Bitter gourd crop was mainly infested by cucumber moth (*Diaphania indica*), red pumpkin beetle (*Aulacophora foveicollis*), whitefly (*Bemisia tabaci*), epilachna beetle (*Henosepilachna septima*) and melon fruit fly (*Bactrocera cucurbitae*) during spring-summer seasons of 2016 and 2017 at Sekhampur and Kalyani. Several species of ladybird beetles were observed dominant at both these locations. Variation in the occurrence and peak activity of these observed insect species might be depending on several factors such as the prevalent weather conditions of these two locations, season of cultivation, growing of particular and suitable host crops for feeding and breeding, presence or absence of suitable host insect species etc. Keeping in mind the above aspects, suitable pest interventions should be implemented accordingly based on their prevalence to minimize crop damage.

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