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Biopotency and toxicity of diverse group of insecticides under laboratory condition against sunflower defoliator *Spilarctia obliqua* (Walker)

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The biopotency and toxicity of two groups, conventional and newer insecticides [eight commercial insecticides] were determined against Bihar or Common hairy caterpillar (BHC) *Spilarctia obliqua* (Walker). Experiment carried out in the laboratory by exposing BHC larvae to insecticides. Biopotency was measured at different time intervals from 12-72 h after insecticidal application showed that all of the insecticides outperformed the control. At 48 h after imposing, the highest mortality percentage (100) was observed on spinetoram 11.7 SC and chlorfenapyr 10 SC, which are comparable to cyantranaliprole 10.26 OD, followed by chlorantraniliprole 18.5 SC, λ-cyhalothrin 5 EC and chlorpyriphos 20 EC, with the lowest mortality percentage observed on tolfenpyrad 15 EC (66.67 %). In chlorantraniliprole, cyantranaliprole, spinetoram, tolfenpyrad, fipronil, chlorfenapyr, λ-cyhalothrin and chlorpyriphos, respectively, the toxicity level of insecticides was calculated based on median lethal concentration (LC_{50}) values of 0.36, 0.48, 0.52, 0.50, 0.69, 0.98, 1.43 and 3.82 ppm. The overall conclusion of this trial was that spinetoram 11.7 SC and chlorfenapyr10 SC are the best chemicals for controlling the early stages of BHC larvae. In comparison to traditional insecticides, new insecticides have the highest level of toxicity.

Keywords: Bihar or Common hairy caterpillar, Insecticides, Pest management, Relative toxicity, *Spilosoma obliqua*, Sunflower

The Bihar or Common hairy caterpillar, *Spilarctia* (=*Spilosoma*) *obliqua* (Walker), belongs to the Lepidoptera order and the Erebidae family of class Insecta, and it is sporadic in nature and polyphagous, with a chewing type of mouthpart that is confined to the oriental region and known to cause severe damage to several agricultural and horticultural crops, and it occurs in large numbers when the conditions are right. It feeds on grains, pulses, oilseeds, vegetables, ornamental, medicinal, plantation, and fibre crops as a polyphagous pest, causing moderate to serious damage in various nations, including India[1] It can be found in Afghanistan's south-eastern provinces, Pakistan's northwestern provinces, India, Bhutan, Bangladesh, and Myanmar. It is a dangerous and widespread pest in Bihar, Uttar Pradesh, Punjab, Madhya Pradesh, Chhattisgarh, Manipur, Karnataka and some other states in India[2].

Spilarctia obliqua is polyphagous and feeds on at least 126 species of plant including pulses, cereals, vegetables, oilseeds, mulberry, turmeric, fibre crops, such as jute, roselle, ramie and sun hemp, and non-cultivated plants and weeds. In India, the insect is a serious pest of fibre crops, sometimes occurring in epidemic outbreaks and causing a high economic loss[3]. The female moths lay eggs in groups. Upon egg hatching, the early stages larvae gregariously scrape the chlorophyll tissues of the leaves, and later they disperse to the entire field and defoliate the plant. The later stage instar larvae cause serious damage and a significant reduction in yield[4]. Timely management of this pest is very important as any delay may even lead to complete defoliation of crop in the field[5]. Availability of microbial biocontrol agents such as SPobMNPV (nuclear polyhedrosis virus), *Bacillus thuringenesis kurstaki*[16,7] and Entomophaga aulicae fungi were effective in managing the BHC under natural ecosystem[8]. For immediate BHC management, CIBRC recommends insecticides like Cypermethrin 10% EC spray for agricultural crops like green gram, soybean, sunflower, mustard, jute, etc. The loss in seed yield due to defoliators in a rainfed Kharif crop was upto 268 kg/ha.

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However, insecticides belong to the conventional group currently showing less efficacy in the field condition[9,10] and the loss in seed yield caused per hectare was upto 20.29% due to defoliators especially *Spilarctia obliqua* and *Spodoptera litura* in a rain-fed sunflower crop[11], by considering the seriousness of the defoliator insect pests on sunflower crop. Many novel insecticides used for the pest management in different crops. Novel insecticides have already been tested under field condition[12]. However, in the current study, we investigated the bioefficacy and toxicity of novel insecticides under laboratory conditions for management of BHC and their relative toxicity to conventional insecticides as well.

Material and Methods

Due to the obvious extensive damage produced by BHC in sunflower, an attempt has been made to reduce the threat by deploying an effective newer molecule of insecticides as well as conventional insecticides as treatments (Table 1) in the laboratory. The following completely randomized design (CRD) with nine treatments, including control, and three replications was implemented in this experiment in 2018, at the Department of Entomology, University of Agricultural Sciences, Dharwad, Karnataka.

Bioefficacy and toxicity of insecticides

Test insects

Spilarctia obliqua (Lepidoptera: Erebidae) was reared for F1 generations on the tender and washed leaves of sunflower in the laboratory at 27±2°C and 70+5% relative humidity, with18D: 6L scotophoto phase.

Insect-bioassay for toxicity

To determine the bioefficacy of novel and conventional insecticides against BHC, sunflower leaves were used under laboratory conditions. Succulent sunflower leaves which are completely free from insecticidal spray were procured from fields. After thoroughly washing and disinfecting them, they were used in the insect-bioassay. Second instar larvae raised in the lab were used for this study. Insecticidal spray was applied to the new delicate sunflower leaves. Treatments were applied using a potter tower and then dried in the shade. 10 larvae were introduced into an insect rearing box (12 cm height and 6 cm diameter) containing treated sunflower leaves for each replication. After 24 h, the larvae were given typical fresh sunflower leaves until they died or pupated.

Table 1 — List of novel insecticide insecticides, their active ingredients (a.i.) and suggested label and rate used in the experiment against BHC

Tr. No.	Name of insecticides	Trade name	Dosage (g or mL/ L)	Company
T1	Chlorantraniliprole 18.5 SC	Coragen	0.2	DuPont
T2	Cyantranaliprole 10.26 OD	Benallia	0.3	DuPont
T3	Spinetoram 11.7 SC	Delegate	0.5	Dow Agro-Sciences
T4	Tolfenpyrad 15 EC	Keefun	2	PI Industries
T5	Fipronil 5 SC	Regent	1	Bayer
T6	Chlorfenapyr 10 SC	Lepido	2	PI Industries
T7	λ-cyhalothrin 5 EC	Karate	1	Syngenta
T8	Chlorpyriphos 20 EC	Dursban	2	Dow Agro Sciences

To determine the toxicity of novel and conventional insecticides, fresh leaves which are free from insecticide, as a natural diet for larvae, were provided and replaced daily to avoid contamination. Second instar of first generation (F1) having an average body weight of 98 mg was used for bioassay. From the stock solution of individual or mixtures of insecticide solutions, serial dilutions were followed to prepare six broad range concentrations that were used in a bioassay using second instar larvae of *S. Obliqua* and based on 10-90% larval mortality again five to six narrow range concentrations were prepared to determine LC_{50} of each insecticide. Test solutions of the insecticides were prepared in five concentrations. Sunflower leaves were dipped in test concentrations for 30-seconds. After air-drying under shade, treated leaves were placed singly in each assay bottle (15 cm height, 6 cm diameter) having a layer of moist cotton and blotting paper to prevent any desiccation of the leaves. Such a set was considered as one replication and three replications were used per concentration. Second instar larva of *S. obliqua* were subjected to such bioassay. Larvae were pre-starved for 6 hrs and subjected to the assay. Each treatment consisted of ten second instar larvae and was replicated thrice including control. Larval mortality was observed at 48 h after treatment.

Observations to be recorded

The observations on larval mortality were recorded at 12 h intervals up to 72 h. Both the control and treated larvae were observed for a period of 12, 24, 36, 48, 62 and 72 h to know bio efficacy based on mortality% of the larvae was recorded at 24, 48 and 72 h after treatment. The mortality% at 48 hours after treatment was considered as the endpoint for the assessment of toxicity of test insecticides. Concentrations limiting the mortality between

20-80% at 48 h was used for probit, log dose mortality analysis. To arrive at this 5 test concentrations a couple of round pilot tests were carried out. The mortality was determined based on the failure of insects to move upon coordinated pronding. The observations recorded were corrected using Abbott's formula[13]. Relative toxicity of insecticides was calculated based on LC_{50} values by using formula as given below,

$$Per\ cent\ mortality = \frac{T - C}{100 - C} \times 100$$

where, T = % mortality of treatment and C = % mortality of control, and

$$Relative\ Toxicity = \frac{LC50\ value\ of\ least\ toxic\ insecticides}{LC50\ value\ of\ tested\ insecticide}$$

The data on % mortality obtained at different time intervals were subjected to ANOVA (Completely Randomized Design) after following arcsine transformation. The treatments were differentiated for the significant differences existing among them by following TuKEY test. Probit log dose analysis was done to know the median lethal concentration of insecticides through SPSS software.

Result and Discussion

Bio potency of insecticides

At 24, 36, 48, 60 and 72 h following treatment application, there were substantial differences in the pesticides' ability to kill larvae (Table 2). The larval mortality ranged from 3.33±2.72 to 6.67±2.72% in five different treatments, including chlorantraniliprole 18.5 SC, spinetoram 11.7 SC, chlorfenapyr 10 SC, λ-cyhalothrin 5 EC, respectively (6.67%) and tolfenpyrad 15 EC (3.33%). Other treatments, such as cyantranaliprole 10.26 OD, fipronil 5 SC, and chlorpyriphos 20 EC, as well as the untreated control, showed no mortality in the larvae (Table 2). spinetoram 11.7 SC had the highest larval mortality rate (43.33%) after 24 h of treatment, followed by chlorfenapyr 10 SC (33.33%), which is comparable to chlorantraniliprole 18.5 SC and λ-cyhalothrin 5 EC (30%). The second best treatment was cyantranaliprole 10.26 OD (26.67%), followed by tolfenpyrad 15 EC (20%) and chlorpyriphos 20 EC (10%) over the untreated control. The untreated control group, on the other hand, had no mortality.

At 36 h of treatment, the highest larval population mortality was recorded in chlorfenapyr 10 SC (76.67%) and spinetoram 11.7 SC (73.33%), which were on par with each other and significantly superior to all other treatments, followed by cyantranaliprole 10.26 OD (63.33%), chlor-antraniliprole 18.5 SC (50%), and 43.33% larval mortality in λ-cyhalothrin 5 EC treated, whereas in chlorfenapyr 10 SC treated and chlorpyriphos 20 EC treated larvae had the same and lowest larval death rate (36.67%), however there was no larval mortality in the untreated control (Table 2).

Table 2 — Evaluation of novel insecticide molecules against *Spilarctia obliqua*, under laboratory condition

Insecticides	Per cent mortality of larvae (Hours)					
	12	24	36	48	60	72
Chlorantraniliprole 18.5 SC	6.67±2.72 (12.29)^{a}	30.00±4.71 (32.99)^{ab}	50.00±8.16 (44.9)^{abc}	83.33±5.44 (66.61)^{b}	100.00±0.00 (89.96)^{a}	-
Cyantranaliprole 10.26 OD	0.00±0.00 (0.00)^{a}	26.67±2.72 (30.98)^{abc}	63.33±2.72 (52.75)^{ab}	90.00±4.71 (74.97)^{ab}	100.00±0.00 (89.96)^{a}	-
Spinetoram 11.7 SC	6.67±5.44 (8.85)^{a}	43.33±2.72 (41.14)^{a}	73.33±5.44 (59.19)^{a}	100.00±0.00 (89.96)^{a}	-	-
Tolfenpyrad 15 EC	3.33±2.72 (6.14)^{a}	20.00±0.00 (26.55)^{abc}	36.67±2.72 (37.21)^{bc}	66.67±2.72 (54.76)^{b}	80.00±0.00 (63.41)^{a}	96.67±2.72 (83.82)^{a}
Fipronil 5 SC	0.00±0.00 (0.00)^{a}	13.33±2.72 (21.14)^{bc}	23.33±2.72 (28.77)^{c}	73.33±9.81 (59.98)^{b}	80.00±12.47 (68.83)^{a}	93.33±5.44 (81.11)^{a}
Chlorfenapyr 10 SC	6.67±5.44 (8.85)^{a}	33.33±2.72 (35.2)^{ab}	76.67±5.44 (61.69)^{a}	100.00±0.00 (89.96)^{a}	-	-
λ-cyhalothrin 5 EC	6.67±2.72 (12.29)^{a}	30.00±4.71 (32.99)^{ab}	43.33±7.20 (41.05)^{bc}	86.67±2.72 (68.83)^{ab}	93.33±5.44 (81.11)^{a}	100.00±0.00 (89.96)^{a}
Chlorpyriphos 20 EC	0.00±0.00 (0.00)^{a}	10.00±4.71 (14.99)^{cd}	36.67±2.72 (37.21)^{bc}	86.67±2.72 (68.83)^{ab}	96.67±2.72 (83.82)a	100.00±0.00 (89.96)^{a}
Untreated control	0.00±0.00 (0.00)^{a}	0.00±0.00 (0.00)^{a}	0.00±0.00 (0.00)^{a}	0.00±0.00 (0.00)^{a}	0.00±0.00 (0.00)^{a}	0.00±0.00 (0.00)^{a}

[Super script lower case letters indicate comparisons of different insecticides within the different time after exposure of insecticides. Letters with similar case are not significantly different (Tukey's HSD Test, Alpha= 0.05), Average mean of three replications, Figures in parentheses are arcsine transferred value]

The most effective chemicals, spinetoram 11.7 SC and chlorfenapyr 10 SC, recorded 100% larval mortality at 48 h of treatment, followed by cyantranaliprole 10.26 OD, λ-cyhalothrin 5 EC, and chlorpyriphos 20 EC, which all showed the same larval mortality of 86.67. fipronil 5 SC and tolfenpyrad 15 EC caused 73.33 and 66.67% moderate larval mortality, respectively, while the untreated control caused no larval mortality.

At 60 h after treatment, chlorantraniliprole 18.5 SC and cyantranaliprole 10.26 OD treatment had 100 (%) BHC larval mortality, which was significantly superior than other treatments. chlorpyriphos 20 EC and λ-cyhalothrin 5 EC similarly had increased larval mortality, 96.67 and 93.33%, respectively, and fipronil 5 SC and tolfenpyrad 15 EC had 80% larval mortality and 3.33% in the untreated control. After 72 h of treatment, chlorpyriphos 20 EC and λ-cyhalothrin 5 EC both showed 100% BHC larval mortality, while tolfenpyrad 15 EC and fipronil 5 SC both showed 96.67 and 93.33% larval mortality, respectively, but the untreated control recorded 6.67% larval mortality (Table 2).

Laboratory test conducted to assess the efficacy of a variety of newer pesticide chemicals, and their findings are somewhat validated by the current findings. They found that spinetoram 11.7 SC and emamectin benzoate 5 SG were considerably superior to other treatments in terms of % mortality after 60 h of treatment against *Spodoptera frugiperda* (Noctuidae: Lepidoptera) on maize[14]. Likely the bioefficacy of some modern insecticides against the Bihar hairy caterpillar, *Spilosoma obliqua* (Walker). Emamectin benzoate + thiamethoxam 3.0% +12.0% WG (66.19%) had the highest mortality percentage, followed by emamectin benzoate 5% SG (56.61%) and cartap hydrochloride 50% SP (47.03%). The least effective treatment was chlorfluazuron 5.4% EC, which resulted in a minimum percentage of larval mortality of 30.13%[15]. Similarly, the novel insecticides flubendiamide 480 SC and indoxacarb 14.5 SC were the most effective against S. *obliqua*, followed by conventional insecticides imidacloprid 17.8 SL and chloropyriphos 20 EC[16].

Toxicity of insecticides

Results from probit, log dose mortality analysis The LC_{50} values among insecticides ranged from 0.36 for chlorantraniliprole 18.5 SC to 3.82 ppm for chlorfenapyr 10 SC (Table 3). The LC_{50} of the new insecticides, chlorantraniliprole 18.5 SC, cyantranaliprole 10.26 OD, spinetoram 11.7 SC, tolfenpyrad 15 EC, fipronil 5 SC, and chlorfenapyr 10 SC, ranged from 0.36 to 0.98 ppm, and were generally lower than those of the older traditional insecticides (λ-cyhalothrin 5 EC and chlorpyriphos 20 EC) with LC_{50}'s 1.43 ppm and 3.82 ppm, respectively. BHC larvae were significantly less susceptible to chlorpyriphos 20 EC than other insecticides. Chlorantraniliprole 18.5 SC (0.36 ppm), cyantranaliprole 10.26 OD (0.48 ppm), and spinetoram 11.7 SC (0.52 ppm) substantially more harmful to BHC than other insecticides. Whereas relative toxicity when compared to higher toxic insecticide chlorantraniliprole 18.5 SC was 2, 3, 3, 5, 6, 7 and 9 times lower LC_{50} than cyantranaliprole 10.26 OD, spinetoram 11.7 SC, tolfenpyrad 15 EC, fipronil 5 SC, chlorfenapyr 10 SC, λ-cyhalothrin 5 EC and chlorpyriphos 20 EC, respectively.

Earlier study revealed that the LC_{50} value of chlorantraniliprole against *Plutella xylostella*, *Spodoptera litura*, *Spodoptera frugiperda*, *Heliothis virescens*, and *Heliothis zea* varied from 0.01-0.118 ppm[17,18,19]. Traditional insecticides such as λ-cyhalothrin 5 EC and chlorpyriphos 20 EC have lesser toxicity, with LC_{50} values of 1.43 and 3.82 ppm, respectively. Similarly, the LC value of λ-cyhalothrin in conventional insecticides ranged from 10.22 ppm to 62.25 ppm against *P. xylostella*

Table 3 — Dose-mortality responses of *Spilarctia obliqua* larvae treated with different insecticides.

Insecticides	LC_{50} (ppm)	95% Confidence Limits	Slope ± SE	Relative toxicity	X^2	df	Sig.
Chlorantraniliprole 18.5 SC	0.36	0.208-0.529	1.856±0.27	--	1.983	3	0.576[a]
Cyantranaliprole 10.26 OD	0.48	0.287-0.687	1.472±0.27	1.33	1.868	3	0.600[a]
Spinetoram 11.7 SC	0.52	0.299-0.730	1.613±0.32	1.44	1.230	3	0.746[a]
Tolfenpyrad 15 EC	0.50	0.267-0.846	0.991±0.19	1.39	2.178	3	0.536[a]
Fipronil 5 SC	0.69	0.494-0.916	1.916±0.28	1.92	1.368	3	0.713[a]
Chlorfenapyr 10 SC	0.98	0.650-1.374	2.18±0.26	2.72	3.318	3	0.345[a]
λ-cyhalothrin 5 EC	1.43	0.984-1.969	1.64±0.47	3.97	0.980	3	0.806[a]
Chlorpyriphos 20 EC	3.82	2.516-5.551	1.43± 0.21	10.61	0.739	3	0.864[a]

[*a since the significance level is greater than 0.150, no heterogeneity factor was used for calculation of confidence limits]

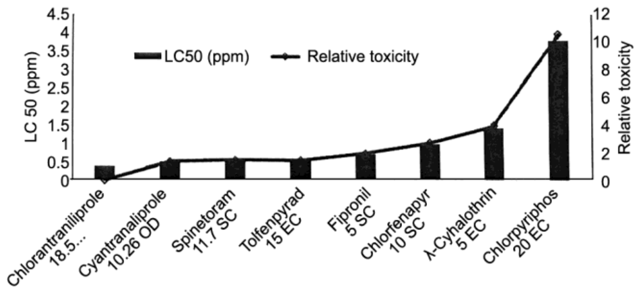

Fig. 1 — Dose-mortality responses and Relative toxicity of *Spilarctia obliqua* larvae treated with different insecticides

and *S. litura*, respectively[19]; 71.31 ppm against *H. armigera*[20]. Similarly, even though profenophos is a different insecticide than chlorpyriphos, it belongs to the same OP group as chlorpyriphos, and its LC_{50} values against *S. littoralis* and *S. litura* are 10.9 and 18.71 ppm, respectively[21,22]. Estimated LC_{50} values for the insecticides chlorantraniliprole (0.212 ppm), λ-cyhalothrin (0.985 ppm) and profenophos (3.263 ppm) and also relative toxicity when compared to greater toxic insecticides, chlorantraniliprole 18.5 SC was 1.33, 1.44, 1.39, 1.92, 2.72, 3.97 and 10.61 times more toxic than cyantranaliprole 10.26 OD, spinetoram 11.7 SC, tolfenpyrad 15 EC, fipronil 5 SC, chlorfenapyr 10 SC, λ-cyhalothrin 5 EC[5], Despite the fact that these findings (Fig. 1) are similar to those of the current study, there are some discrepancies that could be related to pesticide selection pressure among *S. obliqua* field populations and other experimental factors.

These finding indicate the first efforts in combining reference data for many commercial products currently used in the treatment of *S. obliqua* with baseline data for some novel insecticides (cyantranaliprole 18.5 SC, spinetoram 11.7 SC, tolfenpyrad 15 EC and chlorfenapyr 10 SC). Although the use of leaf dip method bioassays may not provide the optimum measure of the toxicity for all compounds, the procedure appeared to perform well for those products that require ingestion. This baseline data should assist in monitoring for changes in susceptibility to these novel insecticides as their use becomes widespread in Karnataka. From the results undeniably it deciphers newer chemistry insecticides precedence (Fig. 1) in the reduction of *S. obliqua* compared to conventional insecticides under laboratory condition as well as in field condition[12]. Conversely, in the current investigation, there was no discernible trend in the toxicity of both novel and conventional insecticides under laboratory conditions.

Conclusion

In the above study we collected some novel and convention insecticides and evaluated their bioefficacy and toxicity under laboratory conditions against BHC and their relative toxicity to conventional insecticides as well. The most effective and 100% larval mortality, were recorded in spinetoram 11.7 SC and chlorfenapyr 10 SC at 48 h and at 60 h after expose chlorantraniliprole 18.5 SC and cyantranaliprole 10.26 OD treatment observed 100% larval mortality, which is significantly over control. We have also estimated relative toxicity level, the result revealed that among evaluated insecticides, the LC_{50} of the novel insecticides, chlorantraniliprole 18.5 SC, cyantranaliprole 10.26 OD, spinetoram 11.7 SC, ranged from 0.36 to 0.52 ppm, which is lower than those of the conventional insecticides *i.e.*, λ-cyhalothrin 5 EC and chlorpyriphos 20 EC which were very high (1.43 ppm and 3.82 ppm) as noticed, respectively. As these novel insecticides have good biopontency with highest toxicity level, we recommend them for effective management of BHC menace.

Conflict of interest

Authors declare no competing interests.

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