

Full Length Research Paper

Studies on bio-ecology and voracity of leaf roller (*Diaphania indica* Saunders, Lepidoptera: Pyralidae) on pointed gourd (*Trichosanthes dioica* Roxb.)

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Field and laboratory studies have been carried out on the bio-ecology of *Diaphania indica* Saund. Correlation coefficient with all seven weather factors considered in the present study indicated that there existed significantly high negative correlation with five factors viz. temperature (°C), relative humidity (%), rainfall and soil temperature (°C) but bright sun shine hours that did bear significant weak positive correlation. Predictive models were developed from pooled data of two years' (2008 and 2009) observations on population vis-à-vis weather factor; one with irrespective of whether they had significant effect on population performance or no, and another with the significant ones. Biology of leaf roller larvae studied under laboratory condition done at temperature varying between 30 and 35°C showed that the two temperature regimes had little effects on duration of different developmental stages. The total developmental period was 16 to 22 days (20.3 ± 1.76 days) in 30°C and 17 to 22 days (19.5 ± 1.43 days) in 35°C. Consumption and efficiency of conversion of ingested food to biomass was worked out through established procedures. Consumption increased progressively through five larval instars from initially 3.74 to finally 81.25 and its conversion of biomass from 3.96 to 140.02 as indicated by indices.

Key words: Bio-ecology, voracity, correlation, predictive model, biology.

INTRODUCTION

Diaphania indica (Saunders) (Lepidoptera: Pyralidae) known as pumpkin caterpillar, is one of the major pests of most cucurbits all over the world (Morgan and Midmore, 2002; Arcaya et al., 2004). The pest attacked on different cucurbitaceous crop and has been reported from several states in India (Ke et al., 1988; Peter and David, 1990; Ravi et al., 1997, 1998; Ambarish and Maitreyi, 1998; Radhakrishnan and Natarajan, 2009). It has also been reported to attack pointed gourd (Chintha et al., 2002;

Jhala et al., 2005). On hatching, larvae feed on leaves where they cluster and fold and weave the leaves together. They can also feed on and puncture the skin of young fruit, especially the fruits that touch leaves (Patel and Kulkarny, 1956; Namvar and Alipanah, 2002; Sobrinho et al., 2003; Arcaya et al., 2004; Jhala et al., 2005). The damage by larvae has been reported to be restricted to leaves of pointed gourd which ranged from 25 to 30% (Jhala et al., 2005) which, in bitter gourd was 3

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to 14% only (Singh and Naik, 2006). The close relationship between population dynamics of any pest and weather can form the basis of pest forewarning system (Chinniah et al., 2007). The said relationship has been worked out in present study in order to understand bio-meteorological interactions. The seasonal incidence of the pest had been recorded and the impact of some of the weather factors viz. temperature maximum and minimum, RH% morning and evening, total rainfall, soil temperature and bright sun shine hours had been analysed. Alongside this biology and food consumption of the pest had also been studied. This will help in preparation of management design of the pest.

MATERIALS AND METHODS

Pointed gourd crop cv. Dhapa was raised in field conditions at Central Research Farm of the Bidhan Chandra Krishi Viswavidyalaya, Gayeshpur, Nadia, West Bengal, India. The population dynamics of leaf roller was monitored in three consecutive years from 2008 to 2010. Experiments were replicated three times with each plot having the size of 6 m² (3 m × 2 m) with a plant spacing 100 cm × 135 cm accommodating six females and one male root cuttings in pits. FYM at 150 q/ha and N, P and K were applied at 90, 80 and 70 kg/ha respectively. Mature root cuttings were planted in three seasons during November to August in 2007-2008, 2008-2009 and 2009-2010. The harvesting of fruits was done at regular interval starting from March-April to August which took 260 to 270 days for attaining maturity. Observations on the pest activity were recorded after beginning of the infestation at weekly intervals till the crop attained maturity. The numbers of leaf roller larvae were counted directly from two randomly selected tagged plants in each of the replications and average population per leaf was estimated. The weekly meteorological data on maximum temperature; minimum temperature, morning relative humidity, evening relative humidity, rainfall, soil temperature and bright sun shine hours were obtained from the Department of Agril. Meteorology and Physics, Bidhan Chandra Krishi Viswavidyalaya.

The culture of leaf roller was maintained on pointed gourd leaves in the laboratory of Plant Health Clinic, Directorate of Research, Bidhan Chandra Krishi Viswavidyalaya. Freshly handpicked mature larvae were brought to the laboratory and then reared in a plastic jar with its mouth tightly covered with a fine muslin cloth tied with rubber band. The larvae were fed with fresh, non-infested pointed gourd leaves. Pupae were collected and transferred to another jar with a fresh tender twig held in a small conical flask containing water and plugged with cotton. On emergence a pair of the female and male was confined in another jar for mating. The jar was provided with diluted honey-glucose solution-soaked cotton. Females laid eggs not only on tender twig either singly or in batches but also on jar walls and muslin cloth. The male and the female were distinguished basing on the presence of bushier anal tuft of brown hairs that can be found on females only. Ten newly hatched larvae were transferred with the help of a soft camel hair brush to the petridishes (5 × 1 cm) and were provided with tender pointed gourd leaves. The bottom of each petridish was lined with a slightly moistened filter paper to prevent desiccation. The leaves were replaced every day with fresh ones and faecal matters were removed. The larval development was observed daily. After completion of the larval development at 5th instar, those went for pupation within leaves folded by spinning web which were kept separately to record pupal duration.

For voracity study, freshly laid eggs were collected and brought to the laboratory to study of efficiency of conversion of ingested leaf

of pointed gourd. The larvae after hatching were reared on fresh leaves of pointed gourd collected from the field. The first instar stage was raised in a common culture within plastic cages. The larvae were segregated just after the first larval moult and about 10 larvae were separately reared in Petri dishes, that were provided with known weight of leaves of almost same size and equal quantity of leaves were taken as aliquot to determine the dry matter content. The larval weights were taken just after moulting. Five larvae of each instar from first to the prepupal stage were weighed and dried to determine the dry weight of such larvae. The total quantity of food consumed by the larvae of each instar was determined by subtracting the weight of left over after feeding from the weight of leaves supplied. The utilization of food was worked out following Waldbauer (1964). The drying of food and the faecal matters was done in a hot air oven at 100°C till the weight was constant.

RESULTS AND DISCUSSION

Biology of leaf roller *D. indica* (Saunders)

The eggs were laid singly or in small clusters on the lower surface of leaves, leaf buds and young stems. Eggs were very small, round in shape and yellow in color. Freshly laid eggs measured from 0.73 mm. to 0.95 mm. in length and 0.30 mm. to 0.45 mm. in width (Table 2). Incubation period was 3.7±0.48 days at 30°C and 3.2±0.42 days at 35°C (Table 1). On hatching, they passed through five larval instars to become adult. The length and width of different instars had been presented in Table 2. The larval period was 9.5±1.43 days at 30°C and 8.4±1.17 days at 35°C. Time requirement to complete different instars had been presented in Table 1. Pupation took place within a white silky cocoon, remaining attached to leaves which were rolled by the caterpillars prior to pupation. The length and width varied from 13.00 to 14.20 mm and 2.54 to 3.03 mm respectively (Table 2). The pre-pupal and pupal periods were 1.9±0.56 and 8.9±1.19 days at 30°C and 2.2±0.78 and 9.1±1.44 days at 35°C respectively (Table 1). The total developmental period from egg to adult emergence was averaged to 20.3±1.76 days at 30°C and 19.5±1.43 days at 35°C (Table 1). The length of the adult varied from 13.80 to 14.80 mm and width from 3.00 to 3.60 mm (Table 2). The longevity of adult moth was 9.5±1.17 days at 30°C and 8.7±1.16 days at 35°C (Table 1). The present finding was more or less in conformity with that of Ganesharachchi (1997) who reported incubation, larval and pupal period to be 3-5 days, 8-10 days, 7-9 days at room temperature respectively on snake gourd and Korgaonkar et al. (2004) who reported it to last for 4.75 days, 11.9 days and 9.4 days respectively on little gourd. The duration of mean developmental period from oviposition to adult emergence and the longevity of adults were ranged from 23 to 33 days with an average of 27.35 and 8.45 to 9 days respectively. Shin et al. (2002) reported that the adult period of the pest on melon was 21 days and on cucumber was 15.5 days. However, no reference could be found out on such study on pointed gourd.

Table 1. Biology of leaf roller, *Diaphania indica* (Saunders) on pointed gourd.

Stage	Duration in days (X±SD) (30°C)	Duration in days (X±SD) (35°C)
Egg period	3.7±0.48 (3-4)	3.2±0.42 (3-4)
Larval longevity	9.5±1.43 (7-11)	8.4±1.17 (6-10)
1 st instar	2.2±0.63 (1-3)	1.3±0.48 (1-2)
2 nd instar	2.6±0.52 (2-3)	1.7±0.48 (1-2)
3 rd instar	1.8±0.42 (1-2)	1.4±0.52 (1-2)
4 th instar	1.6±0.51 (1-2)	1.6±0.51 (1-2)
5 th instar	1.3±0.48 (1-2)	2.4±0.69 (2-4)
Pre pupal period	1.9±0.56 (1-3)	2.2±0.78 (1-3)
Pupal period	8.9±1.19 (7-11)	9.1±1.44 (7-12)
Total developmental period	20.3±1.76 (16-22)	19.5±1.43 (17-22)
Adult longevity	9.5±1.17 (8-11)	8.7±1.16 (7-11)

Table 2. Measurement of different life stages of *D. indica* (Saunders).

Life stage	Length (mm) Mean±S.D.	Width (mm) Mean±S.D.
Egg	0.83±0.08 (0.73 - 0.95)	0.38±0.05 (0.30 - 0.45)
Larval Instar I	3.90±0.24 (3.80 - 4.30)	0.50±0.07 (0.40 - 0.56)
Larval Instar II	6.26±0.61 (5.00 - 7.10)	0.86±0.10 (0.64 - 1.02)
Larval Instar III	9.71±0.89 (8.40 - 11.20)	1.39±0.15 (1.22 - 1.66)
Larval Instar IV	14.67±0.52 (13.80 - 15.40)	2.15±0.20 (2.00 - 2.50)
Larval Instar V	18.04±0.46 (17.20 - 18.50)	3.21±0.13 (3.01 - 3.36)
Pupae	13.63±0.39 (13.00 - 14.20)	2.83±0.15 (2.54 - 3.03)
Adult	14.26±0.35 (13.80 - 14.80)	3.17±0.24 (3.00 - 3.60)

Seasonal history and relationship between leaf roller population and different weather parameters

Leaf roller, *D. indica*, could be recorded throughout the crop season during all three years of 2008, 2009 and 2010. Population was very low during each of the years of study being 0.01 to 0.12 per leaf in 2008, 0.01 to 0.17 in 2009 and 2010. It required 110 days in 2008, 65 days in 2009 and 112 days in 2010 for first appearance of the pest. Population was relatively high in early phase, that is, during March 2008, during January 2009 and again during March 2010. It fluctuated sometimes considerably as during 2009 being not so copious during other two years. Variation in the infestation levels of the insect could be noted which could have been influenced by the weather factors. In the present study the impact of weather factors on the population build up and development of predictive models thereof have been tried.

Relationship between leaf roller population and temperature

It was observed that during 2008, leaf roller population

was active throughout the growing season of the crop. Data was recorded from the beginning of March. The population reached its peak (0.12 larvae/leaf) during second week of March when the weekly average maximum temperature was around 30°C (Figure 1). During April and June, leaf roller population was a bit lower. During 2009, leaf roller appeared in the first week of January and peak population was observed during third week of January when the weekly average maximum temperature was around 27°C (Figure 2). Hence, it may be inferred that when weekly average maximum temperature was around 27 to 30°C, the peak leaf roller population could be observed.

With respect to relationship of number of leaf roller population per leaf with minimum temperature the highest number of leaf roller was found during beginning of March, 2008 and third week of January, 2009 when the weekly average minimum temperature attained the value of 18 and 14°C, respectively (Figures 1 and 2). In respect to soil temperature, it was around 20 and 17°C (Figures 1 and 2). Hence, it may be deduced that when weekly average minimum temperature and soil temperature were around 14-18 and 17-20°C, the peak leaf roller population could be observed. The two years' data indicated that leaf roller population was negatively and significantly

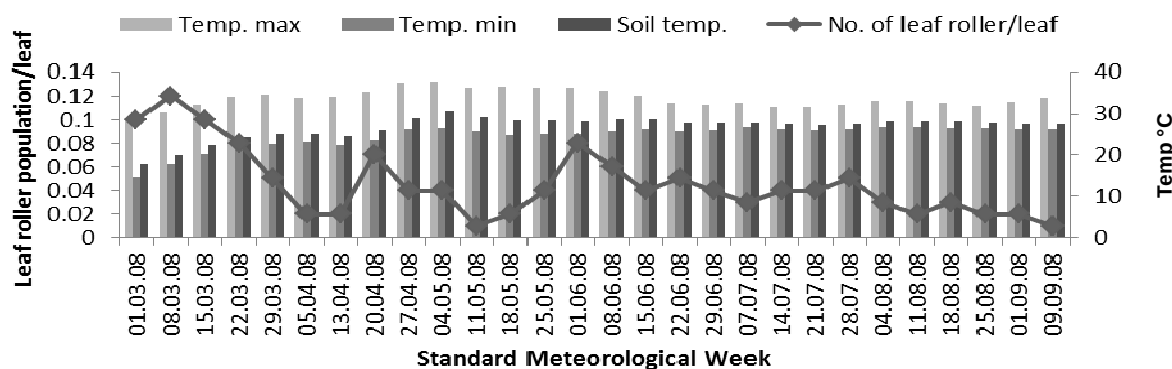


Figure 1. Influence of temperature on leaf roller population during 2008.

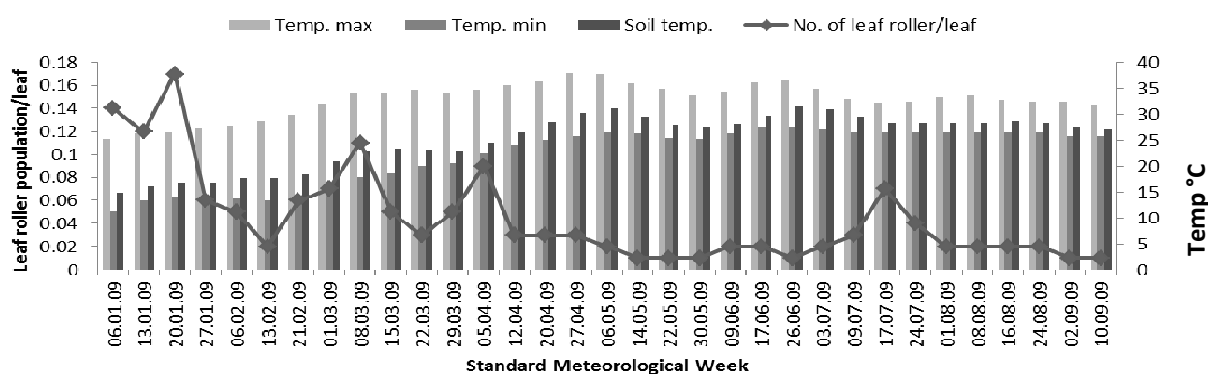


Figure 2. Influence of temperature on leaf roller population during 2009.

correlated with maximum temperature ($r = -0.523$), minimum temperature ($r = -0.774$) and soil temperature ($r = -0.763$). Hence, for formulation of predictive equation minimum weather and soil temperature were considered due to their strong association.

Relationship between leaf roller population and relative humidity

During 2008, peak population (0.12 larvae/leaf) reached during beginning of March when the weekly average morning relative humidity was around 93% (Figure 3). During April and June, leaf roller population was below the highest population and the weekly average morning relative humidity was around 87 to 91%. During 2009, the pest appeared in the first week of January and peak population was observed during that time when the weekly average morning relative humidity was around 95%. Hence, it may be deduced that when weekly average morning relative humidity was around 93 to 95% (Figure 4), the peak leaf folder population could be observed.

The weekly average evening relative humidity attained the value of 50% during beginning of March, 2008 (Figure

3) and 58% during first week of January, 2009 (Figure 4) which coincided with maximum leaf roller population. Hence, it may be deduced that when weekly average evening relative humidity was around 50-58% the peak leaf roller population could be observed.

The two years' data indicated that leaf roller population was negative but non-significantly correlated with morning relative humidity ($r = -0.029$) and negative but significantly correlated with evening relative humidity ($r = -0.535$). Hence, for formulation of predictive equation evening relative humidity was considered.

Relationship between leaf roller population and rainfall

It was observed that during 2008, peak population (0.12 larvae/leaf) reached during beginning of March when there was no or trace rainfall (Figure 5). During April and June, leaf roller population was below the highest population and the weekly rainfall was around 4 to 29 mm. During 2009, leaf roller appeared in the first week of January and peak population was observed during that time when the weekly rainfall was around 0 mm (Figure 6). Hence, it may be deduced that population of leaf

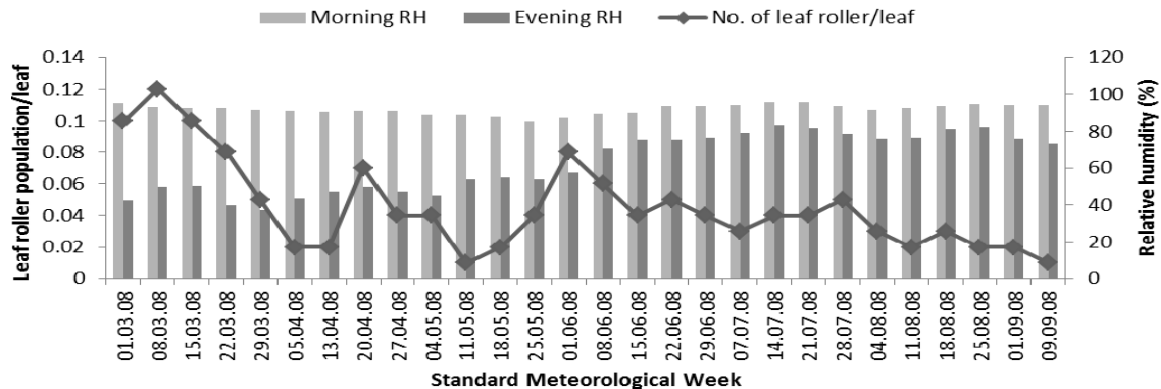


Figure 3. Influence of relative humidity on leaf roller population during 2008.

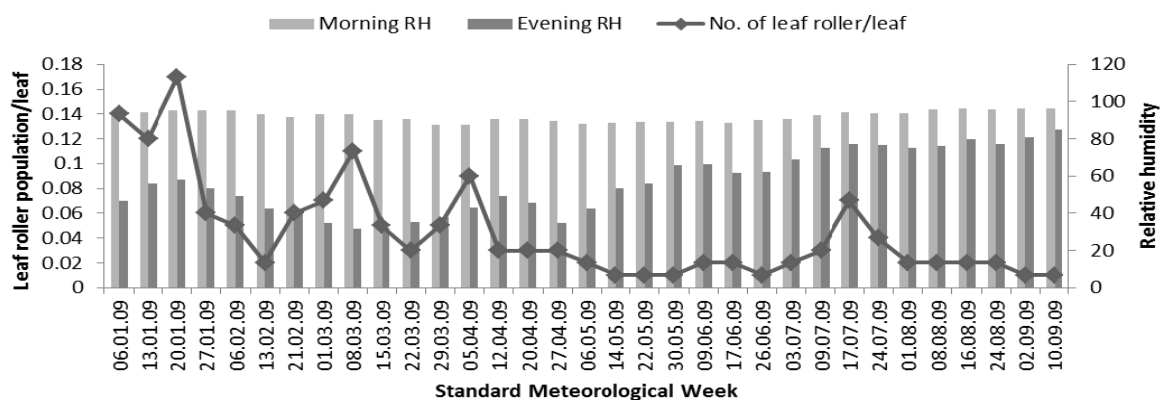


Figure 4. Influence of relative humidity on leaf roller population during 2009.

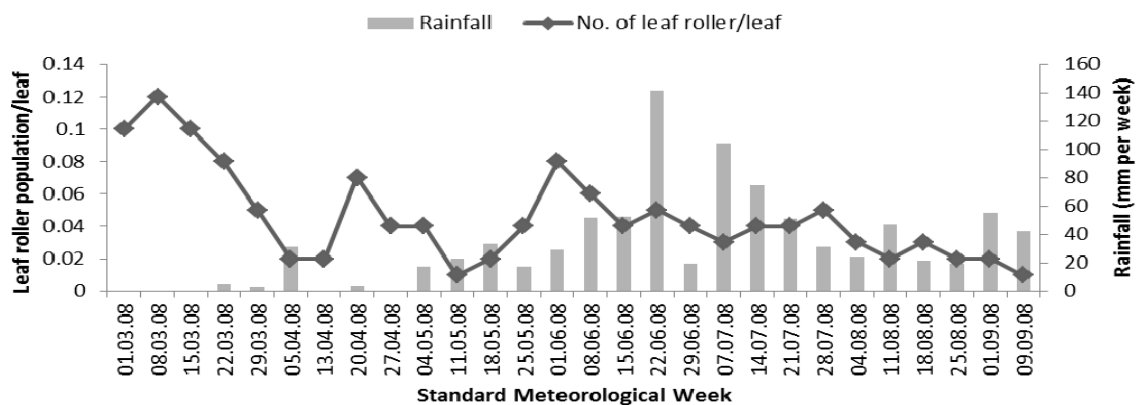


Figure 5. Influence of rainfall on leaf roller population during 2008.

roller better performed under nil or trace rainfall conditions.

The two years' data set indicated that leaf roller population was negatively and significantly correlated with rainfall ($r = -0.524$). Hence, for formulation of predictive equation this weather parameter was considered.

Relationship between leaf roller population and bright sun shine hour

Population peak during March 2008 and January 2009 occurred when the weekly average bright sun shine was 8 and 6 h respectively (Figures 7 and 8). The small high populations during the remaining period of crop season

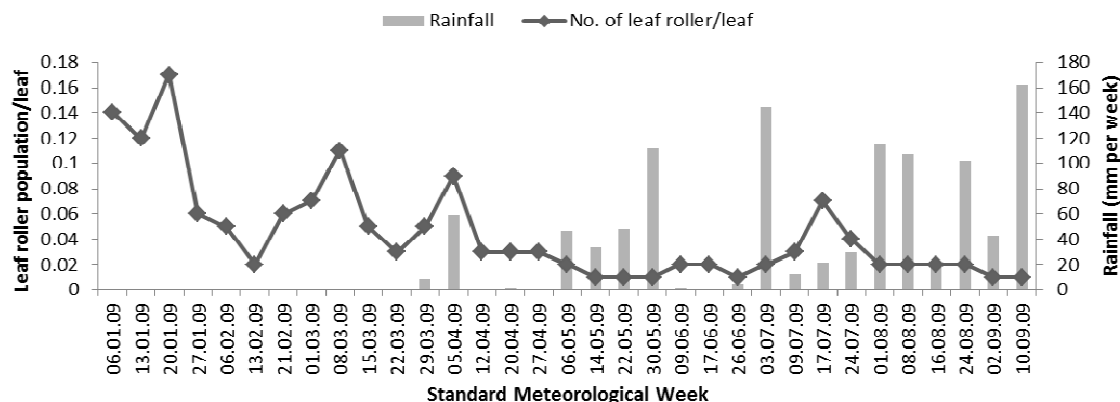


Figure 6. Influence of rainfall on leaf roller population during 2009.

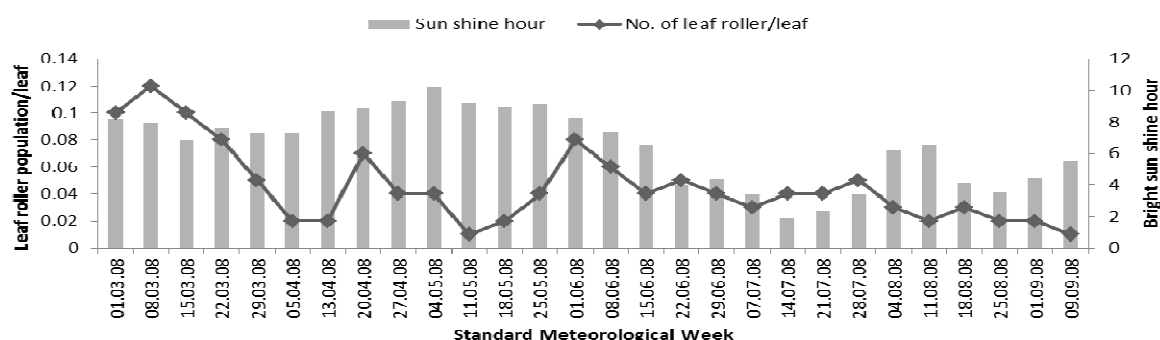


Figure 7. Influence of sun shine hour on leaf roller population during 2008.

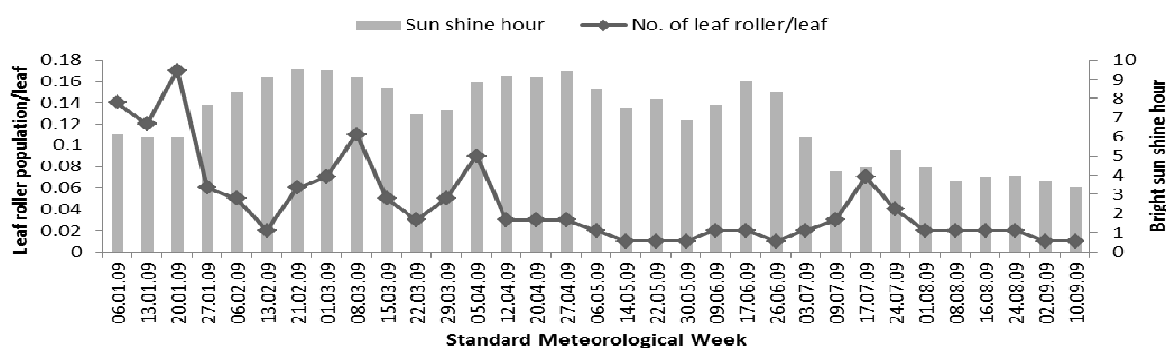


Figure 8. Influence of sun shine hour on leaf roller population during 2009.

did never shoot up to the level of peak incidence records and during this period the sun shine hour was more than eight. Hence, it may be deducted that when weekly average bright sun shine hour was around 6 to 8 h, the peak leaf roller population could be observed.

The two years' data set indicated that leaf roller population was negatively and significantly correlated with bright sun shine hour ($r = -0.396$). Hence, for formulation of predictive equation this weather parameter was considered.

Development of predictive equation to forewarn leaf roller population

The population dynamics of leaf roller influenced by different weather parameters, as discussed previously, were used to develop forewarning model. The data of first two years (that is, 2008 and 2009) were used for developing predictive equation and the last year's data were used for validation purpose.

As per the discussion on leaf roller-weather relationship

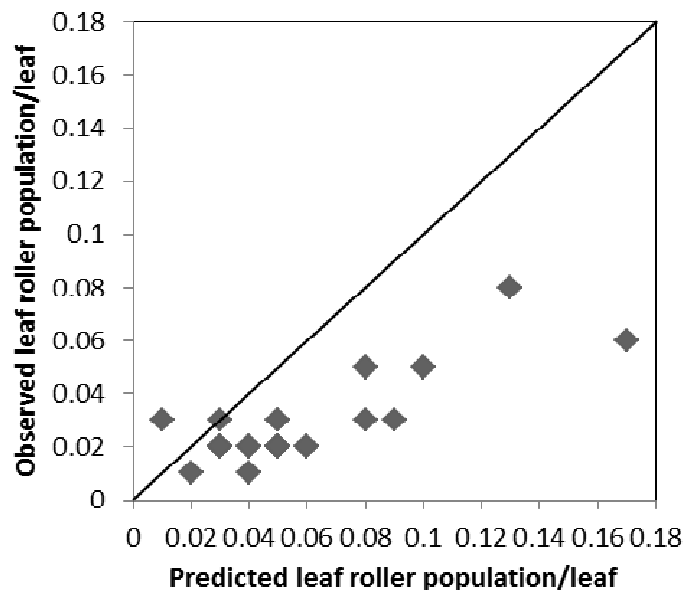


Figure 9. Comparison between observed and predicted leaf roller population per leaf.

done in the previous section minimum temperature, evening relative humidity, rainfall, soil temperature and bright sun shine hour were considered for development of predictive equation. The equation developed in this study was as follow:

$$Y = 0.103 - 0.012X_1 + 0.001X_2 + 0.000X_3 + 0.005X_4 + 0.004X_5 \quad R^2 = 0.632$$

Where, Y–Mean no. of leaf roller/leaf; X_1 , Minimum temperature; X_2 , Evening relative humidity; X_3 , Rainfall; X_4 , soil temperature; X_5 , Bright sun shine hour. Using all the weather parameters, the equation stands as:

$$Y = 0.489 + 0.005X_1 - 0.024X_2 - 0.005X_3 + 0.002X_4 + 0.000X_5 - 0.011X_6 - 0.003X_7 \quad R^2 = 0.664$$

Where, Y, mean no. of leaf roller/leaf; X_1 , maximum temperature; X_2 , minimum temperature; X_3 , morning relative humidity; X_4 , evening relative humidity; X_5 , Rainfall; X_6 , soil temperatures; X_7 , bright sun shine hour.

Comparison between observed and predicted leaf folder population

The predicted and observed leaf roller population per leaf was done through 1:1 line. It was observed that most of the data points were along with 1:1 line and from the Figure 9 it is apparent that the predicted leaf roller population was consistently much lower than that observed. Thus the prediction is much safe and may allow time for arranging management strategies. The root

mean square error value was 0.037, indicating the developed equation can be used safely to predict the leaf roller population on pointed gourd. Thus the leaf roller population is very much closely related with minimum temperature, evening relative humidity, rainfall, soil temperature and bright sun shine hour. The predictive equation thus formed through the present investigation can form the basis of forewarning system towards better pest management of pointed gourd.

From the aforesaid discussion it can be inferred that all abiotic factors other than morning relative humidity influenced significantly the incidence pattern leaf roller population. Multiple correlation analysis with climatological data showed that pest population had significant negative correlation with maximum and minimum temperature. The incidence was high, during the first fortnight of March in 2008, third week of January in 2009 and second week of March in 2010 when the weekly average temperatures ranged from 17.7 to 30.3°C. However, this finding contradicted the observation of Das (2001) who reported that maximum and minimum temperature had significant positive relation with the pest population. The present study further revealed that relative humidity and rainfall had significant negative relation with population buildup of the pest. These findings are also in disagreement with the findings of Das (2001) who reported that relative humidity and rainfall had no significant effect on leaf roller population on pointed gourd. Further to this, present study revealed that the soil temperature was negatively and bright sun shine hour positively correlated with population build up. Through this present piece of study the predictive models to forewarn the incidence of *D. indica* (Saunders) on pointed gourd had been developed. No earlier reference on such model development on the pest of this crop had been found.

Efficiency of conversion of ingested leaf of pointed gourd by *Diaphania indica* (Saunders)

The larvae just after hatching from egg were too small. The weight gained by the larvae through development was spectacular which ultimately attained an average of 120 mg when it became full grown after four larval moults. However, at the end of the 5th instar, that is, during prepupal stage, the larvae stopped feeding and their body shrunk. They also defecated. This resulted in decrease in body weight. During feeding each larvae fed on an average 468.9 mg. of green leaf. Therefore, it may be assumed that a larva, to complete its development, may consume even less than 0.5 gm green matter of the plant.

The conversion of plant biomass into insect biomass is indicated by the rate of consumption and utilization of pointed gourd leaf as food by this insect. The various indices presented in Table 3 revealed that during the development, increase in mean dry weight of larvae at

Table 3. Consumption and utilization of pointed gourd leaf by different larval instar of *D. indica* (Saunders).

Characteristics	Larval instar				
	I	II	III	IV	V
Larval period (days)	2.2±0.63	2.6±0.52	1.8±0.42	1.6±0.51	1.3±0.48
Food consumed (dry matter mg)	5.35	33.1	35.8	69.7	73.8
Faecal matter (dry weight mg)	0.3	9.4	13	28	31
Consumption index (C.I.)	2.21	2.01	1.14	0.84	0.47
Average digestibility (A.D.)	94.39	71.63	63.74	59.83	58.02
Efficiency of conversion of ingesta	3.74	15.09	30.68	57.39	81.25
Efficiency of conversion of digesta	3.96	21.07	48.14	95.92	140.02

various instar tended to increase with the advancement of larval instars. This has also been indicated by various workers with different insects (Chlodny, 1967; Bhat and Bhattacharya, 1978). Consumption index (C.I.) of *D. indica* (Saunders) decreased gradually as the insect grew from first to fifth instar. This indicated that the rate of consumption of food though increased with the advancement of growth stages, it was not reflected aptly in the gain in weight of the larvae. This happened due to decrease of the average digestibility (A.D.) of the larvae in the all the succeeding stages. Efficiency of conversion of ingested food (E.C.I.) and efficiency of conversion of digested food (E.C.D.) into body matter in leaf roller larvae increased gradually at galloping rate all through from first to fifth instar. This indicated gradual increase in physiological activity of the larvae. Mukherjee and LeRoux (1969) in *Podius maculiventris*; Bhat and Bhattacharya (1978) for *Spodoptera litura* and Pal and Ghosh (1986) for *Acherontia styx*, Chlodny (1967) in *Leptinotarsa decemlineata* also reported identical phenomenon.

It, therefore, appears that not only the rate of feeding And relative utilization of ingested food varied from one species to another, the utilization of food consumed related to the growth of insect was also specific. The efficiency of utilization of food also varied between the instars of the same species.

Conflict of Interests

The authors have not declared any conflict of interests.

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