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Influence of temperature levels on the biology of brinjal shoot and fruit borer *Leucinodes orbonalis* (Guenee)

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Abstract
The laboratory experiments were conducted to study the biology of *L. orbonalis* (Guenee) on brinjal at different temperature levels *viz.,* 20˚c, 25˚c, 30˚c and 35˚c temperatures at the Department of Agricultural Entomology, College of Agriculture Latur during 2016-2017. The growth index and the larval duration of *L. orbonalis* were found to be 2.25, 2.63, 3.1 and 3.88 and 25.3, 22.8, 20.74 and 18.53 days on brinjal at 20˚c, 25˚c, 30˚c, and 35˚c temperature, respectively.

Keywords: *Solanum melongena* L., BOD incubator, growth index, larval duration, eggs, oviposition

Introduction
Brinjal (*Solanum melongena* L.) is an important solanaceous crop grown during *Kharif* or the summer season throughout India. The crop occupies an important position among the other regular vegetable crops grown throughout the country. In India, the area under brinjal was 663 thousand hectares with a production of 12,515 thousand tonnes during 2015-16 (Anonymous, 2016) [1].

In India, brinjal is grown throughout the year in almost all parts of the country except in higher altitudes and is liked by both the poor and rich alike. It is a major vegetable crop of the plains (Premanath *et al.,* 1987). Being native of India this crop has gained maximum diversity and there is a number of varieties having different colors, shapes, and sizes (Asati *et al.,* 2002) [2]. Brinjal fruits are supposed to be medium energy vegetables giving 24 calories from 100 g fruits (Kale *et al.,* 1986) [14]. It is quite high in nutritive value and can be compared with tomato (Chaudhari, 1976) [6]. It also contains vitamins A and B.

Among all the insect pests, the shoot and fruit borer (*L. orbonalis* Guenee) is the most destructive insect pest of brinjal throughout India and the Indian subcontinent. The borer starts its attack on the brinjal nursery (young seedling) stage and continues through all the phases of plant growth and fruiting period. Finally, it causes severe direct damage to marketable produce. The yield loss due to the pest was observed to the extent of 70 to 92 per cent (Eswara Reddy and Srinivasa, 2004) [7].

The larval stage of this pest causes serious damage to shoots and fruits of eggplant. Larvae bore into the young shoots and feed on internal tissues resulting in wilting of the shoot, which reduces plant growth and the number and size of fruits (Atwal and Dhaliwal, 2007) [3].

The extent of losses varies from state to state, 74 per cent in Assam (Ramzan *et al.,* 1987) [23], 62.50 per cent in Andhra Pradesh (Raju *et al.,* 1987) [22], 56.30 per cent in Meghalaya (Gangwar and Sachan, 1981) [8], 54 per cent in Tamil Nadu (Shrinivasan and Gowder, 1959) [30], 48 per cent in Maharashtra (Mote, 1981) [18] and 37 per cent in Karnataka (Krishnaiah *et al.,* 1978). Besides quantitative losses, qualitative losses are also evident. In severe cases, it also causes the rotting of the fruits (Bose and Som, 1986) [5]. Sugars and proteins are reduced in infested fruits (Hami, 1955) [10].

The growth and development of *L. orbonalis* are influenced by different temperature conditions prevailing during different seasons. Hence the efforts were made to generate the data on the growth and development of *L. orbonalis* on brinjal at different temperature levels using a B. O. D. incubator.

Material and Methods
The biology of *Leucinodes orbonalis* (Guenee) on brinjal at different temperature levels
The studies on biology of *L. orbonalis* on brinjal were carried out in a completely randomized

design replicated five times at different temperature levels *viz*., 200, 250, 300 and 350C in BOD incubator. The host plant was sown in a plot size of 5m x 5m each with 1 m pathway between two plots at the planting distance of 60 cm x 60 cm at the farm of College of Agriculture, Latur during 2016-17.

The initial culture of *L. orbonalis* was developed by collecting large number larvae from the infested shoots and fruits of brinjal in experimental field. These larvae were kept separately in clean glass tubes size (3'' × 1"). The fresh fruits of brinjal were cut and small pieces were provided daily in the glass tubes to serve as a food for developing larvae. The freshly formed pupae were collected and transferred to a glass jar (size 360 mm × 150 mm) covered with muslin cloth for adult emergence. The male and female moths were collected from the jar, separated and transferred in pair to other glass jar and covered with muslin cloth. A cotton piece soaked in 5 per cent honey solution was provided in jar by hanging through the muslin cloth with the help of thread to feed the adults. The fresh healthy twigs of brinjal kept in conical flask containing water were placed into the cage for the purpose of egg laying.

The freshly laid one hundred eggs of *L. orbonalis* were obtained from the oviposition cage in order to study the biology at four different temperature levels *viz*., 200C, 250C, 300C and 350C. The eggs were transferred to moist tissue paper kept in a Petri plate with a total of 20 eggs in each Petri plate as one replication. The observations on incubation period and per cent egg hatch were recorded. The newly hatched larvae were reared individually in the plastic boxes on small cut pieces of brinjal at respective temperature. While rearing care was taken to transfer the larvae into clean plastic boxes by providing fresh food every day.

The observations on larval duration, per cent larvae pupated, pre-pupal and pupal duration, per cent adult emergence and life-cycle duration of male and female moths were recorded on brinjal at respective four different temperature levels.

Result Discussion

Biology of *Leucinodes orbonalis* (Guenee) on brinjal at different temperature levels

A. Egg

The incubation period of *L. orbonalis* was varied significantly when reared on brinjal at different temperature levels. However, incubation period of *L. orbonalis* was significantly highest at 200c temperature (5.00 days) followed by 250c temperature (4.00 days), 300c temperature (3.00 days) and 350c temperature (2.50 days). Significantly the highest egg hatch to the extent of 90.00 per cent was observed on brinjal at 350c temperature followed by 300c (84.00 per cent) 250c (80.00 per cent) and 200c temperature (69.00 per cent) (Table 1).

It seems from the present investigation that the incubation period of *L. orbonalis* was extended when reared at 200c temperature. The incubation period of *L. orbonalis* was ranged from 3 to 4 days (Saxena, 1965) [26], 4 to 5 days (Mehto *et al*. 1983) [17] and 5 to 7 days (Suresh *et al*. 1996) [29]. The results in respect of incubation period of *L. orbonalis* reared on brinjal at different temperature levels are in conformity with the results reported by above referred research workers.

Table 1: The mean incubation period, per cent egg hatch, larval duration, per cent pupation and growth index of *L. orbonalis* on brinjal at different temperature levels.

Different temperature levels in ^{0}C	Mean incubation Period (days)	Per cent Egg hatch	Mean larval duration (days)	Per cent pupation	Growth Index
20	5.00	69 (56.16)	25.30	54 (47.29)	2.25
25	4.00	80 (63.43)	22.80	58 (49.60)	2.63
30	3.00	84 (66.42)	20.74	62 (51.94)	3.10
35	2.50	90 (71.56)	18.53	70 (56.78)	3.88
S.E +	0.10	0.39	0.27	0.26	0.12
C.D at 5%	0.32	1.18	0.82	0.80	0.36
C.V. (%)	6.65	5.61	2.85	5.35	8.7

B. Larva

It is evident from Table 1 that significantly the highest mean larval duration of *L. orbonalis* to the extent of 25.30 days was observed at 200c temperature followed by 22.80 days at 250c temperature, 20.74 days at 300c temperature, and 18.53 days at 350c temperature. This indicates that the larval period of *L. orbonalis* was lengthened at 200c temperature and shortened at 350c temperature.

The larval period of *L. orbonalis* on brinjal reported by Saxena (1965) [26], Baang and Corey (1991), Sandanayake and Edirisinghe (1992) [25], Suresh *et al*. (1996) [29], Singh and Singh (2001) [27] and Singh and Singh (2003) [26] was observed to be 23 to 27, 15.38 ± 0.21, 12.1, 15 to 27, 18.66, and 6.7 to 22 days, respectively. Mannan *et al*. (2015) [16] reported shortened larval duration of *L. orbonalis* to the tune of 10.40 days on potato during the summer season, while it was lengthened to the extent of 14.50 days during winter season.

The significantly lowest pupation of *L. orbonalis* was recorded on brinjal at 200c temperature (54.00 per cent) followed by 250c temperature (58.00 per cent), 300c temperature (62.00 per cent) and 350c temperature (70.00 per cent). The growth index values varied from 2.25 to 3.88. The significantly highest growth index was observed in the case of larvae fed on brinjal at 350c temperature (3.88) over 300c temperature (3.1), 250c temperature (2.63) and 200c temperature (2.25 days) (PLATE-II).

The data on mean larval instars duration of *L. orbonalis* on brinjal at different temperature levels are presented in Table 2

Table 2: The mean larval instars duration of L. orbonalis on brinjal at different temperature levels.

Different temperature levels	Larval instars					Total	Mean
	I	II	III	IV	V		
20	4.00	4.20	5.60	5.50	6.00	25.30	4.74
25	3.00	3.90	4.30	5.80	5.80	22.80	4.56
30	2.60	3.50	4.20	5.20	5.24	20.74	4.2
35	2.40	2.90	3.80	4.43	5.00	18.53	3.62
S.E. +	0.07	0.09	0.13	0.08	0.09	-	-
C.D. at 5%	0.22	0.28	0.40	0.24	0.28	-	-
C.V. (%)	5.84	5.96	6.74	3.58	3.7	-	-

It is evident from Table 2 that the *L. orbonalis* passed through five larval instars when reared on brinjal at different

temperature levels. The duration of I, II, III, IV and V larval instars ranged from 4 to 6.00, 3.00 to 5.80, 2.60 to 5.24 and 2.40 to 5.00 days, respectively on brinjal at different temperature levels. The significantly lowest I, II, III, IV, and V larval instar duration to the extent of 2.40, 2.90, 3.80, 4.43 and 5.00 days, respectively was observed on brinjal when grown at 350c temperature. Kumar *et al*. (2011) [15] reported that the average first, second, third, fourth and fifth larval instar duration was 3.66, 2.58, 2.90, 3.10 and 3.54 days, respectively on brinjal.

C. Pupa

The pre-pupal and pupal duration, per cent adult emergence and total developmental period of *L. orbonalis* on brinjal at different temperature levels are presented in Table 3.

Table 3: The mean pre-pupal and pupal duration, per cent adult emergence and total developmental period of *L. orbonalis* on brinjal at different temperature levels.

Different temperature levels	Pre-pupal duration (days)	Pupal duration (days)	Per cent adult emergence	Total developmental period (days)
20	2.31	12	58.25 (49.74)	35.7
25	2.07	10	66.8 (54.81)	32.8
30	1.72	9	71.64 (57.82)	30
35	1.55	8	76.43 (60.95)	26.1
S.E. +	0.03	0.15	0.16	0.34
C.D. at 5%	0.09	0.45	0.48	1.02
C.V. (%)	3.46	3.47	2.65	2.47

It is evident from Table 3 that the significantly shortest mean pre-pupal and pupal durations of *L. orbonalis* to the extent of 1.55 and 8 days, respectively were recorded on brinjal at 350c temperature. While, these durations were highest at 200c temperature (2.31 and 12 days). According to Singh and Singh (2001) [27], Jat *et al*. (2003) [11], Ghosh *et al*. (2005) [9], Mathur and Jain (2006) [13], Kavitha *et al*. (2008) [12], Wankhede *et al*. (2009) [32], Yadav *et al*. (2015), Kumar *et al*. (2011) [15], Rahman *et al*. (2011) [24], Boopal *et al*. (2013), Onekutu *et al*. (2013) [20], Bindu *et al*. (2015) [4] the pupal period of *L. orbonalis* was observed to be 7 to 11, 8.88, 8 to 9, 7 to 11, 8 to 9, 11.50, 8 to 10, 10.43, 9.42, 13.05 ± 0.47, 9 ± 0.65, 8.01, 10.02 ± 0.36, 9.66, 9.23 ± 0.25 and 8.17 ± 0.21 on potato and brinjal at 27 ± 10c and 80 ± 5 per cent relative humidity, 10.16, 11.2 at 27 to 320c temperature, 8.6 ± 0.89 and 10.40 days, respectively.

The results on the pre-pupal and pupal period of *L. orbonalis* on brinjal grown at different temperature levels under investigation are in good line with above referred research workers.

The significantly highest adult emergence was observed in the case of 350c temperature (76.43 per cent) followed by 300c temperature (71.64 per cent), 250c temperature (66.8 per cent) and 200c temperature (58.25 per cent) (Table 3). This indicates that the 350c temperature was suitable for emergence of adults.

D. Total developmental period

The data presented in Table 3 revealed that the mean total developmental period of *L. orbonalis* was observed to be significantly lowest on brinjal at 350c temperature (26.1 days) as compared to 300c temperature (30 days), 250c temperature (32.8 days) and 200c temperature (35.7 days). The total developmental period of *L. orbonalis* ranged from 25 to 28 days (Nwana, 1992) [19] and 28 to 44 days (Suresh *et al*., 1996) [29]. The results in respect of longevity and life-cycle duration of *L. orbonalis* on brinjal at different temperature levels are tabulated in Table 4.

Table 4: The mean longevity and life-cycle duration of *L. orbonalis* on brinjal at different temperature levels.

Different temperature levels	Longevity (days)		Life-cycle duration (days)	
	Male	Female	Male	Female
20	4.00	6.00	45.00	47.0
25	3.50	5.50	39.50	42.0
30	3.00	5.00	36.00	38.50
35	3.00	5.00	31.50	33.50
S.E +	0.09	0.10	0.54	0.70
C.D at 5%	0.28	0.32	1.62	2.12
C.V. (%)	5.9	4.35	3.14	3.95

The data presented in Table 4 revealed that statistically significant differences were observed in respect of longevity of male and female *L. orbonalis* when reared on brinjal at different temperature levels.

The significantly highest longevity of male and female *L. orbonalis* was recorded at 200c temperature (4 and 6 days). It was followed by the longevity of male and female on brinjal at 250c temperature (3.50 and 5.50 days), and 300c and 350c temperature (3 and 5 days). The adult longevity of *L. orbonalis* was reported to be 3 to 5.20 (Kumar *et al*., 2011) [15], 3.50 to 5.70 days (Kavitha *et al*., 2008) [12]. The data on adult longevity of *L. orbonalis* on brinjal at different temperature levels in the present investigation are in good line with the results reported by above mentioned earlier workers.

Significantly the shortest life-cycle duration of male and female *L. orbonalis* to the extent of 31.5 and 33.5 days was observed at 350c temperature followed by life-cycle duration of the male and female *L. orbonalis* at 300c temperature (36 and 38.5 days) and 39.5 and 42 days at 250c temperature while, it was longest (45 and 47 days) when reared at 200c temperature.

It indicates from the present investigation on biology of *L. orbonalis* reared on brinjal at different temperature levels that the durations of different life-stages were extremely extended when reared at 200c temperature compared to their durations when reared at 250c, 300c and 350c temperatures. Ghosh *et al*. (2005) [9] also stated that temperature had the profound influence on the different biological stages.

The data in respect of mean pre-oviposition and oviposition periods and fecundity of *L. orbonalis* on brinjal at different temperature levels are presented in Table 5.

Table 5: The mean pre-oviposition and oviposition period and fecundity of *L. orbonalis* on brinjal at different temperature levels.

Different temperature levels	Pre-oviposition period (days)	Oviposition period (days)	Fecundity/ female
20	2.00	4	388 (19.69)
25	1.60	4.4	569 (23.85)
30	1.35	4.15	605 (24.59)
35	1.20	3.8	654 (25.57)
S.E. +	0.04	0.18	14.49
C.D. at 5%	0.14	0.56	N.S.
C.V. (%)	6.46	10	5.89

It is evident from Table 5 that significantly highest pre-oviposition period of *L. orbonalis* to the extent of 2.00 days was observed at 200c temperature followed by 1.60 days at 250c temperature, 1.35 days at 300c temperature and 1.20

days at 350c temperature. However, the significantly highest oviposition period to the tune of 4.4 days was recorded at 250c temperature over 350c temperature (3.8 days). However, it was at par with rest of the temperature levels under investigation. The results in respect of pre-oviposition and oviposition period of *L. orbonalis* to the tune of 1.20 and 1.90 days and 1.19 and 2.71 days, respectively were also reported by Kumar *et al*. (2011) [15] and Onekutu *et al*. (2013) [20] on brinjal.

However, the numerically highest fecundity to the tune of 654 eggs per female was recorded at 350c temperature followed by 300c temperature (605 eggs per female), 250c temperature (569 eggs per female) while, lowest fecundity was recorded at 200c temperature (388 eggs per female). The fecundity of *L. orbonalis* on brinjal was reported to be 170 eggs per female (Kavitha *et al*., 2008) [12], 120 eggs per female (Wankhede *et al*., 2009), 149.42 eggs per female (Varma *et al*., 2009) [31], 15 to 127 eggs per female (Radhakishore *et al*., 2010) [21], 170 eggs per female at 35 0c temperature (Yadav *et al*., 2015), 160 eggs per female (Kumar *et al*., 2011) [15] and 81.2 ± 9.07 eggs per female (Bindu *et al*., 2015) [4].

Conclusion

The incubation period of *L. orbonalis* was observed to be significantly minimum to the extent of 2.50 days on brinjal at 35˚c temperature followed by 3 days (30˚c temperature), 4 days (25˚c temperature) and 5 days (20˚c temperature). The significantly maximum egg hatching of *L. orbonalis* (90.00 per cent) was observed on brinjal at 35˚c temperature followed by 30˚c temperature (84.00 per cent), 25˚c temperature (80.00 per cent) and 20˚c temperature (69.00 per cent). The significantly shortest larval duration (18.53 days) and highest growth index (3.88) was observed in the case of those larvae of *L. orbonalis* which were reared on brinjal at 35˚c temperature followed by 30˚c temperature (20.74 days and 3.1), 25˚c temperature (22.8 days and 2.63) and 20˚c temperature (25.3 days and 2.25).

The larval development of *L. orbonalis* was completed by passing through five instars on brinjal at different temperature levels under investigation. The mean larval instar duration of *L. orbonalis* was observed to be minimum to the extent of 3.62 days at 35˚c temperature followed by 30˚c temperature (4.2 days), 25˚c temperature (4.56 days) and 20˚c temperature (4.74 days). The significantly lowest pupal duration to the extent of 8 days was observed when grown on brinjal at 35˚c temperature followed by 30˚c temperature (9 days), 25˚c temperature (10 days) and 20˚c temperature (12 days).

Significantly the highest adult emergence of *L. orbonalis* to the tune of 76.43 per cent was observed in the case of those larvae which were reared on brinjal at 35˚c temperature followed by 30˚c temperature (71.64 per cent), 25˚c temperature (66.8 per cent) and 20˚c temperature (58.25 per cent). The significantly lowest developmental period of *L. orbonalis* to the extent of 26.1 days was recorded on brinjal at 35˚c temperature. The significantly highest longevity of male and female *L. orbonalis* was recorded on brinjal at 20˚c temperature (4 and 6 days) followed by 25˚c temp (3.50 and 5.50 days) and 30˚c and 35^0c temperature (3 and 5 days). Significantly the shortest life-cycle duration of male and female *L. orbonalis* to the extent of 31.5 and 33.5 days was observed on brinjal at 35˚c temperature.

The significantly lowest pre-oviposition period of *L. orbonalis* to the tune of 1.20 days was recorded on brinjal at 35˚c temperature followed by 30˚c temperature (1.35 days). The significantly highest oviposition period (4.4 days) of *L. orbonalis* was observed when reared on brinjal at 25˚c temperature followed by 30˚c temperature (4.15 days), 20˚c temperature (4 days) and 35˚c temperature (3.8 days). The female *L. orbonalis* laid numerically highest eggs (654) when its immature stage fed on brinjal at 35˚c temperature followed by 30˚c temperature (605), 25˚c temperature (569), while its egg laying was numerically lowest (388) on brinjal at 20˚c temperature.

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