https://doi.org/10.17221/3/2024-PPS

Brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) seasonal activity and association with abiotic factor

Prince Mahore[1*], *Nikki Bhardwaj*[1], *Pradyumn Singh*[2], *Mitesh Makwana*[1], *Dheerendra Mahor*[1], *Naveen*[1], *Neeraj Kumar*[3], *Sitaram Seervi*[1], *Sonu Sharma*[4]

[1]*Department of Entomology, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India*

[2]*Department of Entomology, College of Agriculture, Khandwa, Madhya Pradesh, India*

[3]*Department of Entomology, Jawaharlal Nahru Krishi Vishwa, Jabalpur, Madhya Pradesh, India*

[4]*Department of Plant Pathology, Rajmata Vijayaraje Scindia Krishi Vishwa Vidyalaya, Gwalior, Madhya Pradesh, India*

**Corresponding author: princemahore30@gmail.com*

Citation: Mahore P., Bhardwaj N., Singh P., Makwana M., Mahor D., Naveen, Kumar N., Seervi S., Sharma S. (2025): Brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) seasonal activity and association with abiotic factor. Plant Protect. Sci., 61: 183–190.

Abstract: The study has been conducted at Research Farm, College of Agriculture, Gwalior (M.P.), in the summers of 2021 and 2022. In the summers of 2021 and 2022, the crop was first infested by the shoot and fruit borer on the 10th and 13th standard meteorological week (SMW). The infestation persisted until the 23rd and 24th SMW, respectively. During the first year, the 15th SMW had the highest infestation rate for shoot damage, 15.76%, while the 18th SMW had the highest infestation rate for shoot damage, 15.07%, in the second year. Whereas fruit damage per cent is calculated based on number and weight, and its peak per cent infestation was noted on the 22nd SMW with 31.67% based on number, 30.12% based on weight during the first year, and 30.34% based on number and 29.95% based on weight during the second year, which was noted on the 23rd SMW. There was a significant positive correlation between maximum temperature and shoot damage percentage (r = 0.62) and minimum temperature and fruit damage percentage based on number (r = 0.87) and weight (r = 0.88) during the first year of study. However, during the first year of the study, there was a negative association (r = –0.68) between morning relative humidity and shoot damage per cent. The following year's research revealed a highly significant positive link between maximum temperature, minimum temperature, and evaporation with fruit damage (%) based on the number (r = 0.64, 0.92, and 0.82) and based on weight (r = 0.63, 0.92, and 0.82), respectively.

Keywords: standard metrological week; shoot damage; fruit damage; peak population; correlation

Brinjal (*Solanum melongena* L.) is one of the most economically important horticultural crops grown in many parts of India. Various pests that attack the brinjal crop are brinjal shoot and fruit borer (BSFB), stem borer, whitefly, leafhopper, aphid, epilachna beetle, lacewing bug and red spider mite (Borkakati et al. 2019). Among these, BSFB (*Leucinodes orbonalis*) is one of the most destructive pests and is of prime importance. The yield reduction due to its attack could be as high as 70% (Dhan-

https://doi.org/10.17221/3/2024-PPS

dapani et al. 2003). Climate change is the long-term changes in the weather patterns in a region. Apart from directly affecting plant productivity, it can also influence productivity through indirect effects mediated by changes in pests and diseases (Thomson et al. 2010). Climate can act directly on an insect as a mortality factor or by determining insect growth rate and/or development (Bale et al. 2002). Climate affects the abundance and distribution of any species, affecting insect migration and outbreaks (Parmesan 2007; Speight et al. 2008).

Brinjal crops are damaged by several insect pests that can cause considerable damage, which renders the fruit unfit for human consumption (Singh & Abrol 2001). Aphids are one of the most harmful non-indigenous threats to agriculture. The direct consequences of an aphid infestation include production losses, a decline in quality and increased agricultural risks (Miller et al. 2009). The aphid population has increased in the last few years, becoming a common pest in Pakistan (Aheer et al. 2008). The nymphs and adults suck the sap from the leaves and tender shoots, and plants become weak, pale and stunted, which reduces the fruit size (Ghosh et al. 2004). Meteorological parameters play a pivotal role in the biology of pests. Temperature is the most crucial abiotic factor affecting any organism's life economy. However, no single climatic factor governs pests' activity because weather elements' effects on pests are generally confounded (Narendra et al. 2001). The level of sunshine, rainfall, relative humidity and wind speed are the other chief weather parameters that largely control the activity of a given insect species. The association between pest activity and abiotic factors can help to derive predictive models that facilitate the forecasting of pest incidence (Chandrakumar et al. 2008).

MATERIAL AND METHODS

The experiments on Brinjal (*S. melongena* L.) Shoot, and Fruit Borer (*L. orbonalis* Guenee) seasonal activity and association with abiotic factors were conducted at the Research Farm, College of Agriculture, Gwalior, during the Summer 2021 and 2022. For observing shoot and fruit borer seasonal activity as per shoot damage (%) and fruit damage (%) on the basis of number and weight and correlation with abiotic factor, the brinjal variety Pusa Safed Baigen was transplanted in a separate field plot measuring 9 × 3.6 M size on February 14 and 21, during 2021 and 2022, respectively. Ten plants were selected randomly in each plot to record the pest population. Observations were recorded regularly on these plants at weekly intervals, starting from 15 days after transplanting in respective years till the crop harvest. Observation on seasonal activity of shoot and fruit borer was recorded on randomly selected ten plants in each replication per plant. Shoot damage (%) and fruit damage (%) were counted randomly, as mentioned above, and their average population was recorded in the table. The data on the seasonal activity of aphids on different dates were correlated with prevailing minimum and maximum temperature, morning and evening relative humidity, total rainfall and evaporation based on correlation coefficients between the variables. Correlation and regression of the abiotic factors on shoot and borer per cent infestation were worked out using the formula suggested by Snedecor and Cochran (1989).

RESULTS

Shoot damage per cent. According to the first year of observation, the percentage of shoot damage began to be noted on the 10^{th} standard meteorological week (SMW). It continued through the twenty-third SMW, with its peak infestation (15.76% shoot damage) occurring on the fifteenth SMW, when the minimum and maximum temperatures and relative humidity in the morning and evening were respectively 18.7 °C, 40 °C, 49.5%, and 36.1% (Table 1). In contrast, during the second year of the study, the first infestation on the percentage of shoot damage was noted on the 11^{th} SMW and persisted through 24^{th} SMW, with its peak infestation (15.07% shoot damage) occurring on the eighteenth SMW, when the minimum and maximum temperatures and relative humidity in the morning and evening were 26.1 °C, 43.9 °C, 48.4%, and 24.7%, respectively (Table 2).

Fruit damage per cent based on the number. On the 15^{th} SMW of 2021, the first infestation on the % of fruit damage based on the number was noted, and it persisted through the 23^{rd} SMW. During the 22^{nd} SMW, when the minimum temperature, maximum temperature, morning relative humidity and evening relative humidity were 26.1 °C, 35.2 °C, 77.5%, and 35.2%, respectively,

https://doi.org/10.17221/3/2024-PPS

Table 1. Weekly metrological data and shoot and fruit borer infestation observation during the summer crop season of 2021

SMW	Weeks	Temperature		Humidity		Rainfall (mm)	Evaporation (mm)	Shoot damage (%)	Fruit damage number (%)	Fruit damage weight (%)
		max (°C)	min (°C)	morning (%)	evening (%)					
9	February 26–March 4	32.60	12.80	75.70	38.70	0.00	6.60	0.00	0.00	0.00
10	March 5–11	34.60	14.60	75.90	36.00	0.00	6.00	3.33	0.00	0.00
11	March 12–18	32.90	15.40	79.00	47.10	0.00	5.50	5.83	0.00	0.00
12	March 19–25	36.30	17.20	72.30	47.70	7.00	7.10	7.74	0.00	0.00
13	March 26–April 1	37.70	18.30	72.70	41.10	0.00	9.30	9.87	0.00	0.00
14	April 2–8	39.30	17.90	61.80	39.10	0.00	11.10	12.50	0.00	0.00
15	April 9–15	40.00	18.70	49.50	36.10	0.00	9.90	15.76	4.44	6.67
16	April 16–22	39.80	20.70	50.10	35.80	0.00	11.40	14.05	7.78	9.52
17	April 23–29	40.30	19.70	51.70	29.00	0.00	11.70	12.29	10.00	11.43
18	April 30–May 6	41.30	25.20	51.40	31.50	0.00	11.10	10.81	13.89	15.24
19	May 7–13	41.10	23.00	64.20	33.20	4.60	9.70	9.39	17.22	18.57
20	May 14–20	36.90	23.10	78.10	62.00	49.00	6.40	7.33	22.78	21.90
21	May 21–27	36.70	23.20	69.20	39.80	0.00	8.20	5.83	28.33	27.62
22	May 28–June 3	35.20	26.10	77.50	35.20	0.00	11.70	6.67	31.67	30.12
23	June 4–10	42.50	30.30	54.00	32.40	0.00	13.70	4.17	27.22	26.07

SMW – standard metrological weeks

the highest fruit infestation (31.67% fruit damage) was observed (Table 1). The next year, however, saw a similar increase in fruit damage on a percentage basis, starting on the 15th SMW and lasting

Table 2. Weekly metrological data and shoot and fruit borer infestation observation during the summer crop season 2022

SMW	Weeks	Temperature		Humidity		Rainfall (mm)	Evaporation (mm)	Shoot damage (%)	Fruit damage number (%)	Fruit damage weight (%)
		max (°C)	min (°C)	morning (%)	evening (%)					
10	March-5–11	29.90	13.30	83.00	47.00	0.000	4.80	0.00	0.00	0.00
11	March 12–18	33.60	15.40	86.00	38.00	0.000	6.60	3.33	0.00	0.00
12	March 19–25	37.00	14.10	53.40	29.70	0.000	7.50	5.01	0.00	0.00
13	March26–April 1	40.10	17.10	61.10	32.40	0.000	10.20	6.60	0.00	0.00
14	April 2–8	41.90	17.40	52.50	19.10	0.000	11.50	6.85	0.00	0.00
15	April 9–15	43.00	21.40	40.70	19.00	0.000	13.00	9.59	3.45	3.16
16	April 16–22	43.30	22.30	46.00	22.00	0.000	13.10	11.03	7.94	6.19
17	April 23–29	37.20	22.00	45.50	20.40	0.000	13.80	12.85	9.58	9.29
18	April 30–May 6	43.90	26.10	48.40	24.70	0.000	14.50	15.07	10.63	11.31
19	May 7–13	43.00	27.50	56.20	26.00	0.000	14.10	9.99	14.79	14.88
20	May 14–20	45.50	28.63	45.70	22.50	0.000	18.00	6.98	20.41	18.14
21	May 21–27	41.60	26.10	63.70	36.80	3.800	12.30	3.36	23.33	22.14
22	May 28–June 3	44.70	28.20	46.40	26.00	0.000	16.20	5.83	28.09	27.26
23	June 4–10	45.10	30.93	40.14	23.57	0.000	20.90	2.52	30.34	29.95
24	June 11–17	42.90	31.29	53.57	37.00	0.143	16.00	1.34	26.13	25.95

SMW – standard metrological weeks

https://doi.org/10.17221/3/2024-PPS

through the 24th SMW. During the 23rd SMW, when the minimum and maximum temperatures and relative humidity were 30.93 °C, 45.1 °C, 40.14%, and 23.57%, respectively, the highest fruit infestation (30.34% fruit damage) was observed (Table 2).

Fruit damage per cent based on weight. In the first year of the study, the initial infestation on the weight-based percentage of fruit damage was noted on the 15th SMW and persisted through the 23rd SMW. During the 22nd SMW, when the minimum temperature, maximum temperature, morning relative humidity and evening relative humidity were 26.1 °C, 35.2 °C, 77.5%, and 35.2%, respectively, the highest fruit infestation (30.12% fruit damage) was observed (Table 1). Additionally, the following year's first infestation of fruit damage as a percentage based on weight was noted on the 15th SMW and continued through the 24th SMW. During the 22nd SMW, when the minimum temperature, maximum temperature, morning relative humidity and evening relative humidity were 30.93 °C, 45.1 °C, 40.14%, and 23.57%, respectively, the highest fruit infestation (29.95% fruit damage) was observed (Table 2).

Per cent infection of the shoot and fruit borer and the metrological parameter: correlation and regression equation. Studies on the correlation between climatic parameters and shoot damage (%) were conducted in both years. During the first year of the study, there was a positive link between maximum temperature (r = 0.67) and shoot damage (%) but a negative correlation (r = –0.68) between morning relative humidity and shoot damage (%). In contrast, a significant negative connection (r = –0.71) was found between evening relative humidity and shoot damage (%) in the second year of correlation studies between meteorological parameters and shoot damage (%) (Table 3).

The first year's maximum temperature and morning relative humidity was correlated with the percent infestation of shoot damage as follows: $\hat{Y}_4 = -24.37 + 0.87X_1$ and $\hat{Y}_4 = 25.16 - 0.26X_6$, respectively (Figures 1 and 2). In the second year, the regression equation was $\hat{Y}_4 = 17.18 - 0.37X_4$ between the % infestation of shoot damage and evening relative humidity (Figure 3). Based on the aforementioned calculation, it was determined that during the summer of 2021, there was an increase in shoot infestation per plant of 0.87% for every 1 °C in maximum temperature. A decrease of 0.26% shoot infestation per plant

Table 3. Correlation coefficient of per cent infestation of *Leucinodes orbonalis* Guenee with meteorological parameters during Summer 2021 and 2022

Weather factor	Shoot damage (%)		Fruit damage % (number)		Fruit damage (weight)	
	r	Regression equation	r	Regression equation	r	Regression equation
Summer 2021						
Max. temp. (°C)	0.62*	$\hat{Y}_1 = -24.37 + 0.87X_1$	0.29	–	0.34	–
Min. temp. (°C)	0.12	–	0.87**	$\hat{Y}_2 = -33.52 + 2.17X_2$	0.88**	$\hat{Y}_3 = -32.05 + 2.12X_2$
Morning RH (%)	–0.68**	$\hat{Y}_1 = 25.16 - 0.26X_3$	0.05	–	–0.12	–
Evening RH (%)	–0.20	–	–0.07	–	–0.11	–
Rainfall (mm)	–0.07	–	0.26	–	0.24	–
Evaporation (mm)	0.47	–	0.42	–	0.45	–
Summer 2022						
Max. temp. (°C)	0.36	–	0.64*	$\hat{Y}_2 = -54.00 + 1.61X_1$	0.63*	$\hat{Y}_3 = -51.82 + 1.54X_1$
Min. temp. (°C)	0.11	–	0.92**	$\hat{Y}_2 = -27.33 + 1.71X_2$	0.92**	$\hat{Y}_3 = -26.80 + 1.67X_2$
Morning RH (%)	–0.52	–	–0.43	–	–0.42	–
Evening RH (%)	–0.71**	$\hat{Y}_1 = 17.18 - 0.37X_4$	–0.10	–	–0.08	–
Rainfall (mm)	–0.23	–	0.30	–	0.29	–
Evaporation (mm)	0.23	–	0.82**	$\hat{Y}_2 = -16.23 + 2.17X_6$	0.82**	$\hat{Y}_3 = -15.81 + 2.11X_6$

*significant at 5%; **significant at 1%

min. – minimum; max – maximum; temp. – temperature; r – correlation coefficient; X – weather factor (X_1 = min. temp.; X_2 – max. temp.; X_3 – morning RH; X_4 – evening RH; X_5 – rainfall; X_6 – evaporation); Y – pests population/infestation (%); Y_1 – shoot damage (%); Y_2 – fruit damage (%) on the basis of number; Y_3 – fruit damage (%) on the basis of weight

https://doi.org/10.17221/3/2024-PPS

was seen throughout the summer of 2021 for every 1% increase in morning relative humidity. Based on the next year of study, it was determined that for every 1% increase in evening humidity, there was a decrease in 0.37% shoot damage. During both study years, there was no discernible correlation between the shoot damage % and minimum temperature, rainfall and evaporation (Table 3).

Studies on the correlation between climatic conditions and fruit damage (%) were conducted on the basis of the number in both years. Showed a positive connection (r = 0.87) between the minimum temperature and the percentage of fruit damage. While the second year of correlation studies between climatic factors and fruit damage (%) revealed positive correlations between maximum temperature, minimum temperature, and evaporation with fruit damage (%), respectively, found (r = 0.64, 0.92, and 0.82) (Table 3).

The regression equation was $\hat{Y}_5 = -33.52 + 2.17X_1$ for the per cent infestation of fruit damage based on the number and minimum temperature during the first year (Figure 4). At the same time, the second year's regression equation for the fruit damage percentage with maximum temperature, minimum temperature and evaporation were $\hat{Y}_5 = -54.00 + 1.61X_1$, $\hat{Y}_5 = -27.33 + 1.71X_2$ and $\hat{Y}_5 = -16.23 + 2.17X_6$, respectively (Figures 5, 6 and 7). Based on the calculation above, it was determined that during the summer of 2021, there was an increase in fruit infestation per plant of 2.17% for every 1 °C increase in minimum temperature. During the summer of 2022, there were 1.61%, 1.71% and 2.17% fruit infestations per plant for every 1 °C increase in minimum and maximum temperature and 1 mm increase in evaporation, respectively. During the 2 years of the study, there was no correlation between rainfall, morning relative humidity and evening relative humidity with fruit infestation percentage (Table 3).

Studies were conducted on the correlation between climatic conditions and fruit damage (%) based on weight in both years. A positive association was shown during the first year of the study between minimum temperature (r = 0.88) and fruit damage (%). A substantial positive association (r = 0.63, 0.92 and 0.82) was found between maximum temperature, minimum temperature and evaporation with fruit damage (%), respectively, in the second year of correlation studies between meteorological parameters and fruit damage (%) based on weight (Table 3).

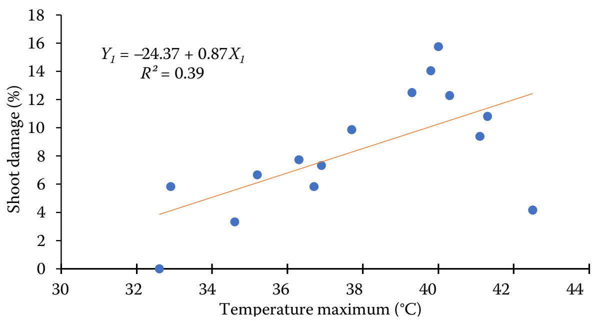

Figure 1. Relation between maximum temperature (°C) and shoot damage (%) during summer 2021

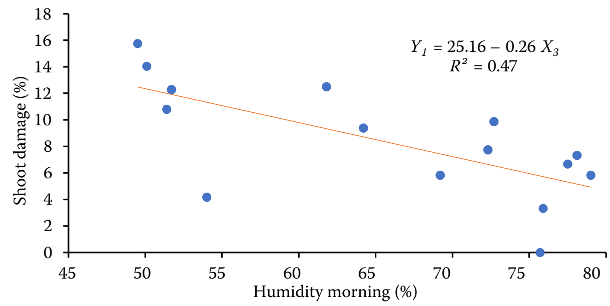

Figure 2. Relation between morning humidity (%) and shoot damage (%) during summer 2021

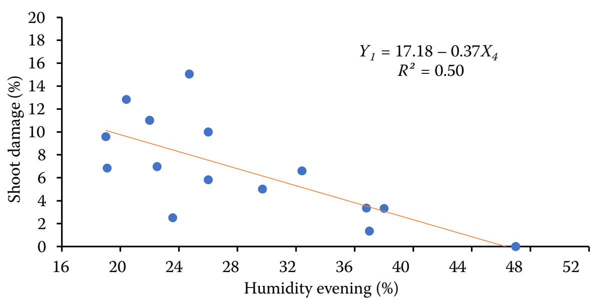

Figure 3. Relation between evening humidity (%) and shoot damage (%) during summer 2022

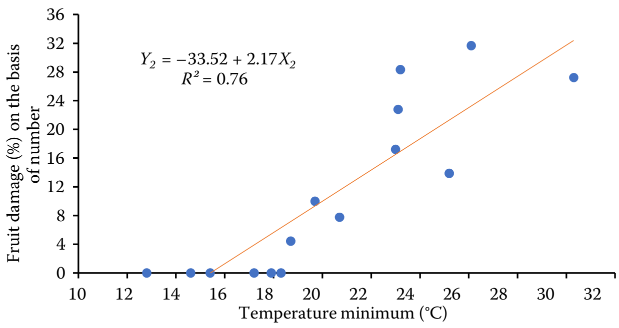

Figure 4. Relation between minimum temperature (°C) and fruit damage (%) based on the number during summer 2021

https://doi.org/10.17221/3/2024-PPS

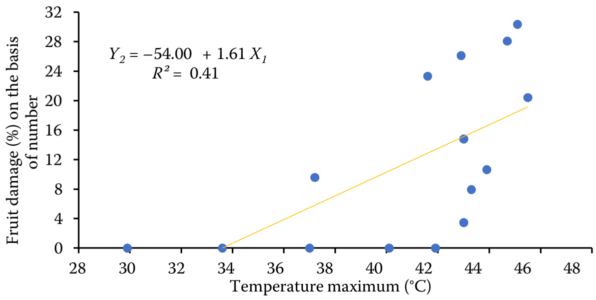

Figure 5. Relation between maximum temperature (°C) and fruit damage (%) based on the number during summer 2022

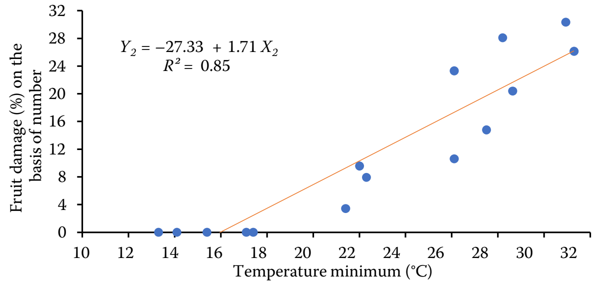

Figure 6. Relation between minimum temperature (°C) and fruit damage (%) based on the number during summer 2022

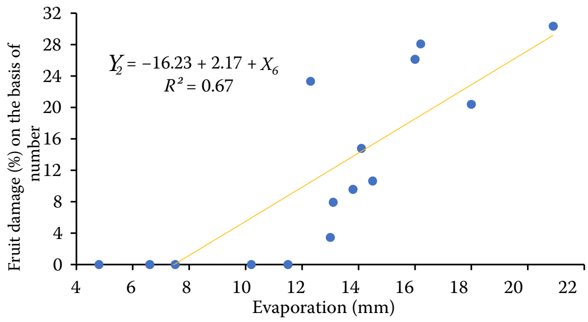

Figure 7. Relation between evaporation (mm) and fruit damage (%) based on number during summer 2022

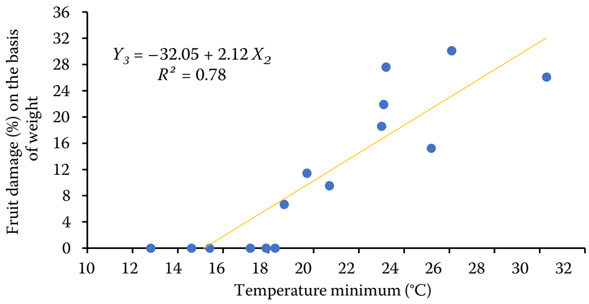

Figure 8. Relation between minimum temperature (°C) and fruit damage (%) based on weight during summer 2021

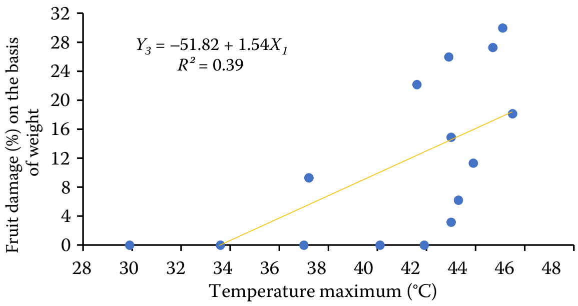

Figure 9. Relation between maximum temperature (°C) and fruit damage (%) based on weight during summer 2022

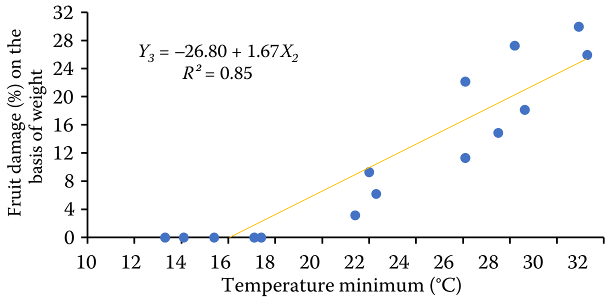

Figure 10. Relation between minimum temperature (°C) and fruit damage (%) based on weight during summer 2022

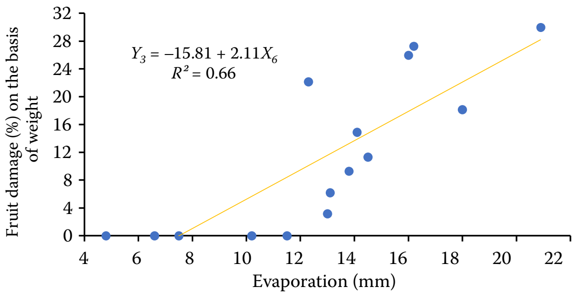

Figure 11. Relation between evaporation (mm) and fruit damage (%) based on weight during summer 2022

The regression equation was $\hat{Y}_5 = -32.05 + 2.12X_2$ for the per cent infestation of fruit damage based on weight and minimum temperature during the first year (Figure 8). The regression equations for the fruit damage percentage and the maximum temperature, minimum temperature, and evaporation in the second year were $\hat{Y}_6 = -51.82 + 1.54X_1$, $\hat{Y}_6 = -26.80 + 1.67X_2$, $\hat{Y}_6 = -15.81 + 2.11X_2$, respectively (Figures 9, 10 and 11). Based on the calculation above, it was determined that during the summer of 2021, there was an increase in fruit infestation per plant of 2.12% for every 1 °C increase in maximum temperature. During the summer of 2022, there was an increase in fruit infestation per plant of 1.54%, 1.67%, and 2.11%, with an increase of 1 °C in maximum and minimum temperature and evaporation,

https://doi.org/10.17221/3/2024-PPS

respectively. During both study years, there was no correlation between the percentage of fruit damaged and evening relative humidity, morning humidity, and rainfall (Table 3).

DISCUSSION

Muthukumar and Kalyanasundaram (2003) noted the highest shoot and fruit damage incidence from May to July. The findings of Ghosh and Senapati (2009), who identified *L. orbonalis* as a major pest of eggplant and showed that it was most active between May and August and caused 49.5–81.0% fruit damage, also support the current finding. Meena et al. (2012) studied the seasonal incidence of *L. orbonalis* in brinjal. They reported that the peak period of shoot infestation was observed in the 9th standard week (5.4%), and the peak infestation of fruit borer was observed in the 18th standard week (43.3%) and 17th standard week (40.1%). Peak infestation was noted in the first week of June (22nd SMW). Singh et al. (2011) noted that in 2003 and 2004, the third and second weeks of June saw the highest shoot infestation rates of 21.26% and 26.75%, respectively. The second week of June saw the highest fruit infestation, 36.12% in 2003 and 57.28% in 2004. The present finding is strongly similar to some other discoveries made by Nayak et al. (2020), Meena et al. (2012), Nayak et al. (2014), Deole (2015), and Devi et al. (2015).

The results above are consistent with Chandi et al. (2021) observations of the relationship between insect pests and meteorological parameters over four years (2016–2019) and their finding that there is a highly significant positive correlation between BSFB and maximum temperature (r = 0.742). The population dynamics of the brinjal shoot and fruit borer were also studied by Pal et al. (2019). It was found that the infestation of the borer on the shoot of the brinjal showed a significant positive correlation with maximum temperature (r = 46) and minimum temperature (r = 0.58). In contrast, the infestation on the fruit of the brinjal showed a non-significant negative correlation with relative humidity. Additionally, the present finding is supported by some additional studies from Chandan et al. (2018) and Nayak et al. (2014).

Acknowledgement

Expressing my sincere gratitude and debt of gratitude to Dr. NS Bhadauria, Professor, RVSKVV, Gwalior, for his invaluable advice, boundless inspiration, keen interest, ongoing encouragement, tremendous assistance, and guidance throughout the entire course of the investigation and preparation of this manuscript gives me great pleasure. I want to express my gratitude to Dr. BS Tomar, Professor and Head, Division of Vegetable Science, IARI, Pusa New Delhi, India, for providing research material as well as the Head, Department of Entomology, College of Agriculture, Gwalior, MP, for providing the facilities required for a successful research trial.

REFERENCES

Aheer G.M., Ali A., Ahmad M. (2008): Abiotic factors effect on population fluctuation of alate aphids in wheat. Journal of Agriculture Research, 46: 367–371.

Bale J.S., Masters G.J., Hodkinson I.D., Awmack C., Bezemer T.M., Brown V.K., Butterfield J., Buse A., et al. (2002): Herbivory in global climate change research: direct effects of rising temperature on insect herbivores. Global Change Biology, 8: 1–16.

Borkakati R.N., Venkatesh M.R., Saikia D.K. (2019): Insect pests of Brinjal and their natural enemies. Journal of Entomology and Zoology Studies, 7: 932–937.

Chandan M.K., Bhavani B., Oraon R. (2018): Population dynamics of brinjal fruit and shoot borer, *Leucinodes orbonalis* Guen. and hadda beetle *Epilachna vigintioctopunctata* Fab. on Brinjal at Allahabad agro climatic region. International Journal of Current Microbiology and Applied Science, 6: 2055–2060.

Chandi R.S., Kaur A., Biwalkar N., Sharma S. (2021): Forecasting of insect pest population in brinjal crop based on Markov chain model. Journal of Agrometeorology, 23: 132–136.

Chandrakumar H.L., Kumar C.T.A., Kumar N.G., Chakravarthy A.K., Raju T.B.P. (2008): Seasonal occurrence of major insect pests and their natural enemies on brinjal. Current Biotica, 2: 63–73.

Dhandapani N., Shelkar U.R., Murugan M. (2003): Bio-intensive pest management in major vegetable crops: An Indian perspective. Journal of Food Agriculture Environment, 1: 330–339.

Deole S. (2015): Population dynamics of major insect pests of brinjal crop in Summer season. Journal of Hill Agriculture, 6: 180–183.

Devi P., Sahu T.K., Ahirwar R.B., Bhagat P. (2015): Population dynamics of major insect pests and natural enemies on brinjal crop and effect of abiotic factor on its dynamics. Ecology, Environment and Conservation Paper, 21: 1421–1425.

https://doi.org/10.17221/3/2024-PPS

Ghosh S.K., Laskar N., Senapati S.K. (2004): Seasonal fluctuation of *Aphis gossypii* Glov. on brinjal and field evaluation of some pesticides against *A. gossypii* under Terai region of West Bengal. Indian Journal of Agriculture Research, 38: 171–177.

Ghosh S.K., Senapati S.K. (2009): Seasonal fluctuation in the population of *Leucinodes orbonalis* (Guen.) in the Sub-Himalayan Region of West Bengal, India and its control on eggplant (*Solanum melongena* L.). Precision Agriculture, 10: 443–449.

Miller G.L., Favret C., Carmichael A., Voegtlin D.J. (2009): Is there a cryptic species within *Aulacorthum solani* (Hemiptera: Aphididae). Journal of Economic Entomology, 102: 398–400.

Meena G.S., Pachori R.K., Panse R. (2012): Extent of damage and seasonal incidence of *Leucinodes orbonalis* (Guen.) on brinjal. Annals of Plant Protection Science, 20: 114–116.

Muthukumar M., Kalyanasundaram. (2003): Influence of biotic factors on the incidence of major insect pests in brinjal (*Solanum melongena* L.). South Indian Horticulture, 51: 214–218.

Narendra R.C., Yesbir S., Premand D., Vijay S.S. (2001): Bio efficacy of insecticides, bio pesticides and their combinations against pod borers in pigeon pea. Indian Journal of Entomology, 63: 137–143.

Nayak U.S., Baral K., Mandal P., Chatterjee S. (2014): Influence of environmental factors on population dynamics and infestation pattern of *Leucinodes orbonalis* in winter brinjal of Odisha. International Journal of Bioresource and Stress Management, 5: 409–412.

Nayak U.S., Rath K., Khuntia A. (2020): 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. Journal of Crop and Weed, 16: 229–235.

Pal J., Katiyar H., Kumar B., Saroj P. (2019): Population dynamics of major insect- pests on kalyanpurtype-3 variety of brinjal. Agriways, 7: 33–37.

Parmesan C. (2007): Influence of species, latitudes and methodologies on estimates of phonological response to global warming. Global Change Biology, 13: 1860–1872.

Singh J.B., Abrol D.P. (2001): Pest complex of brinjal, *Solanum melongena* L. in Jammu. Journal of Insect Environment, 6: 172–173.

Singh R.K.R., Singh T.K., Shah M.A.S. (2011): Population incidence of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen (Lepidoptera: Pyralidae) in Manipur, India. Journal of Experimental Zoology, 14: 229–232.

Snedecor G.W., Cochran W.G. (1989): Statistical Methods. 8th Edition, Iowa State University Press, Ames.

Speight R.M., Hunter D.M., Watt D.A. (2008): Ecology of Insects: Concepts and Applications. John Wiley and sons Ltd., Sussex, UK. 33–60.

Thomson L.J., Macfadyen S., Hoffmann A. (2010): Predicting the effects of climate change on natural enemies of agricultural pests. Biological Control, 52: 296–306.

Received: January 4, 2024
Accepted: November 15, 2024
Published online: March 6, 2025