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Residual toxicity of different insecticides against brinjal shoot and fruit borer *Leucinodes orbonalis* Guenee (Lepidoptera: Pyralidae)

Sugandha Sharma, YS Chandel and Prem Chand Sharma

Abstract
Five new molecule insecticides *viz*., chlorantraniliprole, cyantraniliprole, indoxacarb, lambda-cyhalothrin and thiacloprid were bio-assayed against neonates of *Leucinodes orbonalis* to study the residual toxicity on brinjal at CSK Himachal Pradesh Krishi Vishvavidyalaya, Palampur during the *kharif* 2015 and 2016. Chlorantraniliprole 0.007 percent showed highest Persistent Toxicity (PT) values of 449.16 and 437.50 and LT_{50} values to the tune of 5.16 and 4.99 days during 2015 and 2016, respectively as compared to other insecticides. The lowest PT values to the tune of 297.48 and 309.16 and LT_{50} values to the tune of 2.41 and 2.61 days were recorded by indoxacarb 0.01 per cent during 2015 and 2016, respectively. On the basis of average PT values, the order of toxicity was chlorantraniliprole > cyantraniliprole > thiacloprid > lambda-cyhalothrin > indoxacarb against neonates of *L. orbonalis*.

Keywords: brinjal, *Leucinodes orbonalis*, new molecule insecticides, LT_{50}, persistent toxicity

1. Introduction

Brinjal, *Solanum melongena* Linnaeus is an important and commonly grown vegetable crop, which has high nutritive value [13]. It is the native of India and is grown throughout the country [11, 31]. In India, it occupies an area of 0.72 million hectares with annual production of 13.88 million tonnes [9]. It is an important cash crop of Himachal Pradesh especially in low and mid-hills and covers an area of about 1030 hectares with an annual production of 23,520 tonnes [4].

Among the major constraints in economic cultivation of brinjal, pest infestation causes heavy losses. Brinjal is attacked by number of insect-pests [30]. In Himachal Pradesh, among 27 different insect species and one mite species reported to be associated with brinjal crop [20], Shoot and fruit borer, *L. orbonalis* is the key pest throughout Asia [1, 15, 23]. In India, this pest has a countrywide distribution and has been categorized as the most destructive and most serious pest causing huge losses in brinjal [21]. Yield losses reaching as high as 85-90% has been reported [6, 12, 18].

Soon after hatching from eggs, young caterpillars search for and bore into tender shoots near growing points and into the fruits. Larvae feeding inside shoots result in wilting of young shoots which is the typical symptom of damage by this pest in the field. Larval feeding inside the fruit results in destruction of fruits tissue. The feeding tunnels are often clogged with frass. This makes damaged fruits unfit for marketing [5].

Farmers are currently using too much pesticide frequently to control Shoot and fruit borer, as control of this pest is very difficult due to its internal feeding habit[29]. Several insecticides have been recommended for its effective management. To be effective, these chemicals need to exhibit some persistence. The consequence of this is that residues of the original material or its metabolites may remain in/on food giving a potential threat for consumers. Hence in the light of above facts and also to determine the effective spray schedule, the present study was conceptualized to evaluate the residual toxicity of different insecticides against brinjal shoot and fruit borer *L. orbonalis* Guenee.

2. Materials and Methods

2.1 Field trial

Field trial was laid at Experimental Farm of the Department of Entomology, College of Agriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur situated at an altitude of 1290.8 m above mean sea level at 32.6^0 N latitude and 76.3^0 E longitude

longitude during *kharif* 2015 and 2016. Brinjal crop (Arka keshav) was raised following recommended package of practices. The experiment was laid out in randomized block design (RBD) having plot size of 10.5 m^2 with 6 treatments including untreated check and each treatment was replicated thrice.

2.2 Test insecticides

Commercial formulations of insecticides viz., chlorantraniliprole; anthranillic diamide (Coragen 18.5 SC, EI DuPont India Pvt. Ltd.), cyantraniliprole; anthranillic diamide (Cyzapyr 10.26 OD, EI DuPont India Pvt. Ltd.), indoxacarb; oxadiazine (King Doxa 14.5 SC, Gharda Chemicals Ltd.), lambda-cyhalothrin; synthetic pyrethroid (FAR-RATA 5 EC, Pioneer Pesticides Pvt. Ltd.) and thiacloprid; neonicotinoid (Alanto 21.7 SC, Bayer Crop Science Ltd.) were used. Due care was taken to cover the entire plant while application of insecticides. The required numbers of fruits receiving application of insecticides were tagged.

2.3 Collection and rearing of test insect

Fruits and shoots infested by brinjal shoot and fruit borer (*L. orbonalis*) were collected from field. The larvae were segregated and reared on healthy and untreated fruits of brinjal till pupation. The pupae were collected in Petri dishes and placed inside perforated aluminium cages (15 x 15 x 15 cm). The emerged moths were transferred to clean circular glass jars (20 x 15 cm) for pairing, covered with black muslin cloth and secured tightly with rubber band. The adults were supplied with the pieces of folded paper (black/purple) and cotton swabs dipped into 10 per cent honey solution were kept in Petri dish placed at the bottom of the jars for feeding the moths. Eggs were laid on the black muslin cloth as well on the folded pieces of paper. The jars were examined daily for the hatching of eggs. On hatching, neonate larvae were transferred to fresh brinjal fruits with the help of fine camel hair brush and fruits were placed in the glass jars provided with filter paper at the bottom. The brinjal fruits were changed at periodic intervals to avoid fungal growth. The pupae formed on the filter paper were removed and placed separately in aluminium cages. The emergence of adults was examined daily to ensure continuous supply of eggs and thereafter neonates for testing. Culture was maintained in B.O.D. incubator maintained at 26 ± 1^0C temperature and 70±5 per cent relative humidity.

2.4 Bioassay

The residual toxicity of different insecticides was studied at 1, 3, 5 and 7 days after application of insecticides. Fruits from the sprayed and unsprayed plots were brought to the laboratory in polythene bags. Laboratory reared ten neonate larvae of *L. orbonalis* were released on the treated fruits kept in sample containers (7.4 cm × 4.0 cm). Each treatment was replicated thrice. Treatments were kept in incubator at 26±1ºC temperature and 70±5% per cent humidity for the treatment observations. The mortality of larvae was recorded after 24 hours of treatment.

The observations on mortality of test insects were converted into percentage mortality. The average percentage mortality was calculated from the observations in three replications.

2.5 Statistical analysis

The mortality data obtained in the present studies were subjected to angular transformation and were statistically analyzed using CPCS1 software.

2.6 LT_{50} values

The values of LT_{50} (time required to give 50% mortality) for different insecticides applied on brinjal plants were calculated by using software of probit analysis as suggested by Finney [10].

2.7 PT values

Persistent toxicity values were worked out as per method given by Pradhan[20]

$$\text{Persistent toxicity} = P \times T$$

Where, P = period for which toxicity persisted T = Average residual toxicity

(Average residual toxicity is calculated by adding the values of per cent mortality at different intervals and then dividing by the total number of observations)

Based on persistent toxicity values, relative persistent toxicity values were determined.

3. Results

3.1 Residual toxicity of different insecticides against neonates of *L. orbonalis* during 2015

The data on the residual toxicity of different insecticides on brinjal fruits against neonate larvae of *L. orbonalis* receiving foliar spray of insecticides at 1, 3, 5 and 7 days intervals is presented in Table 1. It is evident from the results that all the insecticides under investigation exhibited mortality of *L. orbonalis* larvae but amongst them chlorantraniliprole 0.007 percent and cyantraniliprole 0.012 percent concentration showed comparatively high percentage mortality, 93.33 and 90.00, respectively at 1 day after application of insecticides. The residual toxicity with time reached 33.33% in chlorantaniliprole, 26.67% in cyantraniliprole, 13.33% in indoxacarb, 20.00 % in lambda-cyhalothrin and 23.33% in thiacloprid at 7 days after application. The residual efficacy based on PT index followed the order: chlorantraniliprole, cyantraniliprole, thiacloprid, lambda-cyhalothrin and indoxacarb with the values of 449.16, 414.17, 379.17, 355.83 and 297.48, respectively.

The data on LT_{50} values of insecticides against neonate larvae of *L. orbonalis* on brinjal fruits receiving foliar spray of insecticides is presented in Table 2. The residual toxicity in terms of LT_{50} value was found to be highest to the tune 5.16 days due to chlorantraniliprole. The relative order of residual efficacy of insecticides in days was found to be chlorantraniliprole 0.007 percent (5.16 days) > cyantraniliprole 0.012 percent (4.47 days) > thiacloprid 0.03 percent (3.83 days) > lambda-cyhalothrin 0.004 percent (3.35 days) > indoxacarb 0.01 percent (2.41 days).

3.2 Residual toxicity of different insecticides against neonates of *L. orbonalis* during 2016

The data on the residual toxicity of insecticides against neonate larvae of *L. orbonalis* on brinjal fruits after foliar spray recorded at 1, 3, 5 and 7 days intervals. It is evident from the results (Table 3) that 90 percent i.e. highest percentage mortality of neonate larvae of *L. orbonalis* on brinjal fruits was observed at one day after application of both chlorantraniliprole and cyantraniliprole. No doubt all the insecticidal treatments persisted for 7 days period but there was difference in percentage of mortality. The residual toxicity with time reached 30.00 % in chlorantraniliprole, 26.67 % in cyantraniliprole, 13.33 % in indoxacarb, 16.67 % in lambda-cyhalothrin and 23.33 % in thiacloprid at 7 days after application. The residual efficacy based on PT index followed the order: chlorantraniliprole, cyantraniliprole, thiacloprid, lambda-cyhalothrin and indoxacarb with the values of 437.50, 425.83, 379.16, 344.17 and 309.16, respectively.

The data in respect of LT_{50} values of insecticides against neonate larvae of *L.orbonalis* on brinjal fruits are presented in Table 4. The LT_{50} value for different insecticides under investigation varied from 2.61 to 4.99 days. The highest LT_{50} value (4.99 days) was recorded by chlorantraniliprole followed by cyantraniliprole (4.69 days), thiacloprid (3.77 days), lambda-cyhalothrin (3.19 days). The lowest LT_{50} value to the tune of 2.61 days was recorded by indoxacarb 0.01 %.

4. Discussion

These findings on the superiority of diamide insecticide, chlorantraniliprole having novel mode of action are supported with the results of Misra [16], Rajavel *et al*., [24], Shah *et al*., [27], Kaur *et al*., [14], Das *et al*., [8], Munje *et al*., [19] and Chandi [7]. Sajjan and Rafee [25] proved cyantraniliprole and chlorantraniliprole to be most effective insecticides by recording significantly maximum reduction in brinjal shoot and fruit borer infestation. Misra [17] also found cyantraniliprole highly efficacious against tomato fruit borer. Thiacloprid was found effective against the potato tuber moth by Saour [26]. Lambda-cyhalothrin (0.004%) was reported to be superior in reducing the shoot infestation by *L. orbonalis* on brinjal by Anil and Sharma[2]. Indoxacarb was found toxic to third instar larvae of *Spodoptera litura* by Sharma [28].

5. Conclusion

The overall results on the basis of residual toxicity and persistence revealed that all the tested insecticides had significant toxicity against *L. orbonalis* larvae till 7 days during both the years. The residual toxicity declined in all the treatments with the lapse of time after treatment. Among all the insecticidal treatments, chlorantraniliprole 0.007 percent was found superior against neonate larvae of *L. orbonalis* followed by cyantraniliprole 0.012 percent, thiacloprid 0.03 percent, lambda-cyhalothrin 0.004 percent and indoxacarb 0.01 percent. Hence, these insecticides can be incorporated to develop a spray schedule for effective management of *L. orbonalis* on brinjal.

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Table 1: Persistence of different insecticides in/on fruits of brinjal against neonates of *Leucinodes orbonalis* during 2015

Insecticide	Conc. %	Per cent mortality after different intervals (days)*				P	T	PT	Relative PT	O.R.E
		1	3	5	7					
Chlorantraniliprole	0.007	93.33 (77.68)	76.67 (61.20)	53.33 (46.90)	33.33 (35.20)	7	64.17	449.16	1.51	1
Cyantraniliprole	0.012	90.00 (71.54)	70.00 (56.77)	50.00 (44.98)	26.67 (30.98)	7	59.17	414.17	1.39	2
Indoxacarb	0.01	70.00 (56.77)	53.33 (46.90)	33.33 (35.20)	13.33 (21.14)	7	42.5	297.48	1.00	5
Lambda-cyhalothrin	0.004	76.67 (61.20)	63.33 (52.75)	43.33 (41.14)	20.00 (26.55)	7	50.83	355.83	1.20	4
Thiacloprid	0.03	80.00 (63.41)	66.67 (54.76)	46.67 (43.06)	23.33 (28.77)	7	54.17	379.17	1.27	3
Control		0.00	0.00	0.00	0.00					
CD (P= 0.05%)		(8.12)	(4.07)	(5.36)	(5.89)					

* Figures in parentheses are the arc sine transformed values; ORE = Observational rating of efficacy of insecticides

Table 2: Relative efficacy of different insecticides against neonates of *Leucinodes orbonalis* in/on fruits of brinjal during 2015

Insecticide	Heterogeneity		Regression Equation	Log LT_{50}	LT_{50} (Days)	Fiducial Limits (Days)	RE	ORE
	df	$\chi 2$						
Chlorantraniliprole	2	1.1467	9.0031-2.3371x	1.71	5.16	4.04-7.34	2.14	1
Cyantraniliprole	2	1.3475	8.6358-2.2035x	1.65	4.47	3.45-6.18	1.86	2
Indoxacarb	2	2.8808	7.3935-1.7325x	1.38	2.41	1.52-3.31	1.00	5
Lambda-cyhalothrin	2	3.0216	7.6106-1.7120x	1.52	3.35	2.33-4.76	1.39	4
Thiacloprid	2	3.1574	7.7574-1.7421x	1.58	3.83	2.75-5.61	1.59	3

RE= Relative efficacy based on LT_{50}; ORE = Observational rating of efficacy of insecticides

Table 3: Persistence of different insecticides in/on fruits of brinjal against neonates of *Leucinodes orbonalis* during 2016

Insecticide	Conc. %	Per cent mortality after different intervals (days)*				P	T	PT	Relative PT	O.R.E
		1	3	5	7					
Chlorantraniliprole	0.007	90.00 (71.54)	76.67 (61.20)	53.33 (46.90)	30.00 (33.20)	7	62.5	437.5	1.42	1
Cyantraniliprole	0.012	90.00 (71.54)	73.33 (58.98)	53.33 (46.90)	26.67 (30.98)	7	60.83	425.83	1.38	2
Indoxacarb	0.01	73.33 (58.98)	56.67 (48.83)	33.33 (35.20)	13.33 (21.14)	7	44.17	309.16	1.00	5
Lambda-cyhalothrin	0.004	80.00 (63.41)	60.00 (50.75)	40.00 (39.22)	16.67 (23.85)	7	49.17	344.17	1.11	4
Thiacloprid	0.03	83.33 (66.12)	66.67 (54.76)	43.33 (41.14)	23.33 (28.77)	7	54.17	379.16	1.23	3
Control		0.00	0.00	0.00	0.00					
CD (P=0.05%)		(4.03)	(5.45)	(5.35)	(4.95)					

* Figures in parentheses are the arc sine transformed values; ORE = Observational rating of efficacy of insecticides

Table 4: Relative efficacy of different insecticides against neonates of *Leucinodes orbonalis* on fruits of brinjal during 2016

Insecticide	Heterogeneity		Regression Equation	Log LT_{50}	LT_{50} (Days)	Fiducial Limit (Days)	RE	ORE
	df	$\chi 2$						
Chlorantraniliprole	2	2.3899	8.6653-2.1587x	1.70	4.99	3.84-7.23	1.91	1
Cyantraniliprole	2	2.1706	8.6737-2.1986x	1.67	4.69	3.63-6.60	1.79	2
Indoxacarb	2	3.4248	7.6332-1.8584x	1.42	2.61	1.76-3.52	1.00	5
Lambda-cyhalothrin	2	2.4877	7.9475-1.9607x	1.50	3.19	2.30-4.30	1.22	4
Thiacloprid	2	2.2369	8.0627-1.9428x	1.58	3.77	2.79-5.24	1.44	3

RE= Relative efficacy based on LT_{50}; ORE = Observational rating of efficacy of insecticides

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