

Some Bio-Ecological Aspects of Jackfruit Shoot and Fruit Borer, *Diaphania caesalis* Walker (Pyralidae : Lepidoptera) under Gangetic Plains of West Bengal

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Abstract The present investigation has been undertaken to study some bio-ecological aspects of jackfruit fruit and shoot borer *Diaphania caesalis* Walker (Pyralidae : Lepidoptera) in Gangetic plains of West Bengal keeping in view of the growing economic importance of the pest and lacking of detailed information regarding biology and bionomics of the pest in the field during 2013-14 and as well as in the Departmental laboratory. The biology studies revealed the mean larval period of 16.1 days, mean pupal period of 8.1 days during summer months and mean pupal period of 14.8 days during winter months. Studies on the seasonal incidence resulted that the mean percentage of shoot damage varied from 0.24% (July) to 2.92% (January). Maximum damage was recorded in eastern face of the plant canopy (2.4%) followed by southern face (2.04%), western face (1.45%) and north-

ern face (0.91%) considering all the months of observation. The pest has been observed to damage fruits for six months only (March to August) and the infestation ranged from 12.69% to 82.22%. The correlation and regression studies indicated that maximum temperature and minimum temperature were negatively correlated with the shoot damage and the damage can be predicted best by maximum temperature (up to 81.29%). The analyzed data also indicated that rainfall was positively correlated with the fruit damage and this factor alone can predict the damage up to 47.05%.

Keywords Jackfruit, *Diaphania caesalis*, Biology, Seasonal incidence, Bionomics.

Introduction

Jackfruit or Jack is one of the important and commonly found fruit trees in the homesteads/gardens of India and Bangladesh [1—4]. It is a multi-purpose species providing food, timber, fuel, fodder and medicinal and industrial products. It is adapted to a wide range of habitats and is known to mitigate the effects of environmental and climatic changes. India is the 2nd largest producer of the fruit in the world and considered as the motherland of jackfruit. In India, jackfruit is cultivated over an area of 66.73 thousand ha, producing 1175.70 thousand tonnes of fruits [5]. The poor productivity, reduction of market value due to poor quality and quantity of jackfruit includes vari-

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ous reasons in India and insect pest infestation is one of the major problems. Over 35 species of insect pests infest jackfruit [6] and 14 species of insect pests have been recorded from West Bengal [7]. Among these, the shoot and fruit borer *Diaphania caesalis* Walker (Pyralidae : Lepidoptera) is the most destructive one especially in West Bengal condition [7, 8]. Though, this pest is one of the most damaging pests, surprisingly, a little work has been done on its seasonal incidence, biology, nature and extent of damage throughout the world. Therefore, the present investigation has been undertaken to study some biological aspects including biology, seasonal incidence, extent of damage as well as the effect of weather parameters on the incidence of jackfruit fruit and shoot borer in Gangetic plains of West Bengal which would be helpful in finding out the suitable options to manage this pest.

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Materials and Methods

To study the seasonal incidence, extent of damage as well as impact of weather parameters on the incidence of *D. caesalis*, the experiment was conducted in the field of AICRP on Fruits (Mohanpur Center), BCKV located at Mondouri, Nadia, West Bengal during 2013-14 on jackfruit whereas the studies on some aspects of biology have been carried out in the laboratory of the Department of Agric. Entomology of BCKV situated at Mohanpur, Nadia. To study the biology, the healthy 1st instar larvae of the pest had been collected carefully from the affected plant parts and reared in petri dishes during March, 2014 (for summer month). Young tender shoots, buds and inflorescence of jackfruit were provided as food. The duration of larval period was recorded maintaining ten replications. After completing the larval stage they moulted to pupae, whereas the pupae turned to the adults after cutting out the pupal case. During this time the pupal periods were counted. Another set of experiment has been followed for recording pupal period during winter month (November, 2013) with five replications. For the incidence study, different parts of

the plant had been investigated thoroughly and attentively to record the infestation on 12 randomly selected trees throughout the year. To determine the distribution pattern of the pest, weekly observations had been recorded from the four sides of the plant canopy facing East, West, North and South, respectively from each of those 12 trees from March, 2013 to February, 2014. Afterwards, such weekly records of incidence had been converted to incidence in monthly basis. To estimate the shoot damage, total number of shoots as well as the number of shoots damaged by the larvae of the pest along the four geographical directions i.e., East, West, North and South, had been counted in a 200 cm² plant canopy area round the year. Afterwards, percentage of infestation by the pest on the shoots of jackfruit was estimated. However, to estimate the fruit damage, randomly selected 12 jackfruit trees bearing fruits were observed. From each of the plants total number of fruits along with the number of infested fruits had been counted and thereafter, percentage of fruit infestation was estimated. For statistical analysis, one-way ANOVA [9] technique was used for each month just to compare the face differences using *F* tests followed by Duncan's Multiple Range Test (DMRT) [10] to compare the month-wise face means of transformed percent shoots infested. General linear model technique repeated over months was also used to compare overall face means for all months and overall month means for all faces using *F* tests along with their interaction effect. Thereafter, correlation coefficients of five meteorological parameters viz. maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall were calculated and tested for their significance using *t* tests. Stepwise regression equation method was used as a variable selection technique from all meteorological parameters as regression to predict percent shoots as well as fruits infested as dependent variable for each face, from which, the best fitted regression equations might be included with corresponding *R*².

Results and Discussion

Morphological description of *D. caesalis*

Single egg is laid on tender shoot, bud, inflorescence or apical part of tender leaf. The first instar larvae

Table 1. Larval and pupal durations of *D. caesalis* Walker during different dates of observation in captive rearing condition.

| No. of replication | Date of collection of 1 st instar larva | Observation during summer months | | | | Observation during winter months | | | |
|--------------------|--|----------------------------------|----------------------|-------------------------|---------------------|----------------------------------|-------------------------|-------------------------|---------------------|
| | | Date of pupation | Larval period (days) | Date of adult emergence | Pupal period (days) | No. of replication | Date of pupation | Date of adult emergence | Pupal period (days) |
| 1 | 1 st Mar,14 | 16 th Mar, 14 | 15 | 25 th Mar,14 | 10 | 1 | 25 th Nov,13 | 10 th Dec,13 | 15 |
| 2 | 3 rd Mar,14 | 19 th Mar, 14 | 16 | 28 th Mar,14 | 9 | 2 | 26 th Nov,13 | 10 th Dec,13 | 14 |
| 3 | 8 th Mar,14 | 24 th Mar, 14 | 16 | 1 st Apr,14 | 8 | 3 | 27 th Nov,13 | 12 th Dec,13 | 15 |
| 4 | 9 th Mar,14 | 24 th Mar, 14 | 15 | 2 nd Apr,14 | 9 | 4 | 10 th Dec,13 | 26 th Dec,13 | 16 |
| 5 | 10 th Mar,14 | 27 th Mar, 14 | 17 | 3 rd Apr,14 | 7 | 5 | 21 st Dec,13 | 4 th Jan, 14 | 14 |
| 6 | 11 th Mar,14 | 27 th Mar, 14 | 16 | 4 th Apr,14 | 8 | | | | |
| 7 | 11 th Mar,14 | 28 th Mar, 14 | 17 | 4 th Apr,14 | 7 | | | | |
| 8 | 11 th Mar,14 | 29 th Mar, 14 | 18 | 5 th Apr,14 | 7 | | | | |
| 9 | 13 th Mar,14 | 29 th Mar, 14 | 16 | 6 th Apr,14 | 8 | | | | |
| 10 | 14 th Mar,14 | 29 th Mar, 14 | 15 | 6 th Apr,14 | 8 | | | | |
| Mean | | | 16.1 | | 8.1 | Mean | | | 14.8 |

have dark brown or blackish head and opaque body. The color changes in the later instars. In the later instars the head becomes yellowish; body color changes from transparent to reddish brown with numerous black flattened horny warts each bearing one short bristle-like hair. Full-grown larvae are 2.5–3.0 cm in length but before pupation the larvae become pale in color and body length gets shortened. Pupation takes place inside the infested buds or leaves folded by them or in tunnels, cracks and crevices of stem. Pupae are reddish or yellowish-brown. Adults are whitish-brown moths, having grayish elliptical patterns and a marginal series of black specks. The length of the adult wing expanse is about 26 to 34 mm. Females are slightly bigger than males.

Biology of *D. caesalis*

Two important parameters of biology viz. larval duration as well as pupal duration of the pest in different dates of observation have been presented in Table 1. The table clearly shows that, the larval period ranged from 15 to 18 days during the month of March. The mean larval period calculated is 16.1 days. The table also states that pupal period ranged from 7 to 10 days during the summer months and the mean pupal period is 8.1 days whereas in the months of November–January pupae took 14 to 16 days time to become adults. The mean pupal period is 14.8 days during winter months. In an experiment Huang [11] had re-

ported the pupal periods of *Diaphania* to be 14–17 days though he experimented on another species of *Diaphania* i.e. *Diaphania pyloalis* Walker and the host plant on which he experimented, was also different i.e. mulberry (Moraceae). It can be said that in summer months the pupae took less time to become adults, probably due to high temperature as well as high RH.

It can be concluded from this study that the mean larval period and pupal period of jackfruit fruit and shoot borer *Diaphania caesalis* Walker was 16.1 days and 8.1 days during summer months and winter months, respectively, while the mean pupal period was 14.8 days during winter months.

Seasonal incidence and level of infestation in shoots by *D. caesalis* on different faces of the plant canopy

Results on the seasonal incidence and the level of infestation of *D. caesalis*, specifically with regard to their activity on different faces of the plant canopy, were recorded systematically and are presented in Table 2 while the percent shoot damage along with the meteorological parameters are shown in Figure 1. The Table and the Figure shows that the mean percentage of shoot damage varied from 0.24% to 2.92% when all the four faces of the plant canopy had been considered. The highest damage was observed in the

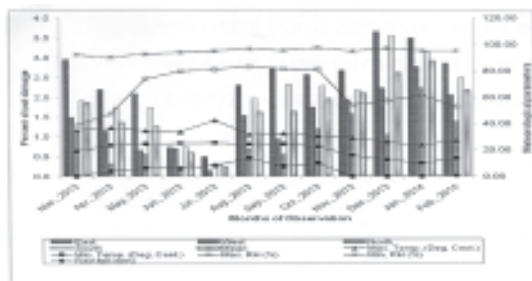


Fig. 1. Damage by *D. caesalis* in shoots of jackfruit on different faces of plant canopy along with meteorological parameters in different months of observation.

month of January, 2014 (average maximum temperature, minimum temperature, maximum RH, minimum

RH and rainfall were 23.61°C, 10.13°C, 95.35%, 61.45% and 0.0 mm, respectively) while, the least damage was observed in the month of July, 2013 (average maximum temperature, minimum temperature, maximum RH, minimum RH and rainfall were 42.34°C, 25.37°C, 95.19%, 81.1% and 8.11 mm, respectively). On the other hand, when all the months of observation had been considered together, maximum damage was recorded in eastern face of the plant canopy (2.4%) followed by southern face (2.04%), western face (1.45%) and northern face (0.91%). The similar trend has been noticed in each of the month of observation. If the faces of the plant canopy are considered individually, then it can be said that highest shoot damage by *Diaphania* in the eastern face ranged from 0.49% (July, 2013) to 3.66% (December, 2013). The damage in the southern face ranged from 0.32% (July, 2013)

Table 2. Effect of face direction of jackfruit plant canopy on the extent of shoot damage by *D. caesalis*. **Significant at 1% level and * Significant at 5% level. # Similar alphabets denote homogenous means where set (a, b) and set (p, q,...) are used respectively for comparing within fortnights between face means of percent infected shoots and the same due to months. \$ Figures in parentheses are angular transformed values.

| Months of observation (variables) | Significant value of the faces | Face wise mean of percent shoot damage in different faces of plant canopy # | | | | Overall mean |
|-----------------------------------|--------------------------------|---|-----------------|-----------------|------------------|------------------|
| | | East | West | North | South | |
| Mar, 2013 | 0.05* | 2.96 \$(9.91)a | 1.49 (7.02)b | 1.09 (5.99)b | 1.91 (7.95)b | 1.86 (7.85)r |
| Apr, 2013 | 0.12 | 2.21 (8.54) | 1.15 (6.16) | 0.33 (3.27) | 1.75 (7.61) | 1.36 (6.70)t |
| May, 2013 | 0.38 | 2.09 (8.32) | 0.66 (4.67) | 0.57 (4.32) | 1.73 (7.56) | 1.26 (6.46)u |
| Jun, 2013 | 0.53 | 0.74 (4.92) | 0.71 (4.83) | 0.18 (2.45) | 0.73 (4.91) | 0.59 (4.40)w |
| Jul, 2013 | 0.23 | 0.49 (4.02) | 0.16 (2.26) | 0.00 (0.00) | 0.32 (3.24) | 0.24 (2.82)x |
| Aug, 2013 | 0.44 | 2.32 (8.75) | 1.54 (7.12) | 0.69 (4.75) | 1.97 (8.07) | 1.63 (7.33)s |
| Sep, 2013 | 0.01** | 2.75 (9.54)a | 0.94 (5.58)b | 0.55 (4.26)b | 2.33 (8.78)ab | 1.64 (7.36)s |
| Oct, 2013 | 0.22 | 2.58 (9.24) | 1.76 (7.62) | 1.21 (6.31) | 2.29 (8.71) | 1.96 (8.05)qr |
| Nov, 2013 | 0.67 | 2.69 (9.44) | 1.93 (7.99) | 1.59 (7.24) | 2.19 (8.51) | 2.10 (8.33)qr |
| Dec, 2013 | 0.10 | 3.66 (11.03) | 2.24 (8.60) | 1.05 (5.87) | 3.56 (10.87) | 2.63 (9.32)pq |
| Jan, 2014 | 0.52 | 3.50 (10.77) | 2.79 (9.61) | 2.24 (8.60) | 3.15 (10.22) | 2.92 (9.83)p |
| Feb, 2014 | 0.27 | 2.86 (9.74) | 2.06 (8.24) | 1.38 (6.76) | 2.50 (9.10) | 2.20 (8.53)q |
| Year round Mean | | 2.40 (8.92) | 1.45 (6.92) | 0.91 (5.46) | 2.04 (8.20) | 1.70 (7.49) |

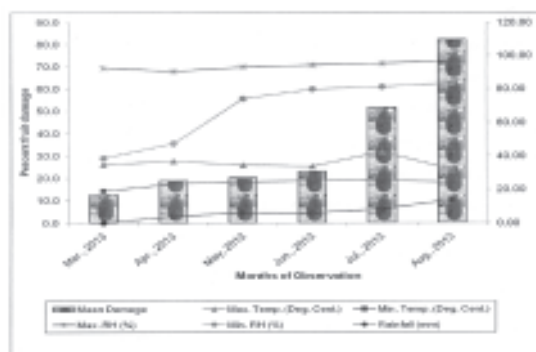


Fig. 2. Damage by *D. caesalis* in fruits of jackfruit along with meteorological parameters in different months of observation.

to 3.56% (December, 2013), in the western face the range of percent damage was 0.16% (July, 2013) to 2.79% (January, 2014). The damage varied from 0.0% (July, 2013) to 2.24% (January, 2014) in the northern face of the plant canopy. The effect of face direction of the plant canopy of jackfruit on the extent of damage by the shoot borer as depicted in Table 2 shows that, among the twelve months of observation, significant difference of canopy face means on the damage has been obtained in both the months of March and September, 2013. From this test it can be stated that in the month of March, 2013, the eastern face of the plant canopy had significantly more damaged shoots than the remaining faces of the plant canopy, while in the month of September, 2013, the eastern face of the plant canopy had significantly more damaged shoots than the western and northern faces, however, in this month, the shoot damage in the Eastern and southern face as well as that of the southern,

western and northern faces are statistically at par. The result of the present study was almost in conformity with the results of Chakraborty et al. [4] and Meetei [8]. Both of these earlier works recorded the highest damage of the pest in the month of January and the least damage in June, though Meetei [8] observed significantly highest damage in the eastern face least damage both in the western and northern face of the plant canopy. However, Bai and Marimadaiah [12] recorded severe infestation by *Diaphania* sp. in October to December, though the species of *Diaphania* was different.

It can be said from the present findings that January is the peak period of infestation of the pest as well as the eastern face of the plant canopy is more prone to be infested.

Incidence of *D. caesalis* in fruits

Incidence of *D. caesalis* in fruits of jackfruit has been recorded from March, 2013 to August, 2013 i.e. the pest has been observed to damage fruits only for six months (Table 3 and Fig. 2) and the infestation ranged from 12.69% to 82.22%. No fruit has been observed to be damaged by this pest from September to February, 2013. During these six months of occurrence in fruits (March to August), maximum fruit damage (82.22%) was recorded in the month of August, 2013 (average maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall were 31.65°C, 24.34°C, 96.77%, 83.51% and 13.81 mm, respectively) while the minimum fruit damage (12.69%) was recorded in the month of March (average maximum temperature, minimum temperature, maximum relative humidity, minimum relative humidity and rainfall were 34.81°C, 19.06°C, 92.29%, 38.54% and 0.00 mm, respectively). The initiation of incidence

Table 3. Extent of fruit damage by *D. caesalis* on jackfruit in different months of observation.

| Months of observation | Mean damage (%) | Months of observation | Mean damage (%) | Months of observation | Mean damage (%) |
|-----------------------|-----------------|-----------------------|-----------------|-----------------------|-----------------|
| Mar 2013 | 12.69 | Jul 2013 | 51.47 | Nov 2013 | 0.00 |
| Apr 2013 | 18.76 | Aug 2013 | 82.22 | Dec 2013 | 0.00 |
| May 2013 | 20.13 | Sep 2013 | 0.00 | Jan 2014 | 0.00 |
| Jun 2013 | 23.11 | Oct 2013 | 0.00 | Feb 2014 | 0.00 |

Table 4. Correlation between meteorological parameters (monthly average) and the extent of damage by *D. caesalis*. ** Significant at 1% level.

| Meteorological parameters | Values of correlation coefficient | | | | | % Fruit damage |
|---------------------------|-----------------------------------|---|----------|----------|----------|----------------|
| | East | % Shoot damage in different faces of plant canopy | | | Mean | |
| | | West | North | South | | |
| Max Temp | -0.792** | -0.915** | -0.844** | -0.873** | -0.902** | 0.517 |
| Min Temp | -0.747** | -0.888** | -0.860** | -0.769** | -0.854** | 0.552 |
| Max RH | 0.229 | 0.368 | 0.305 | 0.377 | 0.335 | 0.010 |
| Min RH | -0.504 | -0.451 | -0.415 | -0.360 | -0.459 | 0.441 |
| Rainfall | -0.497 | -0.520 | -0.553 | -0.444 | -0.527 | 0.686** |

of this pest in fruits took place during March which may be due to their preference to the tender inflorescence and young fruits during this time instead of shoots. Earlier Chakraborty et al. [4] and Meetei [8] reported occurrence of maximum damage on fruit by this pest during June and minimum during January. This may probably due to the presence of late maturing cultivars of jackfruit in the orchard.

Therefore, this study concludes that the incidence of the pest in fruits of jackfruit takes place for

six months in a calendar year (from March to August) and the infestation ranges from 12.69% (March) to 82.22% (August).

Impact of weather factors on the shoot damage by *D. caesalis*

Table 4 shows that, among the five meteorological parameters taken into consideration, highly significant correlation exists between maximum temperature

Table 5. Stepwise regression results for explaining extent of damage by *D. caesalis* on the basis of the significant meteorological parameters. Y=Percent shoot damage ; X_1 = Maximum temperature ; X_2 = Minimum temperature ; X_3 = Maximum relative humidity ; X_4 = Minimum relative humidity ; X_5 = Rainfall \$ Figures in parentheses are standard error of regression coefficient, # Regression coefficient.

| Extent of damage | Faces of plant canopy | Stepwise selection | Regression equation | R^2 |
|------------------|-----------------------|--------------------|---|--|
| Shoot | East | Step-I | $Y = -0.148X_1 + 7.115\#$ \$ (0.036) (1.164) | 0.6265 |
| | | Step-II | $Y = -0.134X_1 - 0.021X_4 + 8.043$ (0.033) (0.010) (1.123) | 0.7408 |
| | West | Step-I | $Y = -0.135X_1 + 5.754$ (0.019) (0.606) | 0.8376 |
| | | Step-II | $Y = -0.127X_1 - 0.012X_4 + 6.309$ (0.016) (0.005) (0.542) | 0.9030 |
| | North | Step-I | $Y = -0.099X_2 + 2.910$ (0.019) (0.389) | 0.7397 |
| | | Step-II | $Y = -0.054X_1 - 0.059X_2 + 3.814$ (0.032) (0.029) (0.647) | 0.8017 |
| | South | Step-I | $Y = -0.152X_1 + 6.881$ (0.027) (0.867) | 0.7619 |
| | Mean | Step-I | $Y = -0.135X_1 + 6.009$ (0.021) (0.662) | 0.8129 |
| | | Step-II | $Y = -0.126X_1 - 0.013X_4 + 6.598$ (0.017) (0.006) (0.602) | 0.8844 |
| | Fruit | | Step-I | $Y = 3.754X_5 - 0.324\#$ \$ (1.259) (8.196) |

and minimum temperature with the mean percentage of shoot damage irrespective of the four faces of jack-fruit by *D. caesalis*. The analyzed data indicated that maximum temperature ($r = -0.902$) and minimum temperature ($r = -0.854$) were negatively correlated with the mean percentage damage done by the pest. These two parameters also showed their significant negative correlation with the damage in all of the faces of the plant canopy. However, the meteorological parameters viz. maximum RH, minimum RH and rainfall showed non-significant correlation with the mean percentage damage by the pest species, though, maximum RH had positive correlation and the rest two (minimum RH and rainfall) had negative correlation with the pest damage. Meetei [8] also reported the similar kind of negative correlation with the temperature and pest damage, though she found existence of significant negative correlation between the rainfall and pest damage. Pozo et al. [13] also established a negative correlation of precipitation with the incidence of *Diaphania* sp. though the pest species as well as the crop plants were different in their experiment. The positive correlation between the relative humidity and the *Diaphania* sp. infestation was earlier established by Gowda et al. [14] though the species of *Diaphania* as well as the test crop were different. Chakraborty et al. [4] found significant positive correlation of maximum RH with the damage by *D. caesalis*.

The analyzed data presented in Table 5 reveals that extent of shoot damage done by *D. caesalis* in all the faces of plant canopy as well as the mean damage can be predicted best by maximum temperature when only single regressor has been selected by the analysis itself (Step-I) excepting the damage in northern face where, minimum temperature shows its superiority over other parameters. Only maximum temperature (X_1) can predict the damage up to 62.65% in eastern face, 83.76% in western face, 76.19% in southern face as well as 81.29% on mean damage, while, minimum temperature (X_2) as the best regressor having the capability of prediction up to 73.97% damage in northern face of the plant canopy. Again, analysis of Step-II presents that minimum relative humidity (X_4) along with maximum temperature (X_1) can predict the shoot damage up to 74.08% in eastern face, 90.30% in western face and 88.44% when the mean

damage had been considered. The exceptional case has been observed in the northern face of the plant canopy where, in Step-II, the maximum and minimum temperatures (X_1 and X_2) together are the best regressors for predicting the damage (prediction up to 80.17%). However, regression analysis simply ignores other parameters itself excepting maximum temperature (X_1) while analyzing prediction of damage in southern face of the canopy and therefore, Step-II analysis was not required. Therefore, it may be concluded from the regression analysis that only maximum temperature can predict the extent of shoot damage by *D. caesalis* significantly better than the rest of the weather parameters while, minimum relative humidity and minimum temperature have the potentiality to be better predictor for describing the shoot damage. Meetei [8] also reported earlier that minimum temperature singly can describe the shoot damage in the southern face of the canopy by the pest up to 93.1% while, Chakraborty et al. [4] observed that maximum temperature was one of the best regressors to predict the pest damage.

Impact of weather factors on the fruit damage by *D. caesalis*

Table 4 shows that, among the five meteorological parameters taken into consideration, highly significant correlation exists between rainfall and the mean percentage of fruit damage by *D. caesalis*. The analyzed data indicated that rainfall ($r = -0.686$) was positively correlated with the mean percentage damage done by the pest. However, other meteorological parameters viz. maximum temperature, minimum temperature, maximum relative humidity and minimum relative humidity showed non-significant positive correlation with the mean percentage damage on fruits by the pest species.

The stepwise regression analysis as presented in Table 5 reveals that among five meteorological parameters taken into consideration, rainfall was the best regressor to predict the fruit damage by *D. caesalis* up to 47.05% and the absence of Step-II analysis signifies that rainfall only can predict the

extent of fruit damage by this pest significantly better than the rest of the weather parameters.

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