International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
IJABR 2025; 9(2): 541-549
www.biochemjournal.com
Received: 01-11-2024
Accepted: 05-12-2024

Rohit Kumar Nayak
S.K.N. Agriculture University, Jobner, Jaipur, Rajasthan, India

Akhter Hussain
S.K.N. Agriculture University, Jobner, Jaipur, Rajasthan, India

Kailash Chand Kumawat
S.K.N. Agriculture University, Jobner, Jaipur, Rajasthan, India

Priyanka Thakur
Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Manoj Kumar Gurjar
Swami Keshwanand Rajasthan Agricultural University, Bikaner, Rajasthan, India

Rakesh Kumar Meena
S.K.N. Agriculture University, Jobner, Jaipur, Rajasthan, India

Corresponding Author:
Priyanka Thakur
Dr. Y.S. Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India

Relative susceptibility of brinjal populations to *Leucinodes orbonalis* Guenee infestation: Insights into pest biology and plant resistance mechanisms

Rohit Kumar Nayak, Akhter Hussain, Kailash Chand Kumawat, Priyanka Thakur, Manoj Kumar Gurjar and Rakesh Kumar Meena

DOI: https://doi.org/10.33545/26174693.2025.v9.i2h.3830

Abstract
Brinjal (*Solanum melongena*) holds substantial place among the Solanaceae crops cultivated widely in India. It is attacked by various insects, but the primary culprit inflicting severe economic damage is *Leucinodes orbonalis* Guenee (Lepidoptera: Crambidae). An experiment carried out at S.K.N. Agriculture University, Jobner (Rajasthan) India during the *Kharif* seasons of 2019 and 2020 year sought to unveil the riddles surrounding brinjal varieties' susceptibility levels to shoot and fruit borer. None of the ten brinjal varieties tested, exhibited absolute immunity to *L. orbonalis*, thus underscoring their varying resistance capacities. Variety, Pant Samrat and Pusa Purple Long emerged as least susceptible, whereas, BR-112, BR-5, and GJB-2 positioned at opposite spectrum-highly susceptible. Detailed laboratory studies on pest biology revealed prolonged larval and pupal stage and reduced fecundity on resistant variety (Pant Samrat) compared to susceptible ones (BR-112). These findings underscore the potential of deploying resistant brinjal varieties as a sustainable pest management strategy.

Keywords: Relative susceptibility, brinjal, *Leucinodes orbonalis*, resistance

Introduction
Brinjal (*Solanum melongena* L.) also known as eggplant, garden egg and aubergine (Tsao and Lo 2006) [44], is cultivated widely across tropical and subtropical regions, and is popular in many Central, South and South East Asia, some parts of Africa and Central America (Harish *et al*. 2011) [13]. It originated in India (Doijode 2001) [7], and is frequently referred to as the "poor man's vegetable" (Lalitha 2016) [22]. Among Solanaceae family, brinjal has the greatest productivity of its species in terms of seeds. Copper, vitamin B1, dietary fibre is all plentiful in brinjal and additionally, it is a good source of manganese, potassium, folate, vitamin B6, and vitamin K. Globally, brinjal is grown on 18.92 lakh ha with 59.31 lakh tons production with India being the second-largest producer (12.76 lakh tons) of global brinjal production (FAOSTAT 2022) [9]. In Rajasthan, largest state of the country (areawise), it is cultivated on 3.64 thousand hectares of land with 16.63 thousand tons of production (CEICDATA 2023) [3]. It is the third most significant vegetable crop cultivated in all seasons of India. The brinjal crop is plagued by several insect pests, namely aphids (*Aphis gossypii*), jassids (*Amrasca biguttula biguttula*), white flies (*Bemisia tabaci*), and shoot and fruit borer (*Leucinodes orbonalis*). Among these, *L. orbonalis* is the most destructive, causing significant reduction in crop yield of up to 60-70% (Singh and Nath 2010) [43], affecting both the quantity and quality of fruits directly. During the early stages of plant development, the larvae bore into the shoots disrupting the vascular system and obstructing the movement of nutrients. This causes thr shoots to wilt, wither, and dry out. The larvae typically bore through the calyx and later into the flower buds and fruits, plugging the bored holes with excreta (Butani and Jotwani 1984) [5]. Fruits with infestations are considered unfit for human consumption and fruits lose their market value.

Conventional chemical pest management health drawbacks including environmental concerns and resistance development. Hence, identifying naturally resistant brinjal varieties offers eco-friendly alternative. Many researchers have attempted to screen brinjal cultivars against *L. orbonalis* (Ghosh and Senapati 2001; Elanchezhyan *et al.* 2008; Khan and Singh

2014; Hautea *et al.* 2016; Payal *et al.* 2015) [11, 8, 19, 14, 32]. These cultivars possess various morphological and physical traits in their shoots and fruits that are associated with feeding, attractiveness, and oviposition of the pest, thus naturally combating yield loss in the crop. Farmers may readily use it, and is among the safest and most compatible approaches when combined with other management techniques (Lit 2009) [23]. Plant resistance can be categorized into constitutive and induced defenses. Constitutive defenses include structural traits and pre-formed chemical barriers, while induced defenses are activated by herbivore attacks, leading to the production of defensive compounds (Gatehouse 2002) [10]. These mechanisms are pivotal for understanding brinjal resistance to *L. orbonalis* and developing targeted pest management strategies. Here we aimed to investigate in the resistance of brinjal varieties to fruit and shoot borer infestation by delving into the pest's biology and the underlying plant resistance mechanisms.

Materials and Methods

Field Experiment: Ten brinjal varieties (Pusa Purple Cluster, Pusa Purple Long, Kalptaru, Pant Samrat, GJB-2, Kavach, Hisar Shyamala, BR-112, BR-5, and GJB-3) were investigated for two consecutive *Kharif* seasons (from the 33rd to 47th SMW of 2019 and 2020) to ascertain their degree of susceptibility to *L. orbonalis*. Ten treatments (varieties), were used in the experiment, each of which was reproduced three times following randomized block design (R.B.D.). The experimental plot size was 3.0 x 2.4 square meters, in which the plants were spaced 60 cm apart, and the rows were maintained at a distance of 60 cm apart. The crop was raised in accordance with recommended agronomic practices, except for plant protection measures. The fruit infestation by the *L. orbonalis* was identified based on indications of bored holes in fruit at each picking. The percent shoot and fruit infestation was worked out using the quantity of healthy and damaged fruits that were tallied and weighed during each harvest. Using the following prescribed formulas, these observations were computed.

$$\text{Percent shoot infestation} = \frac{\text{Number of infested shoots}}{\text{Total number of shoots observed}} \times 100$$

$$\begin{array}{c}\text{Percent fruit infestation}\\ \text{(Number basis)}\end{array} = \frac{\text{Number of infested fruits}}{\text{Total number of fruits observed}} \times 100$$

$$\begin{array}{c}\text{Percent fruit infestation}\\ \text{(Weight basis)}\end{array} = \frac{\text{Weight of infested fruits}}{\text{Total weight of fruits observed}} \times 100$$

The degrees of susceptibility of the brinjal varieties were categorized based on the pooled mean of shoot and fruit infestation (number and weight basis) and the standard deviation of the insect population. The following formula was used to categorize the degree of susceptibility of the brinjal varieties:

Less susceptible = below $\bar{X}-\sigma$, moderately susceptible = $\bar{X}-\sigma$ to $\bar{X}+\sigma$ and highly susceptible = above $\bar{X}+\sigma$

, where $\bar{X}$ = Pooled mean of infestation

σ = Standard deviation of pooled mean insect population

Biological studies: The nursery of brinjal varieties for studying biology was raised at the University Horticultural Farm which were later were transplanted in pots and maintained until the completion of the studies. Five varieties (Pusa Purple Cluster and Pant Samrat from least susceptible category; Hisar Shyamala and Kalptaru from moderately susceptible category and BR-112 from highly susceptible category) were selected based on results of morphological and biochemical parameters, as well as their higher degrees of susceptibility, during the first year of the experiment (2019). These tested types were utilized for biology studies of *L. orbonalis* under the laboratory conditions.

Maintenance of stock culture: A stock culture of *L. orbonalis* was retained in a rearing cage (90 × 60 cm^2) at room temperature (25±5 °C). The larvae of the *L. orbonalis* were collected from the brinjal field. Fresh pieces of brinjal were fed to the larvae in their petri plates, which were changed regularly until the last larval instar and initiation of pupal stage. To avoid any pathogenic infection pupae were transferred to petri plates containing sterilized sand. Water was sprinkled on the sand in the petri plates to keep them damp, providing enough moisture. The emerged adults were sexed on the same day by the appearance of a tuft of hair at the tip of the abdomen. Pairs of freshly emerged adults were released into the rearing cages with the five different varieties selected for oviposition and given a 10% sugar solution in cotton swabs. The eggs laid were maintained in 10 replications consisting of ten eggs each. The plants were examined regularly to monitor the emergence of neonate larvae. The larvae that hatched from the eggs on the same day were used for biological studies. All the parameters were recorded at room temperature (25±5 °C).

Duration of the egg stage: The duration of the egg stage was recorded daily by observing the number of freshly laid eggs for the newly emerged larvae.

Duration of the larval stage: The neonate larva (first larval instar) of *L. orbonalis* was transferred using soft brush into a petri dish containing brinjal pollen grains. To prevent fungal growth, the feeds were changed in mornings. After the first larval instar, the larvae feed inside the shoots and fruits, henceforth, the food is shifted from pollen to brinjal slices. The time when the fully grown fifth larval instar stopped feeding and became inactive was considered the termination of the larval stage.

Duration of the pupal stage: The fully grown fifth instar larvae were transferred to a petri plates containing sterilized soil and observed daily to record the pupal period.

Adult longevity: After the adult emergence, both males and females were sexed by observing the presence of a tuft of hairs at the end of the abdomen and their body size. The males were smaller with no abdominal tuft of hair while the females were larger and had tuft of hairs at the posterior to their abdomen. Adults were kept separately and fed a10% sugar solution and the longevity of the males and females was observed.

Total number of eggs laid: The fecundity of the adult (fecundity per female) on different varieties was calculated by counting the total number of eggs laid by the female on leaves of the brinjal plant during the entire life span.

Sex ratio: The sex ratio was recorded by counting the number of male and female moths that emerged.

To evaluate the effect of different brinjal varieties on various biological parameters of *L. orbonalis*, the whole set of experiments was carried out with 5 treatments and 10 replications and the results were analyzed statistically (C.R.D)

Statistical analysis: The collected data in this experiment analyzed statistically using suitable transformation (where needed) at a 5% level of significance (Gomez and Gomez 1984) in MS Excel 2010.

Results and Discussion

Relative susceptibility of brinjal varieties to *Leucinodes orbonalis*

Shoot infestation

The infestation of shoot damage started in the second week of August (33rd SMW) during both the study years *i.e.* 2019 and 2020 (Table 1). The infestation increased gradually after the 34th SMW (at II observation) and reached its maximum in the 37th SMW (at V observation) during the 2019 and 2020 years (Table 2). During the first peak infestation *i.e.* 37th SMW, the mean percent infestation on all the varieties ranged from 21.47 to 43.74 percent after that shoot infestation declined and again reached to second peak infestation *i.e.* 41th SMW (at IX observation), where mean percent infestation on all varieties ranged from 20.04 to 41.47 percent. The infestation of *L. orbonalis* on shoots gradually decreased from the 42nd SMW and reached a minimum in the 45th SMW (at XIII observation) during both years. Based on the degree of susceptibility of brinjal varieties to shoot infestation, the varieties, Pant Samrat and Pusa Purple Long were ranked as least susceptible. Among the varieties, Pusa Purple Cluster, Kalptaru, Kavach, Hisar Shyamala, and GJB-3 were moderately susceptible, while BR-112, BR-5 and GJB-2 were ranked as highly susceptible (Table 5).

These results are consistent with the findings of Samota and Jat (2017) [38], who reported variations in percent shoot infestation (17.82 to 28.65%) in 8 different varieties of brinjal. Similarly, Rani *et al*. (2018) [34] and Praveen *et al*. (2020) [33] also found similar results where the shoot infestation ranged between 10.43 to 32.46 and 23.25 to 56.07 percent, respectively, among the different brinjal genotypes. Shoot damage was 27.89 percent Pusa Purple Cluster, which was moderately susceptible in the present research, as supported by the observations of Jyani *et al*. (1995) [18] who reported 21.01 percent shoot damage. Naqvi (2005) [27] reported that the varieties Pusa Purple Long and Pusa Purple Cluster were rated as least susceptible and moderately susceptible, respectively, concerning shoot infestation in conformity with the present investigation. Singh *et al*. (2016) [42] reported that Pusa Purple Long, GJB-2 and BR-112 were categorized as tolerant, susceptible and highly susceptible, respectively, based on the mean infestation in shoots which is in agreement with the present findings. Sharma *et al*. (2017a) [39] reported that the Pusa Purple Cluster was moderately tolerant, which also corroborates the present investigation, whereas, Patial (2005) [31], reported that the variety Pusa Purple Cluster is highly susceptible to percent shoot infestation is contrary to the present findings. Rani *et al*. (2018) [34] reported that 10.43 and 20.44 percent shoot damage in Pusa Purple Cluster and Pusa Purple Long, respectively and categorized as fairly resistant conforming with the present investigation. Similarly, Rishi *et al*. (2018) [35] reported that Pant Samrat and Pusa Purple Long were immune and resistant, respectively. The present results are similar to those of Nalini (2020) [26], who reported that the variety Pant Samrat was least susceptible to shoot infestation. Contrary to the present findings, Jat *et al*. (2003) [16] who reported shoot infestation ranged from 3.28 to 12.71 percent in ten different brinjal varieties. Similarly, Patial (2005) [31] also recorded a percent infestation of the shoot, which ranged from 3.01 to 7.81 and 1.18 to 5.88 percent in various genotypes during the years 2003 and 2004, respectively. Many researchers screened brinjal varieties against *L. orbonalis* and reported that none of the brinjal varieties were resistant or immune to insects (Elanchezhyan *et al*. 2008; Mannan *et al*. 2009; Netam *et al*. 2018) [8, 24, 28]. The variation in shoot damage among cultivars examined in different locales is most likely related to changes in agro-climatic conditions, transplanting timing and pest population intensity. The infestation in the remaining ten varieties, which were categorized into different groups in the present case could not be compared and discussed, as other work was available.

All the aforementioned results are more or less consistent with the results obtained in the present study, however, the slightest variance in the range of percent fruit infestation might be attributed to the diverse sets of cultivars employed by the workers in their respective investigations. The variations in the level of infestation could be explained by the presence of a thin stem, more branches, lower third leaf length and width, more spines, rough leaf surface area, heavily lignified thick cuticle, broad and thick hypodermis, a closely packed vascular bundle and small pith area which might have contributed to lower infestation and vice versa. Such phenomena have been documented by various researchers (Mishra *et al*. 1988; Ali *et al*. 1994; Hossain *et al*. 2002) [25, 1, 15].

Fruit infestation

According to the findings, no variety of brinjal was completely free from *L. orbonalis* infestation (Table 1), either on number or weight basis. Fruit infestation began in the 38th SMW (at I observation) in 2019 and 2020, affecting all varieties and ranging from 10.77 to 27.05 percent on a number basis (Table 3) and 11.26 to 27.88 percent on a weight basis (Table 4). The infestation increased gradually and reached its peak in the 42nd SMW (at V observation). Pant Samrat (18.42 and 16.69%), Pusa Purple Long (20.27 and 18.55%), and Pusa Purple Cluster (25.49 and 25.71%) were the varieties with the least infestation, both in terms of number and weight basis. However, there were no significant differences in the degree of infestation among the varieties. The greatest infestation (on a number and weight basis) was observed for BR-112 (41.52 and 45.89%) followed by GJB-2 (41.07 and 43.57%) and BR-5 (40.55 and 40.84%). There were no significant differences between these varieties. Pusa Purple Cluster, Kalptaru, Kavach, Hisar Shyamala, and GJB-3, had fruit infestations of 25.49 and 25.71; 28.16 and 28.10; 28.96 and 29.13; 30.85 and 29.47; 33.28 and 35.80 percent, respectively on a number and weight basis. Pant Samrat and Pusa Purple Long were determined to be least vulnerable (Table 5). The varieties Pusa Purple Cluster, Kalptaru, Kavach, Hisar Shyamala, and GJB-3 ranked as moderately susceptible, while, BR-112, BR-5 and GJB-2 were listed as highly susceptible to *L. orbonalis* based on the degree of susceptibility to fruit infestation (on a number and weight basis).

The present findings are in agreement with those of Naqvi (2005) [27], Arvind *et al*. (2007) [4], Kumawat and Kumawat (2009) [21] and Samota and Jat (2017) [38], who documented that none of the brinjal cultivars were immune to the attack of *L. orbonalis*. These results are in line with those of Kumar and Shukla (2002) [20], who noticed 33 to 53 percent infestation of fruits in twelve different brinjal varieties. Similarly, Jat *et al*. (2003) [16] and Javed *et al*. (2011) [17] reported fruit infestation by *L. orbonalis* in brinjal varieties in the range of 18.33 to 46.51 and 4.77 to 58.60 percent, respectively, which also corroborates the present findings. Netam *et al*. (2018) [28] also reported that the infestation of fruit in brinjal germplasm varied from 20.83 to 79.30 percent corroborating the present investigation. Similarly, Rani *et al*. (2018) [34] and Praveen *et al*. (2020) [33] reported similar results, with fruit infestations ranging between 29.63 and 52.04 and 27.35 to 62.31 percent, respectively, among the different brinjal genotypes. These findings are in agreement with earlier findings of Pal (1999) [30], who reported that Pusa Purple Long and Pusa Purple Cluster were rated as less susceptible to *L. orbonalis* with less damage. Naqvi (2005) [27] reported that the variety Pusa Purple Long was rated as less susceptible while the variety Pusa Purple Cluster was rated as moderately susceptible to fruit infestation (on a number basis), in close proximity with the present findings. The results are in line with Sharma *et al*. (2015) [41] who reported that the variety Pant Samrat was less susceptible with respect to fruit infestation. Singh *et al*. (2016) [42] reported that the varieties Pusa Purple Long, GJB-2 and BR-112 were rated as tolerant, susceptible and highly susceptible, respectively, concerning fruit infestation (number basis) corroborating the present investigations. Similarly, Choudhary *et al*. (2018) [6] reported that BR-112, Kavach and Pant Samrat were highly susceptible, moderately susceptible and least susceptible, respectively, to fruit infestation by *L. orbonalis*, which is consistent with the present findings. These results are also in line with those of Rishi *et al*. (2018) [35] who reported that Pant Samrat and Pusa Purple Long were moderately resistant to fruit infestation, whereas BR-112 was susceptible.

Biology of *Leucinodes orbonalis* reared on the tested brinjal varieties

The prolonged durations of different larval instars, pupal period and lesser egg laying was noticed when *L. orbonalis* was reared on the least susceptible variety, Pant Samrat (I-Instar-5.79 days; II-Instar-5.59 days; III-Instar-5.42 days; IV-Instar-4.82 days; V-Instar-5.19 days; duration of larval stage-26.81 days, duration of pupal stage-7.21 days and total number of eggs-119.83 eggs), whereas, the duration of larval and pupal stage shortened, along with higher number of eggs, when reared on highly susceptible variety BR-112 (I-Instar-2.44 days; II-Instar-2.21 days; III-Instar-2.04 days; IV-Instar-1.82 days; V-Instar-2.21 days; duration of the larval stage-10.72 days, duration of pupal stage-5.09 days and total number of eggs-254.89 eggs per female) (Table 6). The sex ratios (female-male) were 1:1.33, 2:1, 4:5, 2:1, and 1:1.52 for the varieties Pant Samrat, Pusa Purple Cluster, and BR-112, respectively. Kavach and Kalptaru, respectively and all these were in line with results obtained by Sharma *et al*. (2017b) [40] who recorded low fecundity and total development period from egg to adult narrowed on susceptible variety, whereas, longer on resistant variety.

These findings concur with those of Nalini (2020) [26], who reported that resistant genotypes had longer durations of larval instars and pupal stages than susceptible genotypes, with no observable differences in the sex ratio. From the aforementioned findings, it can be concluded that different biochemical compounds and morphological characteristics present in varieties with varying degrees of resistance against insect pests may have had adverse effects on the biology of the pest, leading to a prolonged life cycle by increasing the developmental periods of immature stages and thereby reducing the number of generations per year as compared to susceptible varieties. The varietal response might indicate an induced defensive system based on the production of proteins as principal gene products, which could function as poisons or impair pest metabolism (Ryan, 1998) [37]. Such a reaction cannot occur unless the pest inflicts injury. A parallel response was reported in potato and tomato where proteinase inhibitors, and polyphenol oxidase are synthesized in response to attack by the lepidopteran larvae, *Manduca sexta* (Ryan, 2000; Orozo Cardenas *et al*. 2001) [36, 29]. In this species, the primary insecticide that induced defense does not make the plant completely impervious to pest attack; but rather interferes with insect digestion and food intake, which may further shorten grown stages as observed in the present study (Table 6). In contrast, susceptible varieties such as BR-112, BR-5, and GJB-2 may lack these effective defense mechanisms, resulting in shorter pest development periods and higher fecundity. This is parallel to the concept that the absence or insufficiency of defensive traits can lead to increased herbivore performance and subsequent plant damage.

Table 1: Relative susceptibility of brinjal varieties to *Leucinodes orbonalis* during the *Kharif* 2019 and *Kharif* 2020

S. No.	Varieties	Mean percent infestation of shoot*		Mean percent infestation of fruit (number basis) *		Mean percent infestation of fruit (weight basis) *	
		***Kharif*, 2019**	***Kharif*, 2020**	***Kharif*, 2019**	***Kharif*, 2020**	***Kharif*, 2019**	***Kharif*, 2020**
1.	Pusa Purple Cluster	13.85	15.36	14.04	14.38	14.95	15.68
		(21.85)	(23.07)	(22.01)	(22.28)	(22.75)	(23.33)
2.	Pusa Purple Long	10.93	12.69	10.80	11.20	11.11	11.71
		(19.31)	(20.87)	(19.19)	(19.55)	(19.47)	(20.01)
3.	Kalpatru	15.85	17.67	16.47	16.84	16.62	17.23
		(23.46)	(24.86)	(23.94)	(24.23)	(24.06)	(24.53)
4.	Pant Samrat	10.27	12.02	9.83	10.31	10.39	11.30
		(18.69)	(20.28)	(18.27)	(18.72)	(18.81)	(19.64)
5.	GJB-2	22.95	24.53	24.81	24.84	25.60	25.94
		(28.62)	(29.69)	(29.87)	(29.89)	(30.39)	(30.62)
6.	Kavach	16.41	18.13	17.23	17.57	17.16	17.70
		(23.90)	(25.20)	(24.53)	(24.78)	(24.47)	(24.88)
7.	Hisar Shyamala	16.80	18.52	17.91	18.25	17.80	18.54
		(24.20)	(25.49)	(25.03)	(25.29)	(24.96)	(25.50)
8.	BR-112	23.63	25.07	25.41	25.35	26.85	27.28
		(29.08)	(30.04)	(30.27)	(30.23)	(31.21)	(31.49
9.	BR-5	22.49	23.92	24.03	24.26	24.29	24.83
		(28.31)	(29.28)	(29.35)	(29.51)	(29.53)	(29.89)
10.	GJB-3	18.35	19.62	19.35	19.43	20.51	21.11
		(25.37)	(26.29)	(26.10)	(26.16)	(26.93)	(27.35)
	SEm±	1.29	1.27	1.45	1.38	1.48	1.38
	CD (P=0.05)	3.82	3.76	4.30	4.11	4.39	4.10

*Mean of the weekly observations Figures in parentheses are angular transformed values

Table 2: Relative susceptibility of brinjal varieties to *Leucinodes orbonalis* in the *Kharif* season of 2019 and 2020

S. No.	Varieties	Mean percent infestation of shoot at weekly intervals*													
		33 SMW	**34 SMW**	**35 SMW**	**36 SMW**	**37 SMW**	**38 SMW**	**39 SMW**	**40 SMW**	**41 SMW**	**42 SMW**	**43 SMW**	**44 SMW**	**45 SMW**	**Mean**
		I	**II**	**III**	**IV**	**V ****	**VI**	**VII**	**VIII**	**IX ****	**X**	**XI**	**XII**	**XIII**	
1.	Pusa Purple Cluster	0.59	1.98	8.76	18.35	27.89	26.38	25.58	19.92	25.84	23.08	21.91	9.71	4.26	14.60
		(4.41)	(8.08)	(17.22)	(25.37)	(31.88)	(30.91)	(30.38)	(26.51)	(30.55)	(28.71)	(27.91)	(18.16)	(11.92)	(22.46)
2.	Pusa Purple Long	0.42	1.46	6.58	13.62	22.88	22.05	20.06	15.73	20.27	22.08	17.47	8.60	3.56	11.80
		(3.70)	(6.95)	(14.87)	(21.66)	(28.58)	(28.01)	(26.61)	(23.37)	(26.76)	(28.03)	(24.71)	(17.05)	(10.88)	(20.09)
3.	Kalpatru	0.71	2.21	9.62	19.36	31.95	30.56	28.08	21.48	29.91	29.62	24.02	11.84	5.33	16.75
		(4.82)	(8.56)	(18.07)	(26.11)	(34.42)	(33.56)	(32.00)	(27.61)	(33.16)	(32.97)	(29.35)	(20.13)	(13.35)	(24.16)
4.	Pant Samrat	0.40	1.36	6.19	13.40	21.47	20.71	19.79	14.71	20.04	19.31	16.67	7.97	3.22	11.13
		(3.62)	(6.69)	(14.41)	(21.48)	(27.61)	(27.07)	(26.42)	(22.56)	(26.60)	(26.07)	(24.10)	(16.40)	(10.33)	(19.49)
5.	GJB-2	1.11	3.36	14.88	28.20	43.00	40.59	40.30	32.14	39.89	38.75	34.23	15.82	7.82	23.68
		(6.04)	(10.57)	(22.69)	(32.08)	(40.98)	(39.58)	(39.41)	(34.54)	(39.17)	(38.50)	(35.81)	(23.44)	(16.24)	(29.15)
6.	Kavach	0.73	2.31	10.07	20.58	32.36	30.98	29.11	22.07	30.24	(29.94	25.84	11.84	5.54	17.26
		(4.91)	(8.74)	(18.51)	(26.98)	(34.67)	(33.82)	(32.65)	(28.02)	(33.36)	(33.18)	(30.55)	(20.13)	(13.61)	(24.55)
7.	Hisar Shyamala	0.75	2.33	10.45	20.82	32.74	31.37	30.23	23.26	30.79	30.38	26.43	11.99	5.62	17.65
		(4.98)	(8.78)	(18.86)	(27.15)	(34.91)	(34.07)	(33.36)	(28.84)	(33.70)	(33.45)	(30.94)	(20.26)	(13.71)	(24.84)
8.	BR-112	1.14	3.55	15.63	29.19	43.74	40.87	42.00	33.01	41.47	39.02	34.42	16.14	7.95	24.34
		(6.12)	(10.87)	(23.29)	(32.71)	(41.41)	(39.74)	(40.40)	(35.07)	(40.09)	(38.66)	(35.93)	(23.69)	(16.38)	(29.56)
9.	BR-5	1.06	3.28	14.18	27.34	42.71	40.38	39.02	31.42	39.36	36.96	33.96	15.58	7.69	23.20
		(5.92)	(10.43)	(22.13)	(31.53)	(40.81)	(39.46)	(38.66)	(34.09)	(38.86)	(37.44)	(35.65)	(23.25)	(16.11)	(28.79)
10.	GJB-3	0.84	2.70	11.77	22.69	34.14	33.10	33.33	25.93	33.29	30.86	27.51	12.85	6.03	18.98
		(5.25)	(9.45)	(20.07)	(28.45)	(35.76)	(35.12)	(35.27)	(30.61)	(35.24)	(33.75)	(31.64)	(21.01)	(14.21)	(25.83)
	SEm+	0.30	0.51	1.10	1.46	1.94	1.78	1.74	1.40	1.66	1.77	1.56	1.00	0.78	1.28
	CD (P=0.05)	0.88	1.52	3.27	4.34	5.76	5.28	5.16	4.16	4.92	5.26	4.62	2.98	2.31	3.80

*Mean of three replications **Peak shoot infestation SMW = Standard Meteorological Week Figures in parentheses are angular transformed values

Note: The table contains pooled data from *Kharif* 2019 and *Kharif* 2020

Table 3: Relative susceptibility of brinjal varieties to *Leucinodes orbonalis* during the *Kharif* season of 2019 and 2020

S. No.	Varieties	Mean percent infestation of fruit (number basis) at each harvesting *										Mean
		38 SMW	39 SMW	40 SMW	41 SMW	42 SMW	43 SMW	44 SMW	45 SMW	46 SMW	47 SMW	
		I	II	III	IV	V**	VI	VII	VIII	IX	X	
1.	Pusa Purple Cluster	15.40	17.83	19.05	22.53	25.49	15.12	12.52	8.08	6.27	6.03	14.21
		(23.11)	(24.98)	(25.88)	(28.34)	(30.33)	(22.88)	(20.72)	(16.51)	(14.51)	(14.22)	(22.15)
2.	Pusa Purple Long	11.70	14.67	15.64	16.43	20.27	11.56	9.05	6.36	4.84	4.60	11.00
		(20.00)	(22.52)	(23.30)	(23.92)	(26.76)	(19.88)	(17.51)	(14.61)	(12.71)	(12.38)	(19.37)
3.	Kalpatru	17.67	20.43	23.11	25.33	28.16	17.84	14.81	10.02	7.43	7.76	16.65
		(24.86)	(26.87)	(28.73)	(30.22)	(32.05)	(24.99)	(22.63)	(18.46)	(15.82)	(16.17)	(24.09)
4.	Pant Samrat	10.77	12.71	12.88	15.66	18.42	10.47	8.46	5.29	4.01	4.09	10.07
		(19.16)	(20.89)	(21.03)	(23.32)	(25.42)	(18.88)	(16.91)	(13.30)	(11.56)	(11.67)	(18.50)
5.	GJB-2	26.84	28.58	33.15	37.76	41.07	26.16	22.09	14.87	11.69	11.41	24.86
		(31.21)	(32.32)	(35.15)	(37.92)	(39.86)	(30.76)	(28.04)	(22.69)	(19.99)	(19.75)	(29.90)
6.	Kavach	19.31	20.94	23.64	26.41	28.96	18.70	15.24	10.83	7.83	7.98	17.38
		(26.07)	(27.24)	(29.09)	(30.93)	(32.56)	(25.62)	(22.98)	(19.21)	(16.25)	(16.41)	(24.64)
7.	Hisar Shyamala	20.32	21.59	24.23	27.19	30.85	19.43	15.63	10.97	8.13	8.29	18.08
		(26.79)	(27.69)	(29.49)	(31.43)	(33.74)	(26.16)	(23.29)	(19.34)	(16.57)	(16.73)	(25.16)
8.	BR-112	27.05	29.85	33.33	39.07	41.52	26.38	22.65	15.10	12.12	11.57	25.38
		(31.34)	(33.12)	(35.27)	(38.69)	(40.12)	(30.91)	(28.42)	(22.87)	(20.38)	(19.89)	(30.25)
9.	BR-5	26.56	28.32	32.86	36.19	40.55	25.43	21.19	14.82	11.31	11.27	24.14
		(31.03)	(32.16)	(34.98)	(36.99)	(39.56)	(30.29)	(27.41)	(22.64)	(19.65)	(19.62)	(29.43)
10.	GJB-3	20.96	23.73	25.49	30.62	33.28	20.43	17.29	11.40	9.03	8.61	19.39
		(27.25)	(29.16)	(30.32)	(33.60)	(35.23)	(26.88)	(24.57)	(19.73)	(17.49)	(17.07)	(26.13)
	SEm±	1.41	1.47	1.72	1.79	1.74	1.38	1.32	1.10	1.03	1.01	1.43
	CD (P=0.05)	4.18	4.37	5.11	5.33	5.17	4.11	3.92	3.27	3.06	3.01	4.25

*Mean of three replications **Peak fruit infestation SMW = Standard Meteorological Week Figures in parentheses are angular transformed values

Note: The table contains pooled data from *Kharif* 2019 and *Kharif* 2020

Table 4: Relative susceptibility of brinjal varieties to *Leucinodes orbonalis* during the *Kharif* season of 2019 and 2020

S. No.	Varieties	Mean percent infestation of fruit (weight basis) at each harvesting *										Mean
		38 SMW	39 SMW	40 SMW	41 SMW	42 SMW	43 SMW	44 SMW	45 SMW	46 SMW	47 SMW	
		I	II	III	IV	V**	VI	VII	VIII	IX	X	
1.	Pusa Purple Cluster	16.18	19.09	23.33	24.75	25.71	15.94	12.78	11.02	6.48	5.02	15.31
		(23.72)	(25.91)	(28.89)	(29.84)	(30.47)	(23.54)	(20.95)	(19.39)	(14.75)	(12.95)	(23.04)
2.	Pusa Purple Long	11.72	15.76	17.63	18.36	18.55	12.51	9.14	8.15	4.64	3.54	11.41
		(20.02)	(23.39)	(24.83)	(25.37)	(25.51)	(20.71)	(17.60)	(16.59)	(12.44)	(10.84)	(19.74)
3.	Kalpatru	16.79	21.74	25.55	26.93	28.10	20.07	14.03	11.58	7.04	5.34	16.93
		(24.19)	(27.80)	(30.37)	(31.26)	(32.01)	(26.62)	(22.00)	(19.90)	(15.39)	(13.36)	(24.29)
4.	Pant Samrat	11.26	13.53	17.03	17.31	16.69	10.38	8.91	7.73	4.33	3.40	10.88
		(19.61)	(21.59)	(24.38)	(24.59)	(24.11)	(18.80)	(17.37)	(16.15)	(12.01)	(10.63)	(19.26)
5.	GJB-2	25.49	30.82	36.50	40.99	43.57	28.83	21.35	17.07	11.84	9.20	25.73
		(30.33)	(33.72)	(37.17)	(39.81)	(41.31)	(32.48)	(27.52)	(24.40)	(20.13)	(17.66)	(30.48)
6.	Kavach	17.25	21.86	25.87	27.46	29.13	20.57	14.75	12.15	7.17	5.48	17.47
		(24.54)	(27.88)	(30.58)	(31.60)	(32.67)	(26.97)	(22.59)	(20.40)	(15.53)	(13.54)	(24.71)
7.	Hisar Shyamala	18.18	22.50	27.65	29.23	29.47	21.06	15.06	12.43	7.75	5.71	18.20
		(25.24)	(28.32)	(31.73)	(32.73)	(32.88)	(27.32)	(22.84)	(20.64)	(16.17)	(13.83)	(25.26)
8.	BR-112	27.88	32.14	37.77	41.58	45.89	29.47	22.21	18.98	12.00	9.43	27.07
		(31.87)	(34.54)	(37.92)	(40.15)	(42.65)	(32.88)	(28.12)	(25.83)	(20.27)	(17.89)	(31.35)
9.	BR-5	24.65	29.31	35.48	38.91	40.84	28.48	20.58	16.48	11.64	8.08	24.56
		(29.77)	(32.78)	(36.56)	(38.60)	(39.72)	(32.26)	(26.98)	(23.95)	(19.95)	(16.52)	(29.71)
10.	GJB-3	21.79	25.41	30.25	32.80	35.80	22.30	17.30	14.78	9.05	7.04	20.81
		(27.83)	(30.27)	(33.37)	(34.94)	(36.75)	(28.18)	(24.58)	(22.61)	(17.51)	(15.39)	(27.14)
	SEm±	1.39	1.50	1.84	1.81	2.17	1.65	1.24	1.10	0.95	0.85	1.47
	CD (P=0.05)	4.14	4.45	5.46	5.39	6.43	4.89	3.70	3.26	2.81	2.52	4.36

*Mean of three replications **Peak fruit infestation SMW = Standard Meteorological Figures in parentheses are angular transformed values

Note: 1. The table contains pooled data from *Kharif* 2019 and *Kharif* 2020

2. I, II,...X indicates the pooled mean of observations taken at weekly intervals during the *Kharif* season of 2019 and 2020.

Table 5: Categorization of brinjal varieties in degrees of susceptibility against shoot infestation and fruit infestation based on a study of the *Kharif* season of 2019 and 2020 (Pooled data)

Varieties	Per cent shoot infestation	Per cent fruit infestation (Number basis)	Per cent fruit infestation (Weight basis)	Categories
Pant Samrat and Pusa Purple Long	Below 13.23	Below 12.64	Below 13.19	Least susceptible
Pusa Purple Cluster, Kalpatru, Kavach, Hisar Shyamala, GJB-3	13.23 to 22.65	12.64 to 23.59	13.19 to 24.53	Moderately susceptible
BR-112, BR-5 and GJB-2	Above 22.65	Above 23.59	Above 24.53	Highly susceptible
Pooled mean ($\bar{X}$)	17.94	18.12	18.86	
Standard deviation (σ)	4.71	5.47	5.67	

Table 6: Comparative biological parameters of *Leucinodes orbonalis* reared on tested brinjal varieties

Biological parameters*	Pant Samrat Mean±SE (days)	Pusa Purple Cluster Mean±SE (days)	BR-112 Mean±SE (days)	Kavach Mean±SE (days)	Kalpatru Mean±SE (days)	CD (p-0.05)
Duration of the egg stage	4.23±0.48 (3-5)	3.81±0.26 (3-4)	3.43±0.52 (2-4)	2.80±0.26 (2-3)	3.19±0.26 (3-4)	0.26
I-instar	5.79±1.03 (4-8)	4.21±0.48 (3-5)	2.44±0.26 (2-3)	2.60±0.32 (2-3)	2.83±0.32 (2-3)	0.24
II-instar	5.59±0.66 (4-7)	4.40±0.32 (4-5)	2.21±0.41 (2-4)	2.84±0.26 (2-3)	3.05±0.26 (2-3)	0.21
III-instar	5.42±0.52 (4-6)	4.03±0.41 (3-5)	2.04±0.26 (2-3)	2.41±0.52 (1-3)	2.78±0.41 (1-3)	0.29
IV-instar	4.82±0.75 (3-6)	3.61±0.52 (2-4)	1.82±0.52 (1-3)	2.19±0.26 (2-3)	2.44±0.26 (1-2)	0.25
V-instar	5.19±0.84 (4-6)	3.82±0.26 (3-4)	2.21±0.32 (2-3)	2.39±0.52 (2-4)	2.63±0.26 (2-3)	0.28
Duration of larval stage	26.81±1.60 (22-29)	20.07±1.92 (17-25)	10.72±2.37 (9-19)	12.43±1.81 (9-15)	13.73±1.86 (8-15)	3.92
Duration of pupal stage	7.21±0.63 (6-8)	6.82±0.75 (5-8)	5.09±0.26 (6-7)	5.44±0.52 (4-6)	6.19±0.82 (3-6)	0.41
Adult longevity (days)						
Male	2.42±0.52 (1-3)	3.27±0.48 (2-4)	5.08±0.32 (3-4)	4.23±0.26 (4-5)	3.59±0.58 (4-6)	0.89
Female	3.19±0.48 (2-4)	4.20±0.63 (3-5)	6.18±0.52 (3-5)	5.22±0.48 (4-6)	4.39±0.75 (4-7)	1.06
Total number of eggs	191.83±15.42 (145-211)	219.24±19.25 (167-248)	254.89±21.12 (172-257)	241.28±19.12 (187-268)	237.29±20.94 (190-277)	12.94
Sex ratio (Female : male)	1:1.33	2:1	1:1.52	2:1	4:5	

Figures in parenthesis are range in days
*Number of replications (r) = 10

Conclusion

Prevailing research on the resistance levels of different brinjal varieties to *L. orbonalis* revealed crucial insights into variance in susceptibility among different field populations. The varieties, Pant Samrat and Pusa Purple Long exhibit significant resistance characterized by prolonged larval and pupal stages and reduced fecundity, whereas, BR-112, BR-5 and GJB-2 were highly sensitive to *L. orbonalis* infestation. Understanding the balance between constitutive and induced defenses in brinjal varieties provides valuable perceptions for developing integrated pest management strategies. Thus, breeding focus on enhancing both types of defenses in pest populations ensures long-term sustainability and cultivation of brinjal crops in the face of evolving pest pressures.

Authors' contributions statement

Conceptualization and design of the research (Akhter Hussain); Execution of field/lab experiments (Rohit Kumar Nayak, Kailash Chand Kumawat), data collection and preparation of the manuscript (Rohit Kumar Nayak, Kailash Chand Kumawat, Priyanka Thakur and Rakesh Kumar Meena); Analysis of the data and interpretation (Rohit Kumar Nayak, Priyanka Thakur, Manoj Kumar Gurjar, Rakesh Kumar Meena).

Acknowledgments

The authors are thankful to the University Head, Department of Entomology for providing the facility to conduct the present experiment Department of Entomology, S.K.N. Agriculture University, Jobner, Jaipur (Rajasthan) India.

Ethical approval

The work is original and has neither been published nor under consideration for publication elsewhere. No data, text or theories by others are misused in the manuscript. No animal or plant has been exploited in any unscrupulous form in the experimental design.

Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data Deposit: Once the article is accepted, the data would be deposited in the journals Dataverse Repository

References

1. Ali MI, Ahmed S, Rhaman T. Host plant resistance in brinjal against the brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. Ann Res Rep. 1994;94:52-53.
2. Anonymous. Nutrient database, eggplant, US Department of Agriculture. https://fdc.nal.usda.gov. Accessed 25 Jan 2021.
3. CEICDATA. Area and production: horticulture crops: vegetables: brinjal: Rajasthan. https://www.ceicdata.com. Accessed 18 Feb 2023.
4. Arvind K, Ishar RK, Arora RM, Bhagat N, Monobrullah MD. Evaluation of brinjal (*Solanum melongena* L.) cultivars against shoot and fruit borer, *Leucinodes orbonalis* Guenee. Indian J Appl Entomol. 2007;21:53-56.

5. Butani DK, Jotwani MG. Insect pests in vegetables, periodical. Expert Book Agency, Delhi, India. 1984.
6. Choudhary RS, Rana BS, Kumar A, Murdia A, Singh B. Screening of brinjal varieties against *Leucinodes orbonalis* Guenee infestation. J Entomol Zool Stud. 2018;6(2):194-198.
7. Doijode SD. Seed storage of horticultural crops. Haworth Press, London. 2001.
8. Elanchezhyan K, Baskaran RK, Rajavel DS. Field screening of brinjal varieties on major pests and their natural enemies. J Biopestic. 2008;1(2):113-120.
9. FAOSTAT. Statistics for 2010-2014. https://www.fao.org. Accessed 22 Feb 2023.
10. Gatehouse JA. Plant resistance towards insect herbivores: a dynamic interaction. New Phytol. 2002;156(2):145-169.
11. Ghosh S, Senapati SK. Evaluation of brinjal varieties commonly grown in Terai region of West Bengal against pest complex. Crop Res. 2001;21(2):157-163.
12. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John Wiley & Sons, New York. 1984.
13. Harish DK, Agasimani AK, Imamsaheb SJ, Patil SS. Growth and yield parameters in brinjal as influenced by organic nutrient management and plant protection conditions. Res J Agric Sci. 2011;2(13):221-225.
14. Hautea DM, Taylor LD, Masanga APL, Sison MLJ, Narciso JO, Quilloy RB, Hautea RA, Shotkoski FA, Shelton AM. Field performance of Bt eggplants (*Solanum melongena* L.) in the Philippines: Cry1Ac expression and control of the eggplant fruit and shoot borer (*Leucinodes orbonalis* Guenée). PLoS One. 2016;11(6):e0157498.
15. Hossain MM, Shahjahan M, Prodhan AKM. Study of anatomical characters about resistance against brinjal shoot and fruit borer. Pak J Biol Sci. 2002;5:672-678.
16. Jat KL, Singh S, Maurya RP. Screening of brinjal varieties for resistance to shoot and fruit borer, *Leucinodes orbonalis* Guenee. Haryana J Hort Sci. 2003;32(1&2):152-153.
17. Javed H, Ata UM, Muhammad A, Muhammad MA, Tariq M. Relationship between morphological characters of different aubergine cultivars and fruit infestation by *Leucinodes orbonalis* Guenee. Pak J Bot. 2011;43:2023-2028.
18. Jyani DBN, Patel C, Ratanpara HC, Patel JR, Board PK. Varietal resistance in brinjal to insect-pest and disease. Agric Res J. 1995;21:59-63.
19. Khan R, Singh YV. Screening for shoot and fruit borer (*Leucinodes orbonalis* Guenee) resistance in brinjal (*Solanum melongena* L.) genotypes. The Ecoscan. 2014;6:41-45.
20. Kumar A, Shukla A. Varietal preference of fruit and shoot borer, *Leucinodes orbonalis* Guenee on brinjal. Insect Environ. 2002;8(1):44.
21. Kumawat SR, Kumawat KC. Varietal susceptibility in brinjal, *Solanum melongena* L. against shoot and fruit borer, *Leucinodes orbonalis* Guenee. Proceedings of the National Conference on Applied Entomology. 2009;177-178. Sept 26-28, Udaipur.
22. Lalitha RG. Genetically Modified Aubergine (Also Called Brinjal or *Solanum melongena*). In: Ronald RW, Victor RP, editors. Genetically Modified Organisms in Food. Cambridge, United States: Academic Press; 2016.
23. Lit MC. Combined resistance of eggplant, *Solanum melongena* L. to leaf hopper, *Amraca biguttula* (Ishida) and the eggplant borer, *Leucinodes orbonalis* Guenee. Dissertation. University of Los Bafios; 2009.
24. Mannan MA, Begum A, Hossain MM. Screening of local and exotic brinjal varieties/cultivars for resistance to brinjal shoot and fruit borer (*Leucinodes orbonalis*). Bangladesh J Agril Res. 2009;34(4):705-712.
25. Mishra PN, Singh YV, Nautiyal MC. Screening of brinjal varieties for resistance to shoot and fruit borer (*Leucinodes orbonalis* Guenee) (Lepidoptera: Pyralidae). South Indian Hort. 1988;36:188-182.
26. Nalini C. Studies on host plant resistance in brinjal against *Leucinodes orbonalis* Guenee. Dissertation. Dr. YS Parmar University of Horticulture and Forestry Solan, (HP) India; 2020.
27. Naqvi AR. Management of major insect pests of brinjal in the hyper-arid region of Rajasthan. Dissertation. Rajasthan Agricultural University, Bikaner, India; 2005.
28. Netam M, Lakra R, Koshta VK, Sharma D, Deole S. Screening of shoot and fruit borer (*Leucinodes orbonalis* Guenee), for resistance in brinjal (*Solanum melongena* L.) Germplasm Lines. Int J Curr Microbiol App Sci. 2018;7(2):3700-3706.
29. Orozco-Cardenas ML, Narvaez-Vasquez J, Ryan CA. Hydrogen peroxide acts as a second messenger for the induction of defense genes in tomato plants in response to wounding, systemin, and methyl jasmonate. Plant Cell. 2001;13:179-191.
30. Pal A. Screening of brinjal cultivars against major insect pests and their insecticidal management. Dissertation. Indira Gandhi Agricultural University Raipur, (C.G.) India; 1999.
31. Patial A. Bioecology and management of *Leucinodes orbonalis* Guenee on brinjal. Dissertation. CSK Himachal Pradesh Krishi Vishvavidyalaya Palampur, (H.P.) India; 2005.
32. Payal D, Preeti G, Koshta VK. Screening of some brinjal cultivars for resistance to shoot and fruit borer (*Leucinodes orbonalis* Guenee). The Bioscan. 2015;10(1):247-251.
33. Praveen PK, Saha T, Prakash R, Yadav AK. Screening of brinjal genotypes resistance against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee). Int J Chem Stud. 2020;8(1):1907-1909.
34. Rani N, Akhtar S, Kumari P, Verma RK. Screening of local and exotic eggplant genotypes for tolerance to shoot and fruit borer. Int J Curr Microbiol Appl Sci. 2018;7:4553-4559.
35. Rishi P, Vikrant SD, Sharma S, Kumar S. Screening of some brinjal germplasm line against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee in central (U.P.). J Entomol Zool Stud. 2018;6(2):160-166.
36. Ryan CA. The systemin signaling pathway: a polypeptide signal for plant defensive genes. Annu Rev Cell Dev Biol. 2000;14:1-17.
37. Ryan CA, Pearce G. Systemin; a polypeptide signal for plant defensive genes. Annu Rev Cell Dev Biol. 1998;14:1-17.
38. Samota RG, Jat BL. Screening of brinjal varieties against shoot and fruit borer, *Leucinodes orbonalis*

Guenee with biophysical and biochemical factors. Trends Biosci. 2017;10(17):3007-3002.

39. Sharma A, Rana RS, Sharma KC, Kumar A, Singh S. Screening of brinjal cultivars resistance against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee). Int J Entomol Res. 2017a;2:69-75.
40. Sharma A, Rana RS, Sharma KC, Singh S, Kumar A. Biology of brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) on brinjal crop under laboratory conditions. J Entomol Zool Stud. 2017b;5:415-419.
41. Sharma N, Sharma S, Chudasama JA, Bhadauria NS. Varietal screening against shoot and fruit borer (*Leucinodes orbonalis* G.) of brinjal. Res Environ Life Sci. 2015;8:779-782.
42. Singh JP, Gupta PK, Chandra U, Singh VK, Singh AK. Field screening of brinjal germplasm against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guenee) at different stages of the plant. Int J Plant Prot. 2016;9:84-90.
43. Singh SP, Nath P. Cultural and biophysical management of brinjal shoot and fruit borer (*Leucinodes orbonalis*). In: A biannual newsletter of the CIPS in cooperation with IRAC and WRCC-60. 2010;42-43.
44. Tsao JS, Lo HF. Vegetables: types and biology. In: Handbook of Food Science, Technology and Engineering. Florida: CRC Press; 2006