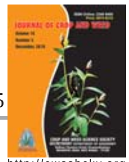
Journal of Crop and Weed, 16(1): 229-235 (2020)
ISSN- O : 2349 9400 ; P : 0974 6315



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Effect of environmental factors on the seasonal incidence and infestation of *Leucinodes orbonalis* Guenee in summer brinjal under North Central Plateau Agro-climatic Zone of Odisha

U. S NAYAK, [1]K. RATH AND A. KHUNTIA

Regional Research and Technology Transfer Station (RRTTS), Ranital-756111
[1]College of Agriculture, Siripur, Bhubaneswar-751003
Orissa University of Agriculture and Technology, Odisha, India

Received : 17.05.2020 ; Revised : 28.06.2020 ; Accepted : 29.06.2020

DOI: https://doi.org/10.22271/09746315.2020.v16.i1.1298

ABSTRACT

The seasonal incidence and damage intensity of Leucinodes orbonalis and their relationship with different weather parameters was observed during the summer seasons of 2010 and 2011 at Keonjhar, Odisha. The peak moth activity was recorded during 14th and 19th SMW in 2010 and during 13th and 19th SMW in 2011, whereas, the maximum larval population of L. orbonalis was observed one week after the maximum adult activity in each case. The shoot damage was initiated from 4th SMW in both the years and the highest shoot damage was observed during 13th SMW in 2010 and during 12th SMW in 2011. However, the peak infestation on flower buds and fruits occurred during 15th and 20th SMW in 2010 and on 14th and 20th SMW during 2011, respectively. In all the cases the peak incidence and infestation stage has coincided with higher atmospheric temperature. From the correlation study it was established that all the temperature factors (maximum, minimum and average) influenced positively and relative humidity had a negative influence on the population build up and infestation of L. orbonalis. Besides, among the environmental parameters temperature and relative humidity had maximum contribution towards the variation in the incidence and infestation of Leucinodes orbonalis.

Keywords: Brinjal, environmental parameters, *Leucinodes orbonalis*, seasonal incidence,

Brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* Guenee is the most serious insect pest of brinjal, widely distributed in the Indian subcontinent causing considerable yield and economic losses (Kumar *et al*., 2017). The apparent yield loss due to BSFB varies from 20-90 per cent in different parts of the country (Raju *et al*., 2007) and over 90 per cent of fruits can be damaged in the years of heavy infestation (Dhandhapani *et al*., 2003). This pest is reported to cause 47.6- 85.8 per cent damage to fruits in Odisha condition (Patnaik, 2000). During the initial stages the larvae feed mostly on the tender shoots and flower buds and later they bore into the fruits reducing the yield and market value of the crop. To minimize the pest incidence farmers mostly rely on the chemical pesticides and as a result of the indiscriminate use of various synthetic insecticides both alone and in combination, there has been a serious adverse impact on the human health and surrounding environment. Hence, early detection of the pest and adoption of deliberate plant protection measure just before its peak activity is highly essential to minimize the loss in marketable fruit yield in brinjal. Use of sex pheromone traps are gaining popularity to monitor the seasonal activity of *L. orbonalis* in order to schedule the appropriate time of plant protection measures (Tiwari *et al*., 2009). Besides, weather is known to exercise an important role in insect pest occurrence and influence its seasonal fluctuation and infestation level. Thus, a comprehensive knowledge on the relationship between various weather parameters and seasonal incidence and infestation of BSFB in a particular locality is crucial for development of effective management strategies. The present study aimed to have an understanding on the seasonal incidence of BSFB and the influence of various environmental parameters on its incidence and infestation pattern. Though two seasons data are not sufficient to establish a valid relationship between the fluctuation in abundance and infestation of BSFB with weather parameters, it will give a preliminary idea about the influence of different abiotic factors on the seasonal variation in BSFB.

MATERIALS AND METHODS

Experiments were conducted in the instructional farm of Krishi Vigyan Kendra, Keonjhar, Odisha during summer 2010 and 2011. Thirty days old brinjal seedlings (variety Blue Star) were transplanted in the experimental plots of 10 x 5 m size during 9th to 12th January with the standard agronomic package of practices. The seasonal activity of *L. orbonalis* was monitored by installing pheromone traps from the pheromone traps installed in the unprotected brinjal plots and the trap catches were

Email : usnayak74@gmail.com

recorded as number of male moths per trap per week. In each plot five numbers of funnel traps were installed at a distance of 5 m with the lure position just above the crop canopy. Week wise larval population from shoot, flower bud and fruit was recorded as average number of larvae/ plant/week from 10 randomly selected plants from the initiation of damage and expressed as larval intensity. Besides, per cent infestation of shoots, flower buds and fruits were recorded from 10 randomly selected plants in weekly interval. The environmental factors like maximum temperature, minimum temperature, relative humidity (morning and evening) and rainfall were recorded from the automated weather station, Regional Research and Technology Transfer Station, Keonjhar located 50 m away from the experimental site during the crop growth period to study the impact of different weather variables on the incidence and damage of BSFB. The weather variables were subjected to multiple correlation analysis with the trap catch, larval intensity, shoot damage, flower bud damage and fruit damage to study their relationship whereas, regression analysis was taken up to determine the contribution of each weather parameter on the seasonal activity and damage. In all the cases of analysis, the weather variables prevailed during the previous standard week were correlated and regressed with the population and damage level recorded in the succeeding week.

RESULTS AND DISCUSSION

Seasonal fluctuation in abundance and infestation of BSFB

The seasonal activity of *L. orbonalis* in terms of adult moth population trapped in the pheromone traps, the corresponding larval population in terms of larval intensity, infestation expressed as shoot damage, flower bud damage and fruit damage in different standard weeks have been studied and presented in Table 1 and Fig. 1 and 2. It was observed that the adult moth first appeared during 3rd SMW (3rd week of January) in both the years and the pest attained the first peak in 14th SMW (first week of April) during 2010 with 9.6 male adults insects/ trap/ week. In 2011, the same was observed in 13th SMW (last week of March) with 9.2 male adults/trap/week. Thereafter the trap catch showed a gradual declining trend and then again attained the second peak during 19th SMW (2nd week May) with 9.2 and 9.0 male adults/ trap/week in both the years of study, respectively. Samal (2008) also reported that under Bhubaneswar condition, the pheromone trap catches showed two distinct peaks i.e. on 15th SMW (9.5 adults/trap/week) and on 19th SMW (10.7 male adults/trap/week) and therefore, the present finding lie in close conformity with the above findings. However, the peak larval intensity was recorded one week after the peak adult trap catch in both the years of experiment.

The infestation of BSFB on brinjal shoot started from 4th SMW (4th week of January) *i.e*. 18 DAT during both 2010 and 2011 and continued up to the end of the crop period. Highest shoot damage to the tune of 43.35 % was observed during 13th SMW in 2010 and to the extent of 41.64 per cent shoot damage during 12th SMW in 2011. The flower buds infestation was noticed for the first time on 6th SMW (2nd week of February) *i.e*. 33 DAT in both the years of investigation with two peak infestation levels during the crop period. The initial peak was observed on 15th SMW (2nd week of April) with 40.33 per cent flower bud damage during 2010 and on 14th SMW (first week of April) during 2011 with 38.42 per cent floral damage. However, the second peak was attained on 20th SMW (3rd week of May) in both the years with 37.55 and 36.29 per cent incidence respectively. However, the fruit infestation started on 8th SMW (fourth week of February) i.e. 47 DAT in both the years. The highest fruit damage was observed on 15th SMW (2nd week of April) in 2010 with 51.25 per cent fruit damage, while during 2011, the damage was noticed in 14th SMW (1st week of April) with 47.68 per cent fruit infestation. The fruit infestation decreased gradually and again gathered momentum with second peak on 20th SMW (3rd week of May) in both the years of observation with 41.85 and 45.24 per cent fruit damage in 2010 and 2011, respectively. It was evident from two years observation that in summer season the fruit infestation was higher during second fortnight of March to second fortnight of May. It has been also evident that the abundance and infestation of the insect was increasing along with the increase in temperature during both the years of experiment (Fig. 3 and 4). These results are in close conformity with the findings of Sasmal (1997) who reported that there are two definite peak fruit infestation levels during the summer season. The first peak was observed during fourth week of March with 69.12 per cent fruit damage and the second peak was attained during fourth week of May with 85.0 per cent fruit infestation. The present findings also had some similarity with the findings of Patel *et al*., 2015 who observed that the shoot infestation was observed from last week of February to third week of April with maximum in fourth week of March whereas, fruit damage was noticed first at last week of March with maximum in the first week of June.

Correlation of environmental factors with the seasonal incidence and infestation of BSFB

The multiple correlation analysis with the pooled mean values of the weather parameters and the insect abundance and infestation during two years of

Table 1:Seasonal fluctuation in abundance and infestation of BSFB

SMW	Pheromone trap catch (No. trap^{-1} week^{-1})		Larval intensity (No.plant^{-1}week^{-1})		Shoot damage (%)		Flower bud damage (%)		Fruit damage (No basis) (%)	
	1st Year	2ndYear	1st Year	2ndYear	1st Year	2ndYear	1st Year	2ndYear	1st Year	2nd Year
3	2.60	1.80								
4	2.40	2.40	0.30	0.30	7.34	9.23				
5	2.80	3.40	0.50	0.50	11.58	13.84				
6	3.00	3.00	0.80	0.70	16.33	14.37	7.36	4.88		
7	4.20	4.20	1.10	1.10	23.00	19.76	11.58	7.64		
8	4.60	4.80	1.40	1.40	22.45	29.85	18.54	13.44	14.24	9.86
9	5.60	4.20	1.90	1.40	29.28	22.66	21.28	11.33	19.56	11.25
10	6.80	6.00	2.20	2.10	34.28	34.58	28.24	19.45	26.33	20.88
11	7.20	7.00	2.60	2.60	38.66	38.60	31.25	28.55	31.56	31.64
12	7.40	7.80	2.80	2.70	35.46	41.64	29.46	30.38	28.66	36.29
13	8.20	9.20	3.10	2.90	43.35	39.84	32.52	36.59	34.84	44.74
14	9.60	8.60	3.10	3.20	34.58	31.25	35.27	38.42	41.67	47.68
15	9.20	8.20	3.40	2.70	31.78	24.14	40.33	31.66	51.25	39.39
16	8.80	7.40	3.00	2.20	29.85	25.86	33.25	28.74	42.56	37.62
17	8.80	6.80	2.90	2.10	29.25	26.14	34.28	27.45	40.48	34.87
18	8.20	5.80	2.60	1.90	23.24	19.56	29.26	23.24	32.78	31.28
19	9.20	9.00	2.20	2.40	19.56	23.24	27.34	31.72	29.58	38.16
20	8.60	8.80	3.20	2.90	23.45	26.26	37.55	36.29	41.85	45.24
21	7.80	8.20	2.60	2.40	17.24	19.78	31.38	29.25	30.34	41.68
22	5.20	6.40	1.70	2.00	13.56	18.22	24.54	24.27	24.46	34.25
23	4.80	5.20	1.50	1.70	11.56	15.33	20.29	20.23	21.28	26.87
24	3.80	3.40	1.10	1.30	9.22	13.86	14.37	16.84	18.76	20.35

Note:S.W- Standard week

Table 2: Correlation of weather parameters with the abundance and infestation of BSFB (Pooled data)

Abiotic factors	Correlation Coefficient value (r)				
	Pheromone trap catch	Larval Intensity	Shoot damage	Flower bud damage	Fruit Damage
Maximum Temperature(^{o} C)	0.830*	0.779*	0.317	0.780*	0.757*
Minimum Temperature(^{o} C)	0.702*	0.646*	0.103	0.613*	0.515*
Average Temperature(^{o} C)	0.771*	0.730*	0.203	0.699*	0.641*
Rainfall(mm)	0.188	0.173	0.192	0.082	0.122
RH (%)(Morning)	- 0.662*	-0.638*	-0.629*	-0.615*	-0.640*
RH (%) (After noon)	- 0.646*	-0.664*	-0.616*	-0.657*	-0.603*

*Note: * Significant at 0.05 level*

investigation indicated a strong positive correlation between the adult catch and temperature variables (r = 0.702 to 0.830) (Table 2). While, rainfall did not influence the trap catch significantly, relative humidity (both morning and afternoon) was negatively correlated with the adult population level of BSFB (r= -0.662 and - 0.646). Shukla and Khatri (2010) also observed that both maximum and minimum temperature had positive correlation and relative humidity had negative correlation with the adult moth population of *L. orbonalis* and thus supported the findings of the present investigation. Similarly, a significant positive correlation was observed between temperature variables and larval intensity (r =0.646 to 0.779) and the relative humidity had negative influence on the variation of larval population (r = -0.638 and – 0.664).

All the temperature factors (maximum, minimum and average) exerted a positive impact on shoot infestation, but the impact was found to be insignificant. However, a significant negative influence was visualized between

Table 3: Multiple interactions of weather parameters on the abundance and infestation of BSFB (Pooled)

Abundance and infestation of BSFB	Coefficient of determination (R^2)	Prediction equation	Per cent Contribution #					
			Max. Temp. (º C)	Min. Temp. (º C)	Avg. Temp. (º C)	Rainfall (mm)	RH % (Morning)	RH % (After noon)
Adult trap catch	0.802	Y= -22.6+1.076 X1- 0.501 X2+ 0.055 X4 + 0.203 X5-0.208 X 6	73.25 (1.81)	20.65 (0.961)	-	0.06 (-0.052)	3.16 (0.376)	2.88 (0.359)
Larval Intensity	0.794	Y= -12.91+0.573 X1- 0.338 X2+ 0.06X4 + 0.106 X5-0.096 X 6	63.09 (2.382)	31.35 (-1.679)	-	0.25 (0.151)	3.04 (0.523)	2.26 (-0.451)
Shoot damage	0.560	Y= -120.86 +7.654 X1- 6.382 X2+ 1.542 X4 + 0.524 X5-0.566 X 6	49.57 (2.929)	49.03 (-2.913)	-	0.73 (0.356)	0.33 (0.238)	0.35 (-0.245)
Flower bud damage	0.749	Y = -140.66+ 6.119 X1-3.242 X2+ 0.616 X4 +1.110 X5 -1.040 X6	63.59 (2.004)	27.84 (-1.326)	-	0.34 (0.147)	4.57 (0.537)	3.66 (-0.481)
Fruit damage	0.726	Y= -235.95 + 8.859 X1 – 4.717 X2+ 0.263 X4 +1.034 X5 -0.354 X6	67.51 (2.251)	29.08 (-1.48)	-	0.04 (0.056)	3.05 (0.479)	0.31 (-0.154)

Note:
 # Contribution of different abiotic factors to abundance and infestation of BSFB
Note: Per cent contribution of individual abiotic factor = $[(\hat{a}_i)^2 / d(\hat{a}_i)^2 \ldots\ldots\ldots (\hat{a}_j)^2]$ *X 100*
(Figures in the parentheses are the standardized partial regression coefficient values, â)
Y = Pheromone trap catch
X_1 = *Maximum Temperature (ºC),* X_2 = *Minimum Temperature (ºC),* X_3 = *Average Temperature (ºC),* X_4 = *Rainfall (mm)*
X_5 = *Morning Relative Humidity (%),* X_6 = *Afternoon Relative Humidity (%)*

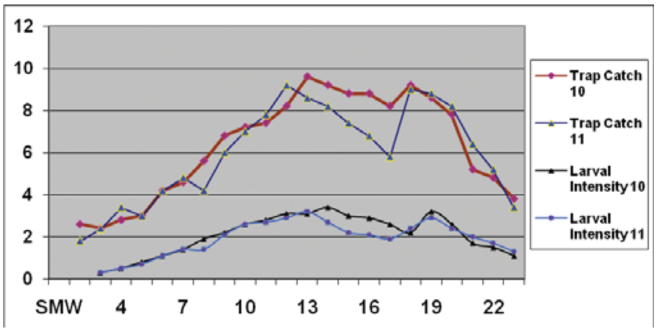

Fig. 1: Seasonal variation in adult and larval population of BSFB

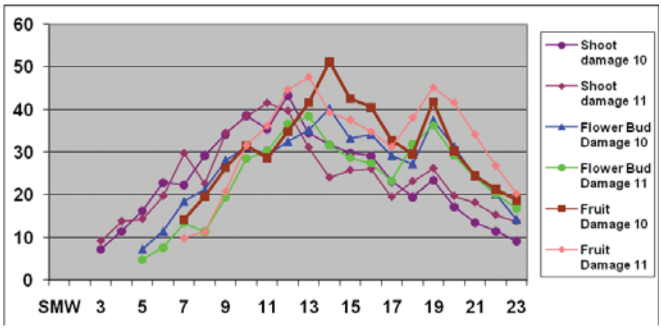

Fig. 2: Seasonal variation in infestation level of BSFB

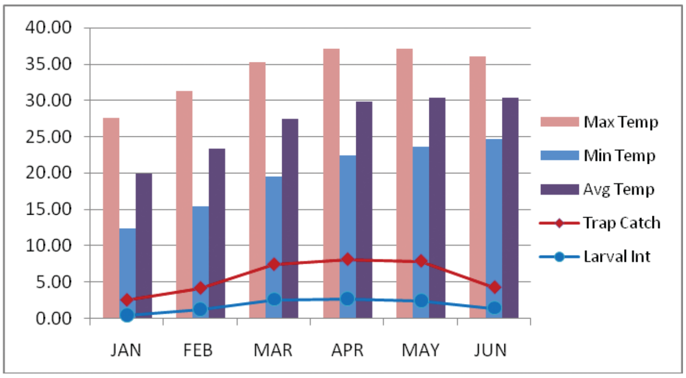

Fig. 3: Seasonal variation in mean adult and larval population of BSFB in relation to the fluctuation in corresponding temperature variables

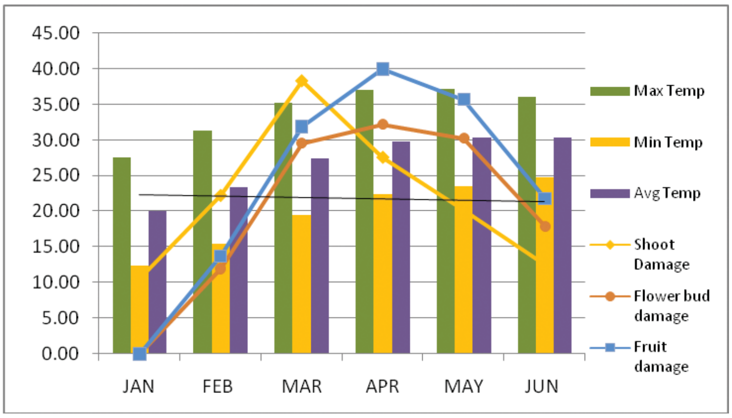

Fig. 4: Seasonal variation in the infestation pattern of BSFB in relation to the fluctuation in corresponding temperature variables

the relative humidity (R.H) and shoot infestation (r = -0.629 and -0.616) (Table 2). The significant positive effect of maximum, minimum and average temperature on the flower bud infestation was visualized with the correlation coefficient values ranging from 0.613 to 0.780. In contrast R.H (both morning and afternoon) imparted a significant negative influence on the pest infestation on flower bud (r = - 0. 615 and - 0.657). Similarly, a strong correlation was noticed between the temperature variables and fruit infestation with correlation coefficient values ranging from 0.515 to 0.717 depicting the important role of temperature in governing the fruit infestation level in brinjal. Relative humidity was found to exert negative influence on the fruit damage (r= -0.640 and -0.603). The role of rainfall on the incidence and infestation of BSFB was not at all conspicuous and exerted a non-significant effect during both the years of observation. The present findings are in agreement with the opinion of Rao and Bhavani (2010) who reported that fruit borer incidence had positive correlation with maximum and minimum temperature and negative correlation with maximum relative humidity. Kaur *et al.,* 2014 also reported that the caterpillar population showed positive and negative correlation with temperature and relative humidity, respectively. Further Maru and Kumar, 2018 opined that fruit infestation had positive influence with maximum temperature and sun shine hours and negative relationship with evening relative humidity and evening cloud cover.

Multiple interactions of environment factors with the seasonal incidence and infestation of BSFB

The multiple regression analysis based on the pooled mean values of two years of investigation indicated that the combined contribution of weather parameters on the pheromone trap catch was estimated to be 80.2 % (R^2 = 0.802), whereas maximum temperature was found to be the most important factor contributing 73.25 % towards fluctuation of trap catch followed by minimum temperature (20.65 %) (Table 3). Similarly, the larval population of *L. orbonalis* was also significantly influenced by various weather factors as evidenced by the higher coefficient determination value (R^2) of 0.794. Major contribution to the variation of larval population was exerted by maximum temperature (63.09 %) followed by minimum temperature (31.35 %), whereas, other abiotic factors have very negligible effect on it. Regarding the cumulative effect of all the weather factors on shoot damage, it was observed that the abiotic factors influence to the tune of 56.0 % (R^2 = 0.560). In respect of relative importance of weather parameters maximum and minimum temperature had almost equal percentile contribution (49.57 and 49.03 %, respectively) towards the shoot infestation. The results of the experiment derived ample support from the findings of Pramanik (2010), who opined that during 2003-04 the highest contribution was made by maximum temperature (94.55%) on the shoot damage whereas, during 2004-05 minimum temperature exerted maximum influence on shoot damage (82.75 %). As far as the combined effect of weather parameters on flower bud damage is concerned, all the weather parameters governed the flower bud damage to the tune of 74.9 per cent (R^2=0.749) and maximum temperature exhibited highest contribution (63.59 %) towards the flower bud infestation followed by minimum temperature (27.84 %). The collective impact of all the abiotic factors on fruit infestation was estimated to be 72.6 per cent and maximum temperature exerted highest influence with 67.51 per cent role in fruit infestation followed by minimum temperature (29.08 %). The findings of the experiment are in accordance with the findings of Pramanik (2010), who opined that during the year maximum and minimum temperature produced major contribution on the fruit damage in brinjal. Maru and Kumar (2018) observed that the contribution of all the climatic factors on larval incidence was 70.30 per cent whereas, on fruit damage it was 76.7 per cent which substantiated the present findings of higher contribution of weather variables on the incidence and infestation of brinjal shoot and fruit borer.

From the above experiment it may be concluded that during summer season the adult moths of BSFB appeared from 9 and 11 days after transplanting (DAT) and prevailed throughout the crop period with two distinct peak levels *i.e.* one during last week of March to first week of April and other at 2nd week of May. However, the highest larval population of BSFB was observed one week after the peak adult trap catch in both the years of experiment. The pest infestation on shoots started from 4th week of January *i.e*. 18 DAT and continued up to the end of the crop period with highest shoot damage during last week of March to first week of April. While, the flower buds infestation was noticed for the first time during 2nd week of February, the fruit damage started from fourth week of February. However, the peak flower bud and fruit infestation was noticed during first fortnight of April to 3rd week of May. Among the parameters temperature had positive and relative humidity had negative effect on the population variation and damage of BSFB and both ecological parameters had maximum contribution towards the seasonal variation in pest incidence and infestation.

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