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# Seasonal dynamics of *Diaphania indica* (Saunders) (Lepidoptera: Crambidae) on ridge gourd

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**Abstract**
In this study, the population dynamics and bio-ecology of the *Diaphania indica* (Saunders) (Lepidoptera: Crambidae) have been investigated. The abundance of *D. indica* was recorded throughout the year between 2018 and 2019 indicating an overlapping of generations. We found that abundance/incidence between June - July was maximum compared to early summer and winter. The population density and weather parameters i.e., relative humidity was positively correlated and temperature was negatively correlated with the incidence of *D. indica.* The regression model also supported the relationship between the pest population buildup and weather factors. In addition, we found *Apanteles taragamae* Viereck and *Phanerotoma* sp. (both Hymenoptera: Braconidae) were the key mortality factors of *D. indica* as parasitoids. The present investigation helps to develop integrated pest management practices for *D. indica.*

**Keywords:** *Diaphania indica*, *Apanteles taragamae* Viereck and *Phanerotoma* sp. parasitoids, relative humidity

## Introduction

Ridge gourd, *Luffa acutangula* (L.) Roxb, native to the old tropics probably India, constitutes an important green vegetable. It is commonly cultivated throughout the tropical region (Sangeeta *et al*., 2022) [18]. The conservation and management of insect pollinators is gaining importance in recent days. Ridge gourd is an important commercial vegetable in selected pockets of Karnataka, where it is cultivated in large areas. *Diaphania indica* Saunders, *Liriomyza trifolii* Burgess, *Bactrocera cucurbitae* Conquillett*, Aphis gossypii* Glover *and Thrips palmi Koch* were identified as the main pests of the crop. Among these, *D. indica* (Lepidoptera: Crambidae) is a serious pest on ridge gourds during June and October (Nagaraju *et al*., 2018) [13]. *Diaphania indica* (Saunders) (Lepidoptera: Crambidae), is a polyphagous pest and is particularly serious on ridge gourd. Larvae mainly attack leaves, but also infest flowers and fruits, and cause considerable yield loss during the outbreak. Various studies are available on the biology of *D. indica* all over the world. The change in the population of this pest was studied in India on pumpkin, *Coccinia grandis* L. (Peter and David 1992) [15]. The field biology of this pest was studied in South Korea (Choi *et al*. 2003), Yemen (Angood and Angood 1979) [1], and China (Ke *et al*., 1988) [11]. Various aspects of the biology and natural enemies of this pest were studied by Ganehiarachchi (1997) [7]. (Chintha *et al*., 2002; Kinjo and Arakaki, 2002; Hosseinzade et *al*., 2014; Dai et *al*., 2018; Jalali *et al*., 2019; Capinera, 2020; Debnath *et al*., 2020; Khanzada *et al*., 2021) [8, 4, 9,2, 5, 12]. The first time the studies were conducted on the endoparasitoid, *Apanteles taragamae* Viereck (Hymenoptera: Braconidae) to determine its biology on *Diaphania indica* (Saunders) (Lepidoptera: Pyralidae) by Peter and David (1992) [15]. Data on the seasonal dynamics of *D. indica on* ridge gourd are scarce to date. It is recommended to expand the importance of basic plant pest biology studies as a necessary and decisive first step to undertaking integrated pest management programs, especially when they have an eco- friendly approach. Because of the increasing pest attack of ridge gourd, the present study was undertaken to investigate the seasonal dynamics and mortality determinants against cucumber moth in the field.

## Materials and Methods

### Study area

The study was conducted on ridge gourd (*Luffa acutangula*) farmland in Nelamangala of

Bangalore rural district 13.0973° N, 77.3856° E. The crop is grown extensively by the farmers of this region throughout the year. The experimental field consisted of an 8093.71m$^2$ area of ridge gourd raised in many rows, and plants were trained to a trellis of 4-5 m height and supported by metal wires. Each plant occupied an area of 20m$^2$.

**Sampling procedures**

Sampling was conducted for the collection of larvae of *D. indica* randomly by selecting 50 ridge gourd plants every fortnight during 2018 and 2019. The sampled larvae were collected and placed in plastic jars fed with ridge gourd leaves. The larvae were transferred daily to clean plastic jars with fresh leaves until pupation and the pupae were retained until the adult emerged. Observations were also made on the natural enemies of pests on *D. indica*. The possible number of pupae of parasitoids were collected from the field. The collected materials were placed in the glass vials for the emergence of the parasitoids. The emerged parasitoids from the pupae of the hosts were preserved in 70% alcohol for identification.

**Data analysis**

Population dynamic predictions and their interpretations were analyzed by the forewarning model for *D. indica.* Data on different weather variables were collected from the India meteorological department, Ministry of earth sciences, Government of India. The percentage incidence in specified plants with weather parameters, i.e., rainfall (RF), maximum temperature (Tmax), minimum temperature (Tmin), morning relative humidity (% RH1), evening relative humidity (% RH2) during 2018 – 2019 was assessed. Each year, linear correlation coefficients were annotated between the per cent incidence in different weeks and a weekly mean value of each of the weather parameters. Multiple regression analysis was utilized to quantify the contributions of various weather factors. A linear multiple regression model was developed for each year independently, following the method of Snedecor and Cochran (1967) to assess the percentage incidence. The model accuracy was confirmed by the value of the coefficient of determination (R2). The model reliability was evaluated by comparing the observed and predicted percentage of damage by *D. indica* and the Root Mean Square Error (RMSE) was used to evaluate the regression model fitness. The statistical analysis of the data was carried out using SPSS software (IBM SPSS Statistics for Windows, Version 21.0. Armonk, NY: IBM Corp 2012).

**Results**

The population dynamics and per cent of seasonal pest incidence of *D. indica* were recorded in 2018 and 2019. In January 2018, the incidence and pest population were 7%. Subsequently, till May, the pest incidence and pest population were found to be 9%. Further, the pest incidence was increased during May (23.20%) with a mean pest population of 1.52% and the peak population was noticed in July at 57% with a mean pest population of 2.34% with weather parameters like relative humidity of 93.0 and temperature 20 °C with an average rainfall of 4.61%. The infestation gradually declined over a while and continued up to April 2019 (6%), with a mean pest population of 0.36%. The fluctuation in the population of *D. indica* in the months of 2018 and 2019, followed similar path (Table 1 and Table 2). The correlation between the per cent of pest incidence and weather parameters indicated a positive correlation between its abundance and relative humidity and average rainfall in all the two years 2018 (r=0.811) and 2019 (r=0.662). There was no significant relationship between other weather factors and infestation (Table 3). Forecasting models for *D. indica* is presented in Table 4.

Where: Y=Percentage damage by *D. indica*, X1= Rainfall (mm), X2= minimum temperature (°C), X3= maximum temperature (°C), X4= Morning Relative humidity (%) at 7.30 am, X5= Evening Relative humidity (%) at 5.0 pm. In the present investigation two larval parasitoids *viz*, *Apanteles taragamae* Viereck (Braconidae) and *Phanerotoma* (Braconidae) sp. were recorded in the field. Among the larval parasitoids, *Apanteles taragamae* appeared to be promising parasitoid attacking *D. indica*. The larvae (Fig 3a and 3c) were green in colour and found feeding on the infested host larva. The pupal cocoons (Fig. 3b) were silky white. The number of *A. taragamae* adults (Fig. 3d and 3e) emerging from each host larva was ranging from 14 to 16. *Phanerotoma* (Braconidae) sp. (Fig. 3f) was an internal and solitary larval parasitoid. The parasitized larvae were seen in the field carrying at the posterior end a brown pupal cocoon of the parasitoid. The parasitized larvae do not feed and die of starvation. The percent parasitism of *A. taragamae* and *Phanerotoma* sp. on *D. indica* for the study period is represented in table 5. The incidence of *A. taragamae* was seen all through the study period. Whereas, *Phanerotoma* sp. was recorded from May to December.

**Table 1:** *Diaphania indica* (Saunders) infestation level as influenced by weather factors (2018).

| Months | WKS | No. of larva | Av rain fall(mm) | T Max. | T Min. | RH1 (7.30am) | RH2(1.30 PM) |
|---|---|---|---|---|---|---|---|
| Jan | First FN | 7 | 0 | 28.40 | 27.88 | 72.26 | 39.06 |
| | Second FN | 7 | 0 | 31.04 | 16.76 | 74.26 | 33.86 |
| Feb | First FN | 9 | 0.17 | 30.38 | 17.20 | 65.28 | 29.71 |
| | Second FN | 6 | 0.00 | 31.76 | 17.40 | 52.42 | 17.21 |
| Mar | First FN | 7 | 0 | 33.2 | 18.92 | 45.93 | 22.86 |
| | Second FN | 9 | 1.56 | 35.29 | 22.78 | 76.73 | 37.66 |
| Apr | First FN | 10 | 0.06 | 33.02 | 22.42 | 71.6 | 37.2 |
| | Second FN | 12 | 1.06 | 34.3 | 22.87 | 73.13 | 48.66 |
| May | First FN | 17 | 4.26 | 32.88 | 21.67 | 77.53 | 57.46 |
| | Second FN | 23 | 10.54 | 33.47 | 23.01 | 84.33 | 65.66 |
| Jun | First FN | 26 | 8.18 | 28.34 | 21.16 | 87.06 | 77.33 |
| | Second FN | 27 | 1.17 | 28.32 | 20.18 | 85.86 | 69.8 |
| Jul | First FN | 55 | 4.61 | 27.72 | 20.4 | 88.6 | 74.86 |
| | Second FN | 57 | 0.69 | 29.38 | 21.68 | 93.06 | 75.13 |
| Aug | First FN | 53 | 6.84 | 26.82 | 20 | 89.86 | 84.06 |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| | Second FN | 52 | 1.32 | 29.3 | 21.44 | 92.73 | 70.26 |
| Sep | First FN | 42 | 2.44 | 29.62 | 20.64 | 76.86 | 60.73 |
| | Second FN | 37 | 7.77 | 29.1 | 20.24 | 86.33 | 64.53 |
| Oct | First FN | 45 | 3.66 | 29.41 | 20.79 | 82.53 | 66.6 |
| | Second FN | 46 | 4.38 | 31.19 | 19.77 | 62.8 | 52.66 |
| Nov | First FN | 51 | 0.53 | 29.7 | 28.02 | 70.2 | 52 |
| | Second FN | 44 | 1.86 | 28 | 18.94 | 80.33 | 61.13 |
| Dec | First FN | 24 | 0.46 | 28.54 | 18.19 | 81.33 | 53.93 |
| | Second FN | 23 | 0 | 30.1 | 18.62 | 80.66 | 49 |

**Table 2:** *Diaphania indica* (Saunders) infestation as influenced by weather factors (2019).

| Months | WKS | No. of larva | Av rain fall(mm) | T Max. | T Min. | RH1 (7.30am) | RH2 (1.30 PM) |
|---|---|---|---|---|---|---|---|
| Jan | First FN | 27 | 0 | 28.95 | 13.97 | 72.06 | 27.06 |
| | Second FN | 16 | 0 | 31.42 | 15.21 | 78.2 | 34 |
| Feb | First FN | 16 | 0.00 | 29.95 | 18.01 | 68.07 | 44.57 |
| | Second FN | 22 | 0.00 | 33.00 | 19.30 | 58.42 | 25.07 |
| Mar | First FN | 9 | 0 | 36.46 | 21.3 | 59.4 | 29.26 |
| | Second FN | 10 | 0 | 34.96 | 23.2 | 68.6 | 26.26 |
| Apr | First FN | 6 | 0.58 | 35.73 | 23.48 | 63.73 | 27.4 |
| | Second FN | 0 | 2.86 | 35.1 | 23.52 | 68.13 | 38 |
| May | First FN | 21 | 5.69 | 34.1 | 22.53 | 75.33 | 49.33 |
| | Second FN | 32 | 9.53 | 36.22 | 24.1 | 81.93 | 59 |
| Jun | First FN | 30 | 6.96 | 31.33 | 21.78 | 82.53 | 63.8 |
| | Second FN | 28 | 0.69 | 30.59 | 21.49 | 81.73 | 53 |
| Jul | First FN | 35 | 0.41 | 29.91 | 20.97 | 83.06 | 57.73 |
| | Second FN | 32 | 2.52 | 30.02 | 21.96 | 93.73 | 68 |
| Aug | First FN | 29 | 3.08 | 27.12 | 20.42 | 88.33 | 79.46 |
| | Second FN | 22 | 9.33 | 29.42 | 21.74 | 95.53 | 74.33 |
| Sep | First FN | 22 | 0.54 | 27.8 | 45.24 | 85.4 | 71.53 |
| | Second FN | 24 | 9.9 | 28.66 | 20.83 | 87.06 | 63.2 |
| Oct | First FN | 29 | 13 | 29.65 | 20.6 | 80 | 69.46 |
| | Second FN | 27 | 3.74 | 28.97 | 21.46 | 93.33 | 81.73 |
| Nov | First FN | 23 | 0.05 | 29.21 | 19.67 | 77.13 | 58.8 |
| | Second FN | 24 | 1.86 | 27.88 | 19.23 | 80.33 | 61.93 |
| Dec | First FN | 26 | 0.46 | 25.62 | 18.1 | 82.86 | 70.13 |
| | Second FN | 23 | 0 | 29.29 | 19.12 | 89.26 | 58.53 |

**Table 3:** Relationship between *Diaphania indica* infestation and weather parameters during 2018-19.

| Year | 2018 | 2019 |
|---|---|---|
| RF | 0.32532 | 0.314 |
| Tmax | -0.609** | -0.561** |
| Tmin | 0.116925 | -0.07603 |
| $RH_1$ | 0.585** | 0.647** |
| $RH_2$ | 0.786** | 0.635** |

** Correlation is significant at the 0.01 level

**Table 4:** Forecasting models for *Diaphania indica*

| Year | Model type | Statistical model | R2 |
|---|---|---|---|
| 2018 | Full regression model (All weather parameters) | y=51.27-1.77X1-1.01X2+0.08X3-0.82X4+1.37X5 | 73.70% |
| | Optimized model | y= 14.93+1.16X1-0.63X2 | 65.80% |
| 2019 | Full regression model (All weather parameters) | y= 21.33+0.22X1-0.62X2-0.26X3+0.24X4+0.11X5 | 50.20% |
| | Optimized model | y= -11.34+0.14X1+0.32X2 | 43.90% |

**Table 5:** Percent parasitism of parasitoids on *Diaphania indica* during 2018-2019

| Months | *Apanteles taragamae* (% parasitism) | | *Phanerotoma sp.* (% parasitism) | |
|---|---|---|---|---|
| | 2018 | 2019 | 2018 | 2019 |
| January | - | - | - | - |
| February | 13.33 | 6.90 | - | - |
| March | - | - | - | - |
| April | 15.00 | - | - | - |
| May | 7.50 | 37.74 | - | 11.32 |
| June | 7.55 | 29.31 | 3.77 | 3.45 |
| July | 9.03 | 23.88 | - | 5.97 |
| August | 8.65 | 27.45 | 1.92 | 21.57 |
| September | 8.86 | 13.04 | 2.53 | 6.52 |

| | | | | |
|---|---|---|---|---|
| October | 7.69 | 10.71 | - | 3.57 |
| November | 7.37 | 8.51 | - | 6.38 |
| December | 7.41 | 10.20 | - | 4.08 |

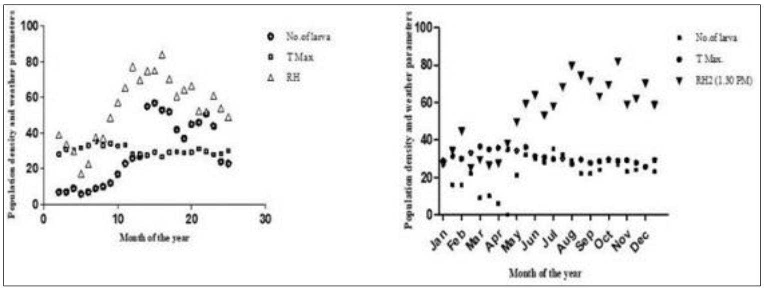


**Fig 1:** Incidence of *Diaphania indica* (Saunders in relation to weather parameters during 2018-2019.

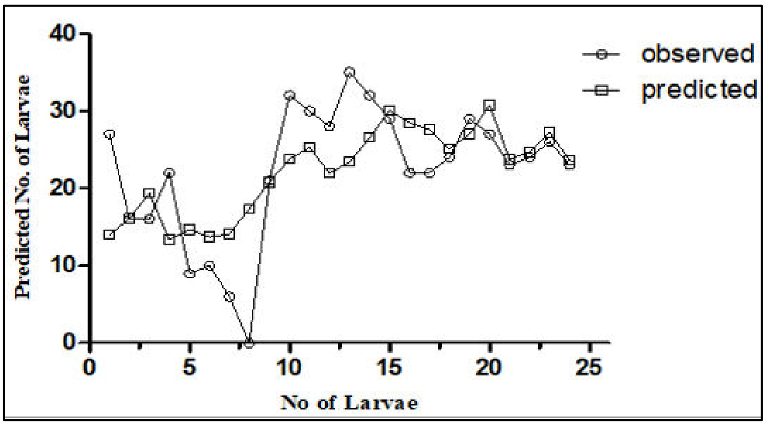


**Fig 2:** Observed and predicted levels of *Diaphania indica* infestation in different standard meteorological weeks (SMW) during 2018-19.

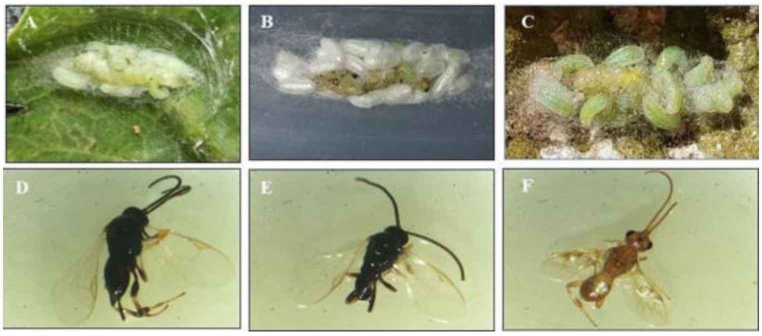


**Fig 3:** Parasitoids of *Diaphania indica* – 3a and 3c Larvae of *Apanteles taragamae*, 3b pupae of *A. taragamae*, 3d and 3e Adults of *A. taragamae* and 3f *Phanerotoma* sp.

## Discussion

The study periods indicated the percentage of abundance was more in July at the onset of high relative humidity and average rainfall. Our results agree with the results of other species of leaf webber, *Diaphania pulverulentalis* Samuthiravelu *et al*. (2010) [17]. The predicted model in the present investigation for 2018 and 2019 indicated that average rainfall and very high relative humidity could be used in forecasting of *D. indica* abundance. Our results were similar to the results of Caloran and Rahmathulla *et al*. (2012) [16] on the population dynamics of different insect pests. The results of the present investigation agree with the result of Soumya *et al*. (2017) who worked on the population fluctuations of *D. caesalis* in the jackfruit ecosystem. In addition to abiotic factors, our study explored possible mortality determinants in terms of parasitoids. The parasitoid, *A. taragamae* was seen from May to December. The peak incidence (37.74%) was during the second fortnight of May 2019, when the pest population was also higher. The present findings conformed to the earlier observations but differed from another report that the peak parasitism ranged from 68-98 per cent from August to October. These variations may be due to weather conditions prevailing in their places as well as the sowing season. Our results emphasize the insect abundance and abiotic factors relationship and their pivotal role in pest managing strategies. The developed model would further insights into understanding obligatory forecasts of *D. indica* infestation. These indicators would be used appropriately for forecasting the loss of vegetable crop yield.

## Conclusion

The present investigation revealed comprehensive information about the population dynamics and significantly influencing weather factors, details of natural enemies during the study period in the ridge gourd habitat. Further, the data was annotated in correlation with relative humidity, temperature, and incidence of pest abundance. The abundance of the pest was noticed especially in July 2018 and 2019 indicating the population dynamics of the leaf roller were positively correlated with rainfall and relative humidity and negatively correlated with maximum temperature.

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