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Influence of Insecticides on Food Consumption and Utilization Behaviour of Different *Leucinodes orbonalis* Populations from Punjab

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Abstract: *Leucinodes orbonalis* Guenee is a monophagous and serious pest causing high damage in the brinjal crop. The effect of the different insecticides viz. emamectin benzoate 5 SG, chlorantraniliprole 18.5 SC, deltamethrin 2.8 EC, spinosad 45 SC, fenvalerate 20 EC, cypermethrin 25 EC on food consumption and utilization in different *L. orbonalis* larval populations of Punjab were observed in a laboratory. Emamectin benzoate showed the most potent effect on the feeding of *L. orbonalis* larvae and lowest relative consumption rate (RCR), relative growth rate (RGR), the efficiency of conversion of ingested food to body substance (ECI) and efficiency of conversion of digested food to body substance (ECD) with highest approximate digestibility (AD). The nutritional indices value except AD was higher for *L. orbonalis* larvae fed on untreated food followed by deltamethrin, fenvalerate, chlorantraniliprole, cypermethrin, spinosad and emamectin benzoate treated food. The RCR, RGR, ECI, ECD were maximum for larval populations of the Amritsar region followed by Kapurthala, Malerkotla, Ludhiana and susceptible populations. The approximate digestibility (AD) was higher for larvae of the susceptible population followed by Ludhiana, Malerkotla, Kapurthala and Amritsar populations of *L. orbonalis.* The findings of present study would be helpful in designing management strategies for *L. orbonalis*.

Keywords: Insecticides, *L. orbonalis*, Nutritional indices, Punjab

The brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) is the key pest widely distributed throughout the world (CABI 2018, Islam et al 2019). It has high reproductive potential, rapid turnover of generations and cause significant damage during both rainy and summer seasons (Jhala et al 2007, Kaur et al 2014, Singla 2014). Brinjal shoot and fruit borer could cause losses as high as 70 to 92 per cent and even 100 per cent if no control measures are applied (Chakraborti and Sarkar 2011). The synthetic conventional insecticides such as organophosphates, synthetic pyrethroids and carbamates are used generally for the management of this insect pest, but their sole dependency and excessive use has resulted in insecticide residue problems resistance development in *L. orbonalis* (Srinivasan 2008, Kaur et al 2014, Latif et al 2010, Saraswathi et al 2020). The understanding about the nutritional indices of insects such as the rate of ingestion, digestion assimilation and conversion of food would be useful in studying the impact of insecticides on the physiology and behavior of an insect pest (Rashwan 2013). The amount quality and rate and of food consumed by insect's larval stage have a high influence on various aspects of insects such as growth, development, survival and fecundity in adults impacting the overall physiology of insects (Rashwan 2013). The present investigation was designed to study food consumption and utilization in *L. orbonalis* populations from different regions of Punjab concerning various insecticides.

MATERIAL AND METHODS

Culture of *Leucinodes orbonalis*: The infested shoots and fruits of brinjal were collected from vegetable fields of Amritsar, Kapurthala, Malerkotla and Ludhiana regions. The larvae of *L. orbonalis* were extracted from brinjal fruits and reared in the insect physiology laboratory. Larvae of *L. orbonalis* procured from brinjal fruits were transferred to the glass jar (10 ×15 cm) containing fresh pieces of brinjal fruit and placed in an environmental chamber (MAC) at 27° C and 70 per cent relative humidity. The food was changed daily in the morning hours to prevent fungal contamination till reached the fifth instar larvae. The pupae were then shifted to another glass jar, with a moist sponge at the base and the jar was covered with muslin cloth for pupation. On the same day the emerging adults were transferred into new jars for mating and oviposition on the same day. A cotton swab dipped in 10 per cent honey solution was provided food to the adults. The leaf containing eggs was removed daily and replaced with a new leaf to facilitate further oviposition. The population of *L. orbonalis* was collected from untreated infested fruits of the brinjal sown at Entomological Research Farm of Punjab Agricultural University, Ludhiana and reared for twenty generations to develop the susceptible population.

Test insecticides: The commercial preparations of emamectin benzoate 5 SG, chlorantraniliprole 18.5 SC, deltamethrin 2.8 EC, spinosad 45 SC, fenvalerate 20 EC, cypermethrin 25 EC used in toxicity bioassay.

Food consumption and utilization behaviour of *L. orbonalis:* Fresh fruits of brinjal were cut into uniform pieces and treated with LC_{50} concentrations (Table 1) of test insecticides (Chandi and Kaur 2021). The single-piece was placed in an individual plastic cup. Single larva of uniform weight from different populations (Amritsar, Malerkotla, Kapurthala and Ludhiana) was placed in each plastic cup. Ten cups of each treatment replicated thrice were maintained. The initial weight of the larvae was taken before releasing them in cups. After four days of feeding, the weight of these larvae was again recorded to see the larval weight gain. Simultaneously, the weight of food (brinjal fruit) was also recorded for estimation of loss in weight due to evaporation. Based upon these, the corrected weight of the leaf eaten was worked out. Excretal pellets were collected after four days and the weight of the same was recorded. The experiment was replicated thrice. Various consumption and utilization indices were determined (Waldbauer 1968)

i. Relative consumption rate (RCR) = F/TA

Where, 'F' is fresh weight (mg) of food eaten

'T' is duration of feeding period in days

'A' is geometric mean fresh larval weight (mg) during feeding period

ii. Approximate digestibility (AD) = $\frac{F-E}{F}\times 100$

Where, 'F' is fresh weight (mg) of food eaten

'E' is weight (mg) of faeces

iii. Relative growth rate (RGR) = $\frac{G}{TA}$

Where, 'G' is fresh weight (mg) gain of larva

'T' is duration of feeding period in days

'A' is the geometric mean fresh larval weight (mg) during the feeding period

iv. Efficiency of conversion of ingested food to body substance (ECI) = $\frac{G}{F}\times 100$

Where, 'G' is fresh weight (mg) gain of larvae

'F' is fresh weight (mg) of food eaten

v. Efficiency of conversion of digested food to body substance (ECD) = $\frac{G}{F-E}\times 100$

Where, 'G' is fresh weight (mg) gain of larva

'F' is fresh weight (mg) of food eaten

'E' is weight (mg) of faece

Statistical analysis: One-way analysis of variance was done using SPSS software (standard version 16.0). A "P" value of 0.05 was selected as a criterion for statistically significant differences.

RESULTS AND DISCUSSION

The relative consumption rate (RCR), was maximum for Amritsar larval populations of *L. orbonalis* ranging from 1.847 to 9.800 followed by Kapurthala, Malerkotla, Ludhiana and susceptible populations (Table 2). The RGR also showed the same trend (Table 3). Amritsar populations showed maximum ECI ranging from 5.588 to 12.755 followed by Kapurthala, Malerkotla, Ludhiana and susceptible (1.578 to 6.774) populations (Table 4). ECD was maximum for larvae of Amritsar population ranging from 5.692 to 13.888 followed by Kapurthala, Malerkotla, Ludhiana and susceptible populations (1.600 to 7.118) (Table 5). AD was higher for larvae of the susceptible population (95.161 to 98.684) followed by Ludhiana, Malerkotla, Kapurthala and Amritsar populations (Table 6).

RCR was maximum for larvae of *L. orbonalis* fed on untreated food (4.558 to 9.800) followed by deltamethrin-treate, fenvalerate-treated, chlorantraniliprole–treated, cypermethrin-treated, spinosad –treated, and emamectin benzoate-treated food (Table 2). RGR was maximum for larvae of *L. orbonalis* fed on untreated food (0.308 to 1.250) followed by deltamethrin-, fenvalerate, chlorantraniliprole,

Table 1. LC_{50} concentrations of different test insecticides with respect to different regions of Punjab

Insecticides	LC_{50} (%)				
	Amritsar	Kapurthala	Malerkotla	Ludhiana	Susceptible
Emamectin benzoate	0.000046	0.000035	0.000027	0.000023	0.000015
Spinosad	0.000083	0.000058	0.000034	0.000024	0.000016
Cypermethrin	0.0094	0.0049	0.0028	0.0011	0.0009
Chlorantraniliprole	0.0134	0.0117	0.0088	0.0069	0.0046
Fenvalerate	0.0219	0.0176	0.0122	0.0086	0.0065
Deltamethrin	0.0332	0.0275	0.0267	0.0241	0.0198

cypermethrin, spinosad and emamectin benzoate-treated food (Table 3). ECI was maximum for larvae of *L. orbonalis* fed on untreated food (6.774 to 12.755) followed by deltamethrin, fenvalerate, chlorantraniliprole, cypermethrin, spinosad , and emamectin benzoate-treated food (Table 4). ECD was maximum for larvae of *L. orbonalis* fed on untreated food (7.118 to 13.888) followed by deltamethrin, fenvalerate, chlorantraniliprole, cypermethrin, spinosad and emamectin benzoate treated food (Table 5), while AD was recorded more for larvae fed on emamectin benzoate-treated food (98.684 to 98.176), followed by those fed on spinosad, cypermethrin, chlorantraniliprole, fenvalerate, deltamethrin and untreated food (Table 6). The trend was similar for all populations.

The larvae fed on food treated with insecticides showed a decrease in nutrition indices and utilization of food as compared to the untreated one. Among all insecticides, emamectin benzoate was most effective insecticide which hindered the feeding in a significant manner in all populations of *L. orbonalis* collected from different regions of Punjab. The results of the present study are in line with observations of other research workers where emamectin-benzoate, chlorantraniliprole and indoxacarb significantly decreased the nutrition indices and utilization of food in larvae of the cotton leafworm, *S. littoralis* (El-Naggar 2013, El- Sheikh 2015, El-Dewy 2017). Similarly, Xu et al (2016) also reported a decrease in RCR, RGR, ECD and ECI indices but an increase in AD when 4^{th} instar larvae of *Agrotis ipsilon* were fed on an insecticide-treated artificial diet and concluded that cyantraniliprole had antifeedant activity and it prevented insects from feeding which could lead to nutrient insufficiency for normal growth and proper metabolic functioning of insects (Hanning et al 2009, Xu et al 2016). The persistence of food in the digestive tract and slow passage of food through it could have resulted in higher approximate digestibility in *L. orbonalis* in the present study (Nathan 2006, Xu et al 2016). The decreased rates of excretion in treated *L. orbonalis* populations could also have resulted in higher AD. Decrease in consumption index, relative growth rate and efficiency of conversions of either ingested or digested food to body tissue of *S. littoralis* larvae when fed on abamectin and sumialfa was also reported by El-Malla and Radwan (2008). Similarly, Nathan (2006) and Nathan et al (2005) observed significant reduction in RCI, RGR and ECI of *Cnaphalocrocis medinalis*

Table 2. Effect of insecticides on the relative consumption rate (RCR) of different populations of *L. orbonalis*

Treatment (LC_{50})	Relative Consumption Rate (RCR)				
	Susceptible	Ludhiana	Malerkotla	Kapurthala	Amritsar
Emamectin benzoate	1.250	1.341	1.511	1.666	1.847
Spinosad	1.571	1.687	1.890	2.302	3.571
Cypermethrin	1.918	2.697	2.894	3.187	3.783
Chlorantraniliprole	2.916	3.257	3.357	3.684	4.285
Fenvalerate	3.257	3.642	4.296	4.687	5.312
Deltamethrin	4.032	4.500	4.750	5.000	7.083
Untreated	4.558	5.156	6.250	7.666	9.800

Populations F (4,30)= 1.6144 (*NS) , Insecticides F(6,28)= 13.7692 (*NS)
**NS indicate values are non-significant as P>0.05

Table 3. Effect of insecticides on the relative growth rate (RGR) of different populations of *L.orbonalis*

Treatment (LC_{50})	Relative growth rate (RGR)				
	Susceptible	Ludhiana	Malerkotla	Kapurthala	Amritsar
Emamectin benzoate	0.0197	0.042	0.063	0.072	0.103
Spinosad	0.0428	0.075	0.097	0.138	0.241
Cypermethrin	0.0930	0.138	0.177	0.206	0.256
Chlorantraniliprole	0.166	0.189	0.216	0.243	0.307
Fenvalerate	0.189	0.221	0.281	0.3125	0.390
Deltamethrin	0.2415	0.291	0.316	0.342	0.570
Untreated	0.308	0.390	0.482	0.716	1.250

Populations F (4,30)= 1.9301 (*NS), Insecticides F(6,28)= 6.9302 (*S)
*S indicate values are significant as P<0.05
*NS indicate values are non significant as P>0.05

fourth instar larvae upon treatment with *Melia azedarach* and biopesticides (Xu et al 2016). The reduced RGR in the present study might be due to the result of irreparable damage to the cellular surface of the midgut lumen and it is also indicated the treated food was unsuitable for the insect (Jansen and Groot 2004, Schoonhoven et al 2005, Xu et al 2016). Spinosad was also an effective antifeedant after emamectin benzoate in this study. Cypermethrin, chlorantraniliprole and fenvalerate moderately affected nutritional and food utilization indices in all *L. orbonalis* populations, while deltamethrin was least effective. The sublethal concentrations of insecticides give the insight to check the effectiveness and potential of insecticides in integrated pest management programmes by providing valuable data regarding the physiology and behaviour of insect-pest (El-Dewy 2017). Among different populations of *L. orbonalis* susceptible population showed the least RCR, RGR, ECI and ECD values but higher AD, while a trend was

Table 4. Effect of insecticides on the efficiency of conversion of ingested food to body substance (ECI) of different populations of *L. orbonalis*

Treatment (LC_{50})	Efficiency of conversion of ingested food to body substance (ECI)				
	Susceptible	Ludhiana	Malerkotla	Kapurthala	Amritsar
Emamectin benzoate	1.578	3.181	4.230	4.333	5.588
Spinosad	2.727	4.444	5.161	6.000	6.750
Cypermethrin	4.848	5.121	6.136	6.470	6.785
Chlorantraniliprole	5.714	5.813	6.446	6.607	7.166
Fenvalerate	5.813	6.078	6.545	6.666	7.352
Deltamethrin	6.000	6.481	6.666	6.857	8.058
Untreated	6.774	7.575	7.714	9.347	12.755

Populations $F_{(4,30)}$= 3.0904 (*S); Insecticides $F_{(6,28)}$= 6.9828 (*S); *S indicate values are significant as $P<0.05$

Table 5. Effect of insecticides on the efficiency of conversion of digested food into the growth (ECD) of different populations of *L. orbonalis*

Treatment (LC_{50})	Efficiency of conversion of digested food into growth (ECD)				
	Susceptible	Ludhiana	Malerkotla	Kapurthala	Amritsar
Emamectin benzoate	1.600	3.233	4.303	4.411	5.692
Spinosad	2.770	4.518	5.252	6.109	6.882
Cypermethrin	4.984	5.303	6.428	6.832	7.169
Chlorantraniliprole	5.899	6.067	6.808	6.981	7.610
Fenvalerate	6.097	6.378	6.923	7.104	7.836
Deltamethrin	6.302	6.835	7.063	7.361	8.670
Untreated	7.118	8.064	8.346	10.141	13.888

Populations $F_{(4,30)}$= 2.9567 (*S) , Insecticides $F_{(6,28)}$= 7.5161 (*S)
*S indicate values are significant as $P<0.05$

Table 6. Effect of insecticides on approximate digestibility (AD) of different populations of *L. orbonalis*

Treatment (LC_{50})	Efficiency of conversion of digested food into growth (ECD)				
	Susceptible	Ludhiana	Malerkotla	Kapurthala	Amritsar
Emamectin benzoate	98.684	98.409	98.307	98.233	98.176
Spinosad	98.454	98.370	98.258	98.200	98.075
Cypermethrin	97.272	96.585	95.454	94.705	94.642
Chlorantraniliprole	96.857	95.813	94.680	94.642	94.166
Fenvalerate	95.348	95.294	94.545	93.833	93.823
Deltamethrin	95.200	94.814	94.385	93.142	92.941
Untreated	95.161	93.939	92.428	92.173	91.836

Populations $F_{(4, 30)}$= 3.0356 (*S) , Insecticides $F_{(6,28)}$= 8.9845 (*S)
*S indicate values are significant as $P<0.05$

vice versa for the Amritsar population. The difference could be due to heterogeneity in the insecticidal exposure history of *L. orbonalis* in a different region of Punjab, which could be a result of variations in insecticide spray patterns (Chandi and Chandi 2019). The rate of insecticide application for insect-pest control in any region along with other physical and biological factors plays a vital role in the development of pest resistance (Helps and Van den Bosch 2017, Chandi et al 2019, Chandi and Kaur 2019, Chandi and Kaur 2021). Chandi (2015) reported no significant difference in RCR, AD, RGR and ECI values for the larvae of a susceptible and resistant population of *Plutella xylostella* respectively but ECD for susceptible was significantly more as compared to resistant *P. xylostella* larvae.

CONCLUSION

The insecticides exerted the sublethal influences on the *L. orbonalis* in the form of the change in feeding behavior. The current study could be implied to screen the insecticides for their inclusion in various Integrated Pest Programmes of *L. orbonalis*.

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REFERENCES

CABI 2018. Crop protection compendium datasheet on *Leucinodes orbonalis*. http://www.cabi.org/cpc/?compid=1&dsid=30498&loadmodule=datasheet&page=868&site=161.

Chakraborti S and Sarkar PK 2011. Management of *L. orbonalis* Guenee on eggplants during the rainy season in India. *Journal of Plant Protection Research* **51**: 325-328.

Chandi AK and Kaur A 2021. Evaluation of insecticidal toxicity against *Leucinodes orbonalis* Guenee populations from Punjab. *Agricultural Research Journal* **58**: 344-347.

Chandi AK 2015. Studies on food consumption and utilization behaviour in susceptible and resistant diamondback moth, *Plutella xylostella* (Linnaeus). *Indian Journal of Ecology* **42:** 564-566.

Chandi AK and Kaur A 2019. Influence of temperature on spinosad toxicity in different populations of *Plutella xylostella* (Linnaeus). *Journal of Agrometeorology* **21**: 499-503.

Chandi AK, Kaur A and Chandi RS 2019. Evaluation of toxicity of insecticides towards tobacco caterpillar, *Spodoptera litura* (Fabricius) populations from Punjab. *Journal of Insect Science* **32**: 56-61.

Chandi RS and Chandi AK 2019. Pattern of insecticide use on brinjal by farmers in Punjab. *Indian Journal of Extension Education* **55**: 215-219.

El-Dewy MEH 2017. Influence of some novel insecticides on physiological and biological aspects of *Spodoptera littoralis* (Boisduval). *Alexandria Science Exchange Journal* **38**: 250-258.

El-Malla MA and Radwan EMM 2008. Bioresidual toxicity of abamectin and spinosad insecticides on the cotton leafworm *Spodoptera littoralis* (Boisd.). *Bulletin of the Entomological Society of Egypt / Economic Series* **34**: 119-129.

El-Naggar JBA 2013. Sublethal effects of certain insecticides on biological and physiological aspects of *Spodoptera littoralis* (Boisd.). *Natural Sciences* **11**: 19-25.

El-Sheikh ESA 2015. Comparative toxicity and sublethal effects of emamectin-benzoate, lufenuron and spinosad on *Spodoptera littoralis* (Boisd.) (Lepidoptera: Noctuidae). *Crop Protection* **67**: 228-234.

Hannig GT, Ziegler M and Marçon PG 2009. Feeding cessation effects of chlorantraniliprole, a new anthranilic diamide insecticide, in comparison with several insecticides in distinct chemical classes and mode-of action groups. *Pest Management Science* **65**: 969-974.

Helps JC and Van den Bosch 2017. Identifying circumstances under which high insecticide dose increases or decreases resistance selection. *Journal of Theoretical Biology* **428:** 153-167.

Islam T, Roknuzzaman AHM, Kamrul Hassan K and Ullah MS 2019. Temperature impacts on the eggplant shoot and fruit borer *Leucinodes orbonalis*: A life table approach. *International Journal of Tropical Insect Science* https://doi.org/10.1007/s42690-019-00086-7.

Jansen B and Groot A 2004. Occurrence, biological activity and synthesis of drimane sesquiterpenoids. *Natural Product Reports* **21**: 449-477.

Jhala RC, Patel MG, Chavda AJ and Patel YC (ed) 2007. Testing IPM strategy for management of *Leucinodes orbonalis*in farmer's field. In: *Proceeding of National Symposiumon Frontier Areas of Entomology* pp 256.

Kaur J, Kang BK and Singh B 2014. Baseline data for insecticide resistance monitoring in brinjal shoot and fruit borer, *Leucinodes orbonalis* Guenee. *The Bioscan* **9**: 1395-1398.

Latif MA, Rahman MM and Alam MZ 2010. Efficacy of nine insecticides against shoot and fruit borer, *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae) in eggplant. *Journal of Pest Science* **83**: 391-397.

Nathan SS 2006. Effects of *Melia azedarach* on nutritional physiology and enzyme activities of the rice leaffolder *Cnaphalocrocis medinalis* (Guenée) (Lepidoptera: Pyralidae). *Pesticide Biochemistry Physiology* **84**: 98-108.

Nathan SS, Chung PG and Murugan K 2005. Effect of biopesticides applied separately or together on nutritional indices of the rice leaffolder *Cnaphalocrocis medinalis*. *Phytoparasitica* **33**: 187-195.

Rashwan MH 2013. Impact of certain novel insecticides on food utilization ingestion and larval growth of the cotton leafworm *Spodoptera littoralis* (Boisd.). *New York Science Journal* **6**: 1-7.

Saraswathi S, Sarvesh CB, Kiran T, Ravindran M, Ramachandra S, Rao KV and Doddamane MK 2020. A comparative protein profile of accessory glands of virgin and mated *Leucinodes orbonalis* males. *Physiological Entomology*, DOI: 10.1111/phen.12345.

Schoonhoven LM, Van Loon JJ and Dicke M 2005. Insect-plant biology. Oxford University Press. Scriber JM and Slansky JR (1981) The nutritional ecology of immature insects. *Annual Review of Entomo*logy **26**: 183-211.

Singla P 2014. *Biology and seasonal incidence of brinjal shoot and fruit borer, Leucinodes orbonalis Guenee.* M. Sc. Thesis Punjab Agricultural University, Ludhiana.

Srinivasan R 2008. Integrated pest management for eggplant fruit and shoot borer (*Leucinodes orbonalis*) in south and Southeast Asia: past, present and future. *Journal of Biopesticide* **1:** 105-112.

Waldbauer GP 1968. The consumption and utilization of food by insects. *Advances of Insect Physiology* **5**: 229-88.

Xu C, Zhang Z, Cui K, Zhao Y, Han J, Liu F and Wei M 2016. Effects of sublethal concentrations of cyantraniliprole on the development, fecundity and nutritional physiology of the black cutworm *Agrotis ipsilon* (Lepidoptera: Noctuidae). *PLoS ONE* **11**(6): e0156555. doi:10.1371/journal.pone.0156555.

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