Full Length Research Article

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Research Journal of Agricultural Sciences
Volume 17; Issue 04 (July–Aug 2026); pp 525–528

ISSN: 0976-1675 (P)
ISSN: 2249-4538 (E)

Baseline Toxicity of Chlorantraniliprole and λ-cyhalothrin against *Earias vittella* (Fab.)

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Received: 23 June 2026; Revised accepted: 19 Aug 2026

Abstract

Shoot and fruit borer, *Earias vittella* (Fab.) is recognized as one of the most destructive pests of okra, causing substantial losses in marketable fruit yield. In view of its economic importance and reports of resistance development against various conventional insecticides, laboratory bioassays were undertaken to evaluate the baseline toxicity of chlorantraniliprole and λ-cyhalothrin against second instar larvae of *Earias vittella*. Both insecticides exhibited pronounced toxicity, with larval mortality increasing in a dose-dependent manner 24 hours after treatment. Probit analysis estimated the LC_{50} and LC_{90} values of chlorantraniliprole as 7.62 and 46.22 ppm, respectively, whereas those of λ-cyhalothrin were 3.57 and 23.88 ppm. On the basis of LC_{50} values, λ-cyhalothrin was observed to be 2.13 times more toxic than chlorantraniliprole to second instar larvae of *Earias vittella*. These results provide useful baseline toxicity information for future resistance monitoring and judicious insecticide selection for effective management of *Earias vittella*.

***Key words*:** Bioassay study, Intrinsic toxicity, LC_{50}, probit analysis, Novel modes of action

Among various insect pests attacking okra crop, shoot and fruit borer, *Earias vittella* (Fab.), is considered one of the most destructive responsible for an estimated 69 per cent loses in the yield of okra marketable fruit [1]. For managing this pest, use of chemical insecticides remained the primary approach owing to their rapid action and ease of application. Among various insecticides used for pest management, λ-cyhalothrin, a synthetic pyrethroid has been more common due to its strong contact and stomach toxicity, and quick knockdown effect [2]. Among novel insecticides, chlorantraniliprole belonging to the anthranilic diamide group (IRAC Group 28) is widely used by the farmers against *E. vittella* in okra. It acts by activating ryanodine receptors in insect muscle cells, leading to paralysis and death [3]. It has demonstrated excellent efficacy against lepidopteran pests including *Earias* spp. at low application rates, along with selectivity towards beneficial arthropods, making it suitable for inclusion in integrated pest management (IPM) strategies [4-7]. However, the prolonged and intensive use of insecticides over the past eight decades has resulted in the progressive development of insecticide resistance in target insect populations [8].

Laboratory bioassays and estimation of lethal concentration values, particularly LC_{50}, provide a quantitative measure of intrinsic toxicity and insect susceptibility [9]. Probit analysis of dose–mortality data is commonly employed to determine LC_{50} values and to establish baseline susceptibility for detecting shifts in sensitivity and early resistance development [10]. Field efficacy alone cannot adequately describe the intrinsic susceptibility of a pest population or provide a reliable benchmark for resistance surveillance. The baseline toxicity data are critical for rational insecticide selection, dose optimization and formulation of resistance management strategies. In the case of *E. vittella*, although numerous studies have evaluated the field efficacy of chlorantraniliprole and λ-cyhalothrin, information on their quantitative baseline toxicity under controlled laboratory conditions is comparatively limited. This represents an important knowledge gap because chlorantraniliprole and λ-cyhalothrin have contrasting modes of action and differ considerably in their history and pattern of use against lepidopteran pests. Considering the economic importance of *E. vittella* and the need for sustainable insecticide use, the present study was conducted to evaluate the intrinsic toxicity of chlorantraniliprole and λ-cyhalothrin against *Earias vittella* under laboratory conditions with the aim of generating information to support effective and judicious management of this pest in okra.

MATERIALS AND METHODS

The experiment was conducted in laboratory, Department of Entomology, CCS Haryana Agricultural University, Hisar, Haryana, India.

Mass rearing of study insect

The laboratory culture of *Earias vittella* was established from larvae collected from cotton and okra fields at the University Research Farm. Rearing was carried out following Gupta *et al.* [11], with minor modifications. Rearing was done on okra fruits, the most preferred natural food of this pest [12].

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Citation: Singh B, Gaur RK. 2026. Baseline toxicity of chlorantraniliprole and λ-cyhalothrin against *Earias vittella* (Fab.). *Res. Jr. Agril. Sci.* 17(4): 525-528.

Field-collected second–third instar larvae were individually maintained in test tubes, supplied with fresh insecticide-free okra fruits, and reared until pupation. The food was replaced daily and excreta were removed regularly. Pupae were transferred to glass jars for adult emergence. Adults were provided with 10% honey solution, while sterilized cotton cloth served as an oviposition substrate. Eggs were collected and incubated for larval emergence. Newly hatched larvae were transferred to fresh tender okra fruits and maintained under controlled laboratory conditions of 27 ± 1°C and 65 ± 5% RH.

Bioassay study

For bioassay study, the second instar larvae from laboratory cultures were exposed to different concentrations of chlorantraniliprole 18.5 SC and λ-cyhalothrin 5 EC by fruit dip bioassay technique. Formulated insecticides were diluted by serial dilution using distilled water as a solvent. Three replicates for each concentration and control (untreated) were maintained for each test insecticide. Ten second instar larvae of *Earias vittella* were released in each replication. After 24 hours of exposure period, mortality of larvae was recorded in each treatment. The moribund insects were counted as dead and mortality was corrected using formula given by Abbott [13].

Abbott's formula:

$$\text{Corrected per cent mortality} = \frac{T - C}{100 - C} \times 100$$

Where;
T- Per cent mortality in treatment
C- Per cent mortality in control

The value of median lethal concentration (LC_{50}) for each insecticide was calculated according to Finney [9] using the software OPSTAT [14].

RESULTS AND DISCUSSION

The bioassay results clearly demonstrate that both chlorantraniliprole and λ-cyhalothrin were toxic to second instar larvae of *E. vittella*, causing a dose-dependent increase in mortality. The mortality of second instar larvae of *E. vittella* recorded 24 hours of treatment varied from 23.33 to 90.00 per cent when exposed to different concentrations (1.953 to 31.250 ppm) of chlorantraniliprole (Table 1). The mortality in the control was observed to be 3.33 per cent. Probit kill was linearly related with log concentration by the regression equation having slope of 1.641 (Fig 1). The LC_{50} of chlorantraniliprole against target pest was calculated to be 7.62 ppm with fiducial limit (95%) of 3.21 to 18.06 ppm whereas LC_{90} as 46.22 ppm with fiducial limit of 19.49 to 109.60 ppm (Table 2). The chi-square value was observed to be 0.91.

Similarly, when the larvae were exposed to different concentration (0.977 to 15.625 ppm) of λ-cyhalothrin, 26.67 to 90.00 per cent mortality was observed after 24 hours of treatment. Here also, 3.33 per cent mortality of larvae was observed in case of control. The LC_{50} of lambda-cyhalothrin was computed as 3.57 ppm with fiducial limit in the range of 1.45 to 8.81 ppm while LC_{90} as 23.88 ppm with fiducial limit of 9.68 to 58.91 ppm. The slope of regression equation was 1.558 (Fig 2) and chi-square value was calculated to be 0.89. The LC_{50} value of lambda-cyhalothrin against second instar larvae of *E. vittella* was found to be 2.13 times less than that of chlorantraniliprole.

Table 1 Concentration-mortality response of second instar larvae of *Earias vittella* to chlorantraniliprole

Chlorantraniliprole			λ-cyhalothrin		
Concentration (ppm)	Observed mortality (%)*	Corrected mortality (%)	Concentration (ppm)	Observed mortality (%)*	Corrected mortality (%)
31.250	90.00	83.34	15.625	90.00	83.34
15.625	66.67	60.01	7.813	66.67	60.01
7.813	46.67	40.01	3.906	50.00	43.34
3.906	33.33	26.67	1.953	33.33	26.67
1.953	23.33	16.67	0.977	26.67	20.01
0.000	3.33	--	0.000	3.33	

Table 2 Relative toxicity of insecticides against second instar larvae of *Earias vittella*

Particulars	Chlorantraniliprole	λ-cyhalothrin
Period of exposure (h)	24	24
Mortality (%)	23.33 to 90.00	26.67 to 90.00
Regression equation (y)	1.641x +3.557	1.558x + 4.140
Slope	1.641	1.558
LC_{50} (ppm)	7.62 (3.21 to 18.06)	3.57 (1.45 to 8.81)
LC_{90} (ppm)	46.22 (19.49 to 109.60)	23.88 (9.68 to 58.91)
Chi- Square	0.91 (df:3)	0.89 (df:3)
Relative toxicity	1.00	2.13

The present bioassay demonstrated a clear concentration-dependent response of second-instar *Earias vittella* larvae to both chlorantraniliprole and λ-cyhalothrin. Mortality increased progressively with increasing insecticide concentration, reaching 90.00 per cent at 31.250 ppm chlorantraniliprole and 15.625 ppm λ-cyhalothrin after 24 h of exposure. Such a dose-response relationship is a characteristic feature of insecticidal bioassays and indicates that increasing exposure to either insecticide resulted in a corresponding increase in larval mortality. The linear relationship between probit of kill and log concentration, along with acceptable slope values, suggests a uniform response of the test population to both insecticides. Furthermore, non-significant chi-square values indicated a good fit of the probit regression model and

homogeneity of the data. The relatively low mortality observed in the untreated control (3.33%) further indicates that mortality attributable to handling, environmental conditions or other experimental factors was minimal, thereby supporting the reliability of the assay. The toxicity of chlorantraniliprole observed in the present study is consistent with its established activity against lepidopteran larvae. It acts primarily through activation of ryanodine receptors, resulting in uncontrolled release of intracellular calcium, rapid cessation of feeding, muscle paralysis and eventual death. Its strong activity against *Earias vittella* has also been demonstrated under field conditions [15-16].

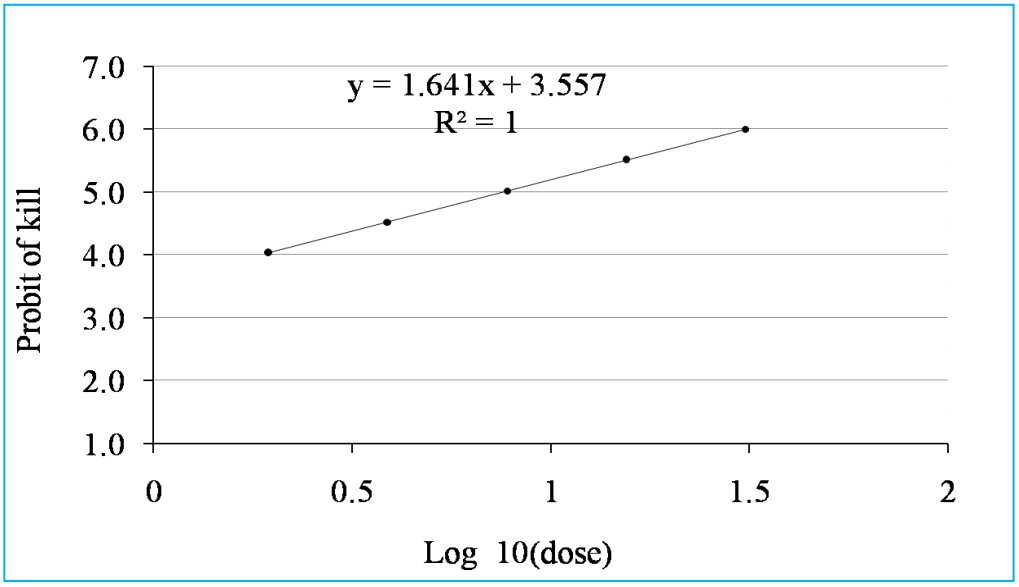

Fig 1 Concentration-response curve of chlorantraniliprole to *Earias vittella*

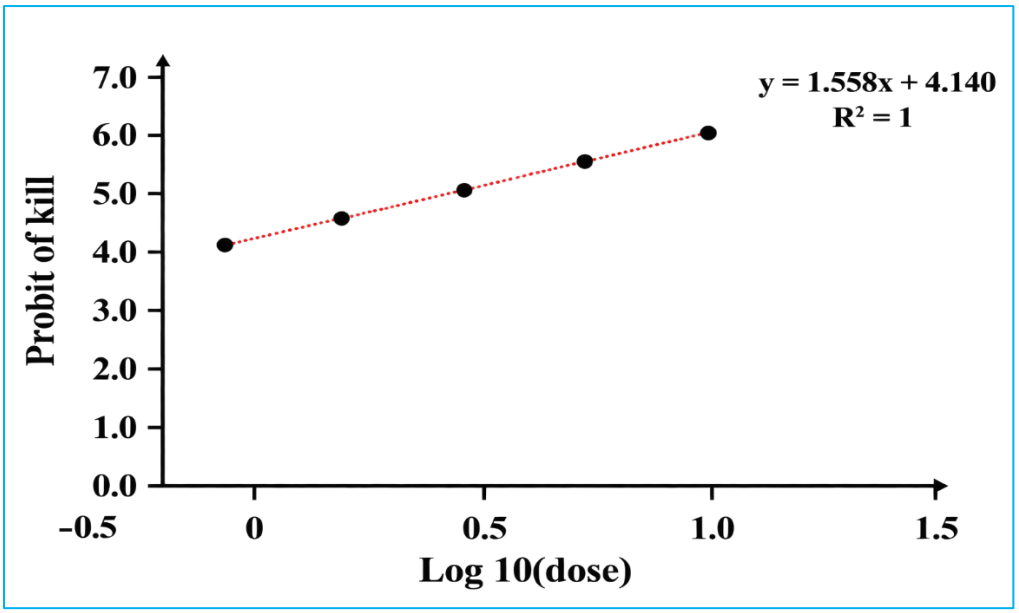

Fig 2 Concentration-response curve of λ-cyhalothrin to *Earias vittella*

The present results also demonstrate appreciable toxicity of λ-cyhalothrin, with an LC_{50} of 3.57 ppm and LC_{90} of 23.88 ppm. The lower LC_{50} compared with chlorantraniliprole indicates that the tested *E. vittella* population was approximately 2.13 fold more susceptible to λ-cyhalothrin than to chlorantraniliprole under laboratory conditions. This difference in relative toxicity may be associated with differences in target site, toxicokinetics, penetration and sensitivity of second-instar larvae to the two insecticide classes. λ-Cyhalothrin is a type-II synthetic pyrethroid (IRAC Group 3A) that acts principally by modifying the gating kinetics of voltage-sensitive sodium channels, producing repetitive nerve firing, hyperexcitation, paralysis and death resulting in quicker mortality within 24 hours of exposure. In contrast, chlorantraniliprole acts by activating ryanodine receptors in insect muscle cells, initially causing paralysis followed by death.

The findings of the present study are in align with the observations of Su *et al*. [17] who also estimated the LC_{50} value of chlorantraniliprole against early and late instar larvae as 0.95 and 4.32 ppm, respectively. These results are also supported by the findings of Pandey *et al*. [18] who suggested the LC_{50} value for rynaxypyr and λ-cyhalothrin against okra shoot and fruit borer as 19.740 and 2.559 ppm, respectively. In contrast, Reddy and Bhamre [19] have reported lower LC_{50} value of chlorantraniliprole (0.059 to 0.124 ppm) compared to λ-cyhalothrin (0.266 to 0.419 ppm) against various strains of *E. vittella* prevailing in Maharashtra. Similarly, Kong *et al*. [20] reported the LC_{50} value of chlorantraniliprole against *Spodoptera litura* moths as 0.56 ppm and suggested it as more

toxic than λ-cyhalothrin having LC_{50} value of 28.12 ppm. The observed variation in insecticide susceptibility across locations may be attributed to differences in insecticide use patterns, prevailing climatic conditions, and the nature of the host plants.

It is also important to be noted that laboratory acute toxicity and field efficacy should not necessarily be considered synonymous**.** Although λ-cyhalothrin had a lower LC_{50} than chlorantraniliprole in the present study, however, recent field studies have demonstrated that chlorantraniliprole was generally superior to λ-cyhalothrin in reducing *E. vittella* population under field conditions [21]. This apparent difference may reflect the longer residual activity, translaminar/systemic properties, feeding cessation and distinctive mode of action of chlorantraniliprole, whereas the efficacy of a pyrethroid in the field can be affected by resistance, environmental degradation and pest behavior.

CONCLUSION

It can be inferred that both the insecticides were effective against *E. vittella*, with λ-cyhalothrin being more potent under laboratory conditions. The LC_{50} and LC_{90} values obtained in the present study can therefore serve as useful baseline susceptibility benchmarks for subsequent resistance-monitoring studies and insecticide selection in pest management programmes.

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