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INSECTICIDE USAGE PATTERN AND EVOLUTION OF RESISTANCE IN EGGPLANT SHOOT AND FRUIT BORER, *LEUCINODES ORBONALIS* GUENÉE (LEPIDOPTERA: CRAMBIDAE) IN INDIA

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Abstract

The shoot and fruit borer, *Leucinodes orbonalis* is the major insect pest of eggplant, causes severe yield loss up to 90 per cent. Chemical insecticides remain the sole option for control of *L. orbonalis*, adopted by most of the farmers. Indiscriminate use of various insecticides led to insecticide resistance and subsequent control failure. The pesticide usage history on eggplant revealed that, the farmers from Dharmapuri area sprayed 22.6 times (5.4 insecticides), followed by Raichur and Guntur area with 21.6 times (8.9 insecticies) and 21.4 times with 7.9 insecticides. The *L. orbonalis* collected from the hilly tracts of Almora and Pune received no or negligible amount of insecticides. The dose-mortality bioassays on field-collected populations of *L. orbonalis* indicated, varying levels of resistance development against phosalone (139.6 to 526.6 fold), flubendiamide (31.9 to 363.9 fold), fenvalerate (37.2 to 128.7 fold), emamectin benzoate (9 to 46 fold) and thiodicarb (7.2 to 22.8 fold) as compared to susceptible iso-female colony (Lo-S). Continous and indiscriminate use of the insecticides poses increased selection pressure that leads to development of insect resistance to insecticide.

Keywords **:** Eggplant, *Leucinodes orbonalis*, insecticide resistance, usage pattern.

Introduction

The eggplant, *Solanum melongena* is native to India, widely cultivated in many Asian countries (Doijode, 2001; Tsao and Lo 2006; Anonymous 2014). India stands second in production after China with 0.66 million hectares and a production of 12.4 million tonnes (Anonymous, 2017). West Bengal, Odisha, Gujarat, Bihar, Madhya Pradesh, Chhattisgarh, Karnataka, Maharashtra, Andhra Pradesh, Haryana, Assam, Uttar Pradesh, Jharkhand and Tamil Nadu are the leading states for commercial eggplant production.

Eggplant crop is damaged by more than 53 important insect pests, out of which 8 species are considered as major pests causing severe damage to the crop. The eggplant shoot and fruit borer, *Leucinodes orbonalis* Guenée (Lepidoptera: Crambidae) is a chronic pest of eggplant that damages the crop throughout the crop season (Biswas *et al.,* 1992; Bhadauria *et al.,* 1999; Muthukrishnan *et al.,* 2005). Yield losses up to 88.7 per cent have been reported in many countries despite best management practices (Haseeb *et al.,* 2009, Mishra *et al.,* 2014). Due to cryptic nature of the larvae, farmers generally adopt calendar-based prophylactic insecticidal sprays to avoid cosmetic damage on the fruits (Chatterjee and Roy, 2004; Sharma *et al.,* 2004; Mishra and Dash, 2007). Out of 13-14 per cent of pesticides used on vegetables in India, eggplant receives the maximum pesticide sprays after chilli (Kodandaram *et al.,* 2013). Due to continous pesticide application evidence of insecticide resistance has been documented in *L. orbonalis* (Kodandaram *et al.,* 2015; Kariyanna *et al.*, 2019). The large population size and year-round multiplication capacity of *L. orbonalis* coupled with continuous exposure to various chemicals might further accelerate resistance evolution in this pest. The present study attempted to analyse the insecticide usage pattern on eggplant and level of insecticide resistance in *L. orbonalis* against selected insecticides.

Materials and Methods

Insect collection and maintenance

The field populations of *L. orbonalis* were collected from intensive eggplant growing regions of India *viz*., North India: Varanasi (18.5204° N, 73.8567° E), Delhi (16.2120° N, 77.3439° E), Almora (16.2120° N, 77.3439° E); Central India: Nagpur (16.2120° N, 77.3439° E); Eastern India: Bhubaneshwar (20.2961° N, 85.8245° E); Western India: Pune (18.5204° N, 73.8567° E); South India: Raichur (16.2120° N, 77.3439° E), Guntur (16.2120° N, 77.3439° E), Dharmapuri (12.0933° N, 78.2020° E) and Coimbatore (16.2120° N, 77.3439° E) (Fig. 1) during 2016-2019. Collected field populations were reared under laboratory conditions at 27 ± 2 ºC, 60-70 per cent RH, and a photoperiod of 14:10h (L:D) on a natural diet (Fig. 2) and the F1 individuals were used for bioassay and biochemical studies. The iso-female line (Lo-S) derived from the Bengaluru area (12.9716° N, 77.5946° E) has been maintaining (since October 2012) at insect genomic resources laboratory at ICAR-NBAIR was used as susceptible control and designated as Lo-S.

Data on insecticide usage pattern

The insecticides that are very frequently used on the eggplant to control *L. orbonalis* were recorded from local farmers. The details on types, numbers and frequency of insecticides used along with insecticides rotation pattern and damage percentage were collected from each location (Table 1; Fig. 1).

Insecticide resistance bioassays

The commonly used commercial formulations *viz.,* fenvalerate (20% EC), emamectin benzoate (5% EC), phosalone (35%), thiodicarb (75%) and flubendiamide (20%) were selected based on their usage history on eggplant by farmers for the control of *L. orbonalis*. The filter paper residue assay (Cheng *et al.,* 2010) with crucial adjustments was used for insecticide resistance bioassays on early second instar larvae of *L. orbonalis* larvae. Based on the preliminary bioassay five to seven appropriate concentrations of each of the selected insecticides were prepared. Filter paper discs of approximately 4.5 cm diameter were immersed in the required dilutions and vertically dried under shade for 1 hour. Then paper discs placed individually in the plastic containers ~5 cm diameter and 10-second instar larvae were allowed on each concentration in three to four repetitions (Fig. 3). After 24 hours of incubation, the larvae were shifted to an untreated natural diet (Fig. 4). The mortality of larvae was recorded from 48 hours. The filter paper residue assay was found simple, precise and consistent in larval mortality for contact insecticides and hence this method was adopted subsequently in all dose-mortality bioassays. The larval mortality data were grouped and used for probit analysis by POLO software (Leora, 1994). For each population, the lethal concentration to kill 50% of the test larvae (LC_{50}) was assessed. The resistance ratios (RR) were analysed by using the formula: LC_{50} of field population/LC_{50} of the Lo-S population.

Fig. 1 : *Leucinodes orbonalis* populations collected from different part of India

Results and Discussion

Insecticide history during crop period

The insecticides used by the farmers in the surveyed location were more diverse and greater numbers than the recommended. Among the eleven collected population (Fig. 1) the Raichur population having highest insecticide uasage history (8.88), followed by Coimbatore (8), Dharmapuri (7.62), Delhi (7.3), Guntur (7.28), Varanasi (7), Nagpur (7) and Bhuvaneshwar (5.33). In contrary, Pune (0.9) (in hilly area) and Almora (0.7) were reported less number of insecticides. The highest number of sprays observed in Coimbatore (22.8) and Dharmapuri (22.62 times), the result was concurrence with 15-time insecticide spray on eggplant and cauliflower, 13 and 12 times spray in chilli and bhendi crop respectively (Jeyanthi and Kombairaju, 2005).

Fig. 2 : Improved rearing method of *L. orbonalis* using natural host

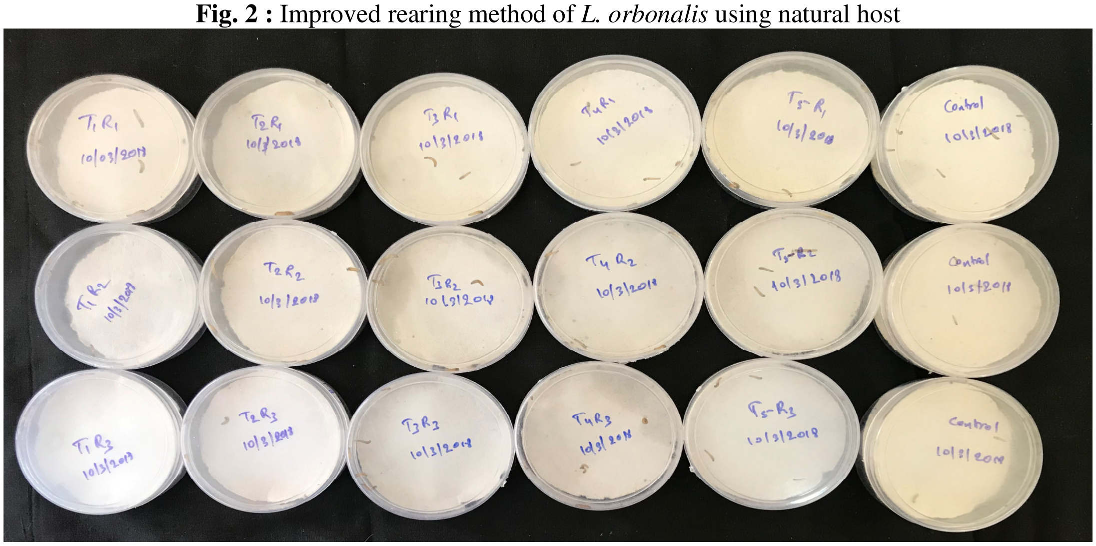

Fig. 3 : Larvae of *L. orbonalis* released on Filter paper discs for 24 hours

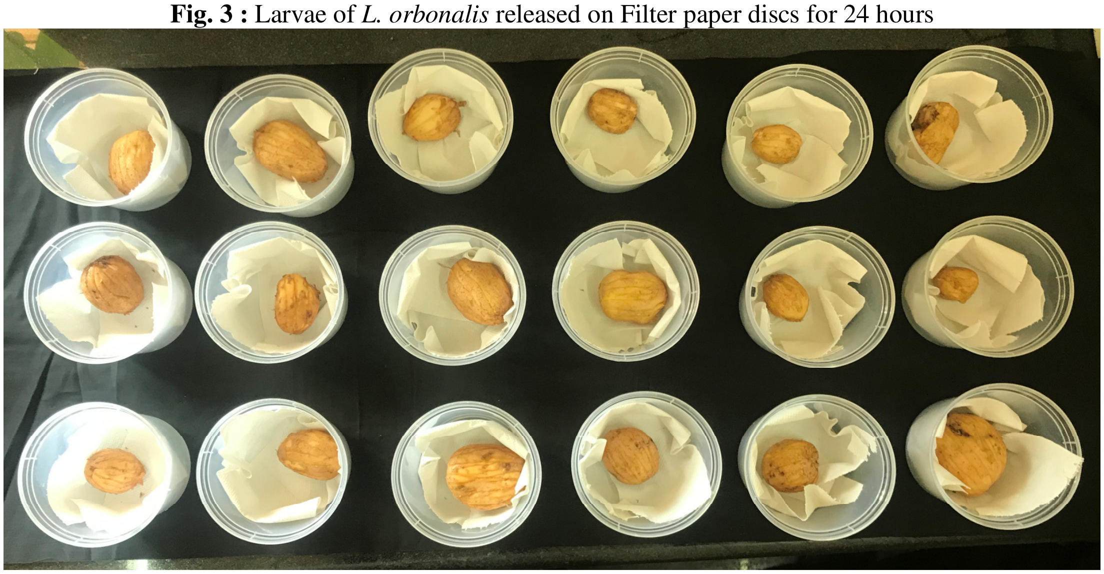

Fig. 4 : Larvae of *L. orbonalis* allowed on natural potato diet for 48-72 hours after filter paper incubation to record the mortality

The overall insecticide usage history in eggplant growing area of India revealed that, the emamectin benzoate is the most commonly used insecticides (12%) in all the locations followed by chlorantraniliprole (10%) (Fig. 5). The spinetoram, fenvalerate, acephate moderately using insecticides (~8%) and corboryl, chlorpyriphos, dimethoate, alphamethrin, triazophos contributing 2 per cent or less in managing *L. orbonalis*. Similarly, highest number of organophosphates and amide group of insecticide to manage insect pests in eggplant and cauliflower were from Himachal Pradesh (Kumar *et al.,* 2017 and Gaganpreet *et al.,* 2018). In bhendi neonicotinoids and combinations of insecticides were largely used to manage sucking pest (Meenambigai *et al.,* 2017) and pyrethroids were the most commonly used insecticides on eggplant followed by organophosphate (Jeyanthi and Kombairaju, 2005).

Table 1 : Insecticides usage pattern against *L. orbonalis* on eggplant

Sl. No.	Place of collection	Commonly used insecticides	Number of farmers interviewed	Number of sprays / crop season (mean ±SE)	Number of insecticides used (mean ±SE)
1.	Almora	Organic by default, rarely fenvalerate	12	0.7 ±0.06	1.0
2.	Bhubaneshwar	Acephate, phosalone, chlorantraniliprole, emamectin benzoate, flubendiamide, acetamaprid	6	18.83 ±2.57	5.33 ±0.33
3.	Coimbatore	Phosalone, acetamaprid, acephate, emamectin benzoate, flubendiamide, spinetoram, fipronil, deltamethrin, fenvalerate	5	22.8 ±1.71	8 ±0.7
4.	Delhi	Chlorantraniliprole, endosulfon, profenophos, corboryl, chlorpyriphos, deltamethrine, dimethoate, emamectin benzoate, endosulfan	3	20 ±1.15	7.3 ±0.8
5.	Dharmapuri	Fipronil, emamectin benzoate, phosalone, fenvalerate, phosalone, chlorantraniliprole, flubendiamide, dimethoate	8	22.62 ±2.18	7.62 ±0.37
6.	Guntur	Acetamaprid, acephate, emamectin benzoate, spinetoram, deltamethrin, cartap-hydrochloride, fipronil, alphamethrin, profenophos	7	21.42 ±1.32	7.28 ±0.52
7.	Nagpur	Emamectin benzoate, acetamaprid, fipronil, acephate, fenvalerate, cartap-hydrochloride, spinetoram, chlrorantraniliprole	6	18.33 ±1.05	7±0.5
8.	Pune	Largely organic, ocaasionally treated with spinetoram and fipronil	10	3.7 ±1.32	0.9 ±0.31
9.	Raichur	Fipronil, acephate, alphamethrin, profenophos, acetamaprid, cartap-hydrochloride, emamectin benzoate, spinetoram, triazophos, monocrotophos, chlorantraniliprole	9	21.55 ±1.38	8.88 ±0.58
10.	Varanasi	Spinosad, fenvalerate, deltamethrin, phosalone, flubendiamide, cartap-hydrochloride, chlorantraniliprole, emamectin benzoate	5	20 ±0.7	7 ±0.54
11.	Bengaluru (Lab S)	Insecticide susceptible (Being maintained since 2012)	-	-	-

Insecticide resistance monitoring

The usage pattern of insecticide to manage *L. orbonalis* indicated that, the insecticides groups *viz.,* organophosphate, carbamate, pyrethroids, synthetic actinomycetes derived chemicals, amide and cartap hydrochloride were commonly used in most of the eggplant growing location. The LC_{50} helps to determine the resistance ratio against the applied insecticides. In present study, the dose-mortality bioassays with insecticides like fenvalerate, phosalone, emamectin benzoate and flubendiamide demonstrated different levels of toxicity against the filed collected *L. orbonalis* compared Lo-S (Table 2).

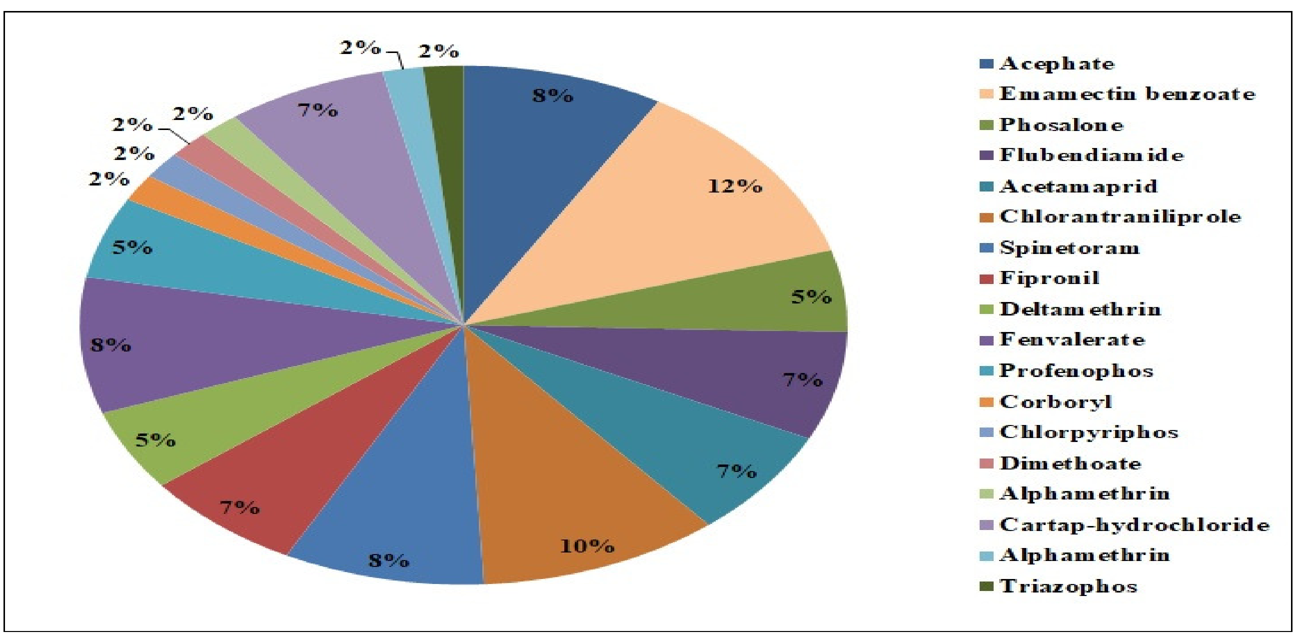

Fig. 5 : Frequency of pesticide used across the eleven eggplant growing regions of India

The bioassay using fenvalerate depicted that, the LC_{50} of Nagpur (128.7 ppm) was highest followed Delhi (114.2 ppm) and least observed in case of Coimbatore (37.2 ppm) populations over Lo-S (table 2) and the range of LC_{50} observed from 1.62 to 259.2 ppm. Similar trend was observed (35.0 ppm to 226.33 ppm) against cypermethrin 10EC on *L. orbonalis* (Ranjith Kumar, 2014).

For phosalone the highest LC_{50} was Nagpure (632.0 ppm) followed by Delhi (483.3 ppm) and least was from Coimbatore (167.5 ppm) population over Lo-S (table 2). Phosalone insecticide has widest LC_{50} range from 1.2 to 632.0 ppm in all the populations. The result was supported with a maximum range of LC_{50} from 140.5 to 1322.5 ppm against monocrotophos on 14 *L. orbonalis* populations across India (Ranjith Kumar, 2014). But the spectrum of LC_{50} was comparatively low when quinolphos used as insecticide against fourteen *L. orbonalis* populations (Ranjith Kumar, 2014).

Thiodicarb displayed the highest LC_{50} in Guntur (264.2 ppm) followed Nagpur (262.8 ppm) and least was observed in Coimbatore (83.2 ppm) population over Lo-S (table 2). The thiodicarb LC_{50} range was 83.2-264.2 ppm in all the tested populations. The data was supported with the LC_{50} of 50-313.53 ppm in 14 population collected across India (Ranjith Kumar, 2014).

The LC_{50} of flubendiamide was highest in Nagpur (83.7 ppm) followed by Delhi (53.0 ppm) and least was observed in Coimbatore (7.34 ppm) over Bengaluru (Lo-S) (table 4). The range of LC_{50} was 7.34-83.7 ppm in all the tested populations. Similalry, for Punjab local populations 11.2 ppm were reported (Kodandaram *et al.,* 2013) and 2.10-28.20 ppm in 14 *L. orbonalis* species tested across India (Ranjith Kumar, 2014).

Emamectin benzoate displayed the least LC_{50} value compared to other insecticides, in which highest was observed in Delhi (0.46 ppm) followed by Nagpur (0.38 ppm) and least was observed in Coimbatore (0.06 ppm) population over Lo-S (table 4). Among all the chemicals use the emamectin benzoate has shown greater mortality with least LC_{50} value (0.06-0.46 ppm) and fold changes (9-46 folds) against all the tested field populations (Table 2). Similar toxicity range of LC_{50} value (302.8 ppm) was reported in neonate *L. orbonalis* larvae (Anil and Sharma, 2010) and from 0.061 to 0.24 ppm in *Leucinodes spp* in Punjab (Kaur *et al.,* 2014).

Table 2 : Insecticide resistance pattern in field populations of *L. orbonalis*

Insecticide	Population	LC_{50} (ppm)	Slope ±SE	F. limits		χ^2 heterogeneity (DF)	Resistance ratio
				Lower	upper		
Fenvalerate	Guntur	93.9	3.2± 0.2	56.8	125.5	3.93 (3)	58.1
	Coimbatore	61.2	2.8± 0.56	30.8	97.5	1.02 (4)	37.2
	Nagpur	208.5	2.2 ± 0.56	103.5	603.2	2.87 (3)	128.7
	Delhi	185.7	3.1 ±0.53	98.05	412.9	6.35 (4)	114.2
	Bengaluru (Lo-S)	1.62	2.2 ± 0.42	0.85	3.57	2.62 (4)	-
Phosalone	Guntur	191.1	1.9± 0.2	109.1	281.1	3.91 (3)	159.3
	Coimbatore	167.5	2.3± 0.34	123.8	245.2	7.0 (4)	139.6
	Nagpur	632.0	2.1 ± 0.09	315.8	2560.5	0.74 (3)	526.6
	Delhi	483.3	1.93± 0.14	243.7	957.5	0.96 (3)	402.8
	Bengaluru (Lo-S)	1.2	1.2± 0.21	0.521	2.42	1.91 (3)	-
Emamectin benzoate	Guntur	0.19	1.1± 0.10	0.07	0.26	1.2 (3)	19
	Coimbatore	0.06	1.3± 0.14	0.03	0.09	0.62 (4)	9
	Nagpur	0.38	2.9 ± 0.21	0.220	1.390	8.62 (4)	38
	Delhi	0.46	1.91 ± 0.19	0.231	0.953	3.77 (3)	46
	Bengaluru (Lo-S)	0.01	1.4 ± 0.07	0.004	0.051	3.17 (3)	-
Thiodicarb	Guntur	264.2	2.2 ± 0.21	122.1	468.1	2.4 (3)	22.8
	Coimbatore	83.2	1.6 ± 0,32	42.78	193.2	6.9 (4)	7.2
	Nagpur	262.8	1.9 ± 0.14	145.9	534.6	7.3 (4)	22.6
	Delhi	106.5	1.82 ± 0.39	55.37	278.4	2.4 (3)	9.17
	Bengaluru (Lo-S)	11.61	1.73±0.32	5.462	23.56	4.7 (3)	-
Flubendiamide	Guntur	42.9	1.72 ± 0.10	22.4	94.02	2.9 (3)	186.5
	Coimbatore	7.34	0.99 ± 0.10	3.23	16.72	6.2 (4)	31.9
	Nagpur	83.7	2.11 ± 0.21	40.00	253.9	3.9 (3)	363.9
	Delhi	53.0	1.92 ± 0.28	26.91	118.0	3.7 (3)	230.4
	Bengaluru (Lo-S)	0.23	1.21 ± 0.26	0.09	1.01	2.1 (3)	-

Conclusion

The present investigation revealed that, the insecticide usage pattern across India with the extent of insecticide resistance in various field collected populations of *L. orbonalis*. Thus, it is important to examine each possible factor that leads to the evolution of insecticide resistance. Lack of resistance in certain populations does not exclude resistance risk in the future. Hence, the insecticide resistance management strategies should essentially include atleast moderately tolerate eggplant cultivar, monitoring of population by pheromone traps, need-based application of effective and softer insecticides in rotation with biopesticides, botanicals and bioagents. Understanding the level of insecticide resistance before a control measure is deployed would help in effective resistance management of *L. orbonalis*.

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Disclosure statement

The authors have no potential conflict

Reference

Alam, S.N.; Rashid, M.A.; Rouf, F.M.A.; Jhala, R.C.; Patel, J.R.; Satpathy, S.; Shivalingaswamy, T.M.; Rai, S.; Wahundeniya, I.; Cork, A.; Ammaranan, C. and Talekar, N.S. (2003). Development of an integrated pest management strategy for brinjal fruit and shoot borer in South Asia. Shanhua, Taiwan: AVRDC—the World Vegetable Center. Technical Bulletin No. 28. AVRDC Publication No. 03-548. 56.

Anil and Sharma P.C. (2010). Bioefficacy of insecticides against *Leucinodes orbonalis* on brinjal. J Envirin. Biol., 31(4): 399-402.

Anonymous (2014). National Horticulture Board. 2014. Indian horticulture database [online]. Ministry of Agriculture, Government of India. Available from http://nhb.gov.in/area-pro/NHB_Database_2015.pdf [accessed 4 February 2016].

Anonymous (2017). Horticultural Statistics at a Glance. Horticulture Statistics Division, Department of Agriculture, Cooperation & Farmers Welfare, Ministry of Agriculture & Farmers Welfare Government of India. p 514. www.agricoop.nic.in

Bhadauria, N.K.S.; Bhadauria, N.S. and Jakhmola, S.S. (1999). Insect pest complex of brinjal, *S. melongena* L in North West M P. Adv. Pl. Sci., 12: 607-08.

Biswas, G.C.; Satter, M.A. and Shaha, M.C. (1992). Survey and monitoring of insect pest of brinjal at Khagrachari Hilly Region. Annual Research Report, 1991-1992, Entomology Division. BARI,Joydebpur, Gazipur, Bangladesh, 41-42.

Chatterjee, M.L. (2004). Roy S. Bio-efficacy of some insecticides against brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee and effect of novaluron on natural enemies of brinjal pests. Pestology, 28(l0): 52-56.

Cheng, X.; Chang, C. and Daia, S-M. (2010). Responses of striped stem borer, *Chilo suppressalis* (Lepidoptera: Pyralidae), from Taiwan to a range of insecticides. Pest Manag. Sci., 66: 762-766.

Dadmal, S.M.; Nemade, S.B. and Akhare, M.D. (2004). Field screening of brinjal cultivar for resistance to *Leucinodes orbonalis* Guen. Pest Management in Horticultural Ecosystems, 10(02): 145-150.

Doijode, S.D. (2001). Seed storage of horticultural crops (pp 157). Haworth Press: ISBN 1-56022-901-2.

Gaur, K. and Chaudhary, B. (2009). The development and regulation of Bt brinjal in India (Brinjal/Aubergine). ISAAA, 38.

Gaganpreet, S.B.; Surender, K.P.; Jatiender, K.D. and Gagandeep, S. (2018). Survey on Pesticide Use Pattern and Farmers Perceptions in Cauliflower and Brinjal Growing Areas in Three Districts of Himachal Pradesh, India. Int. J. Curr. Microbiol. App. Sci., 7(03): 2417-2423.

Haseeb, M.; Sharma, D.K. and Qamar, M. (2009). Estimation of the losses caused by shoot and fruit borer, *Leucinodes orbonalis* Guen. (Lepidoptera: Pyralidae) in brinjal. Trends in Biosciences, 2: 68–69.

Jeyanthi H. and Kombairaju S. (2005). Pesticide Use in Vegetable Crops: Frequency, Intensity and Determinant Factors. Agricultural Economics Research Review. 18: 209-221.

Kariyanna, B.; Prabhuraj, A.; Asokan, R.; Babu, P.; Jalali, S.K.; Venkatesan, T.; Gracy, R.G. and Mohan M. (2019). Identification of suitable reference genes for normalization of RT-qPCR data in eggplant fruit and shoot borer (*Leucinodes orbonalis* Guenée). Biologia.

Kaur, M.; Dhatt, S.; Ajmer, S.; Sandhu, J. and Gosal, S.S. (2010). Genetic transformation of Cry 1AC gene to counter fruit and shoot borer of brinjal (*Solanum melongena* L). Crop Improvement 37(2): 200.

Kodandaram, M.H.; Rai, A.B.; Sireesha, K. and Halder, J. (2015). Efficacy of cyantraniliprole a new anthranilic diamide insecticide against *Leucinodes orbonalis* (Lepidoptera: Crambidae) of brinjal. Journal of Environmental Biology, 36: 1415–1420.

Kodandaram, M.H.; Rai, A.B. and Jaydeep, H. (2013). Susceptibility of brinjal shoot and fruit borer *Leucinodes orbonalis* and whitefly Bemisia tabaci to novel anthranilic diamide insecticide cyantraniliprole 10% OD.In: National Symposium on Abiotic and Biotic Stress Management in Vegetable Crops, IIVR, Varanasi, April 12–14.

Kumar, B.A.; Ragini, K.; Padmasri, A.; Rao, K.J. and Shashibhushan, V. (2017). Survey on pesticide usage pattern in bhendi (*Abelmoschus esculentus* L.). Bulletin of Environment, Pharmacology and Life Sciences, 6(1): 182-188.

LeOra, S. (1987). Polo-Plus, POLO for Windows; LeOra Software: Petaluma, CA, USA.

Meenambigai, C.; Bhuvaneswari, K.; Mohan, K. and Sangavi, R. (2017). Pesticides usage pattern of okra, *Abelmoschus esculentus* (L) Moench in Tamil Nadu. Journal of Entomology and Zoology Studies. 5(6): 1760-1765.

Mishra, K.; Keshav, S. and Tripathi, C.P.M. (2014). Management of infestation of pod borer (*Lucinodes orbonalis* Guenee) and productivity enhancement of brinjal (*Solanum melogena*) through vermiwash with biopesticide.International Journal of Advanced Research, 2(1): 780-789.

Mishra, N.C. and Dash, D. (2007). Evaluation of synthetic and neem based pesticide schedules against shoot and fruit borer (*Leucinodes orbonalis* Guen.) on brinjal. Journal of Plant Protection and Environment, 4: 93–96.

Muthukrishnan, N.; Ganapathy, N.; Nalini, R. and Rajendran, R. (2005). Pest Management in Horticultural Crops, Hindustan Graphics, Madurai. 373.

Ranjith, K.L. (2014). Shoot and Fruit Borer (*Leucinodes orbonalis* G.) in South India. PhD Thesis. Department of Agricultural Entomology, College of Agriculture, Dharwad University of Agricultural Sciences, Dharwad. 1-165.

Sharma, J.D.; Nagreta, D.S. and Amit, N. (2004). Management of brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. and persistence of betacy fluthrin in brinjal fruits. Pesticide Research Journal, 16(2): 139-143.

Talekar, N.S. (2002). Controlling brinjal shoot and fruit borer: A simple, safe and economical approach. International Cooperators' Guide, Publication No. #02-534, Shanhua, Taiwan: Asian Vegetable Research and Development, Center.

Tsao and Lo (2006). In "Vegetables: Types and Biology". Handbook of Food Science, Technology, and Engineering by Yiu H. Hui. CRC Press. ISBN 1-57444-551-0.