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Evaluation of antifeedant and larvicidal activity of some commercial biopesticides and plant extracts on Rice Moth, *Corcyra cephalonica* (Stainton)

Iram Khan and Ayesha Qamar

Insect Physiology Lab, Section of Entomology, Department of Zoology, Aligarh Muslim University, Aligarh, UP, India

ABSTRACT

Chemical insecticides possess inherent toxicities that endanger human health and pollute the environment. Therefore, plant-derived products are being tested as an alternative ecologically more compatible substitute to explore for their insecticidal properties. With this backdrop, the present study was carried out to test and compare the bioefficacy of some botanicals with those of commercially available biopesticides against Corcyra cephalonica. Antifeedant activity and toxicity of commercial formulations of Anosom®, Derisom®, Margosom® and ethanolic extract of Argemone mexicana, Nerium oleander and Parthenium hysterophorus were evaluated. Feeding deterrence was assessed by taking the weight of five larvae at pre and post treatment and percent starvation was calculated. Derisom exhibited 85.76% starvation whereas the least percent starvation recorded in P. hysterophorus (55.19%) at the highest concentration after 24 hrs of treatment. The LC_{50} values of Anosom, Derisom, Margosom, A. mexicana, N. oleander and P. hysterophorus was estimated to be 0.031%, 0.022%, 0.037%, 5.54%, 4.54% and 4.49% respectively after 48 hrs. Significant differences between treatment means were determined by Tukey's multiple comparison tests. The present study revealed that plant extracts have feeding deterrent and toxic effects which are compare favourable to that of commercial biopesticides currently in use and thus they have the potential for development as commercial insecticides.

Keywords: *Corcyra cephalonica*, Biopesticides, *Argemone mexicana*, *Nerium oleander*, *Parthenium hysterophorus*, Antifeedant assay, LC_{50}

INTRODUCTION

The rice moth, *Corcyra cephalonica* (Stainton) is the major and serious pests of stored grains in the tropics [1], Asia, South America and Africa [2, 3]. The larval stages of rice moth cause substantial loss to wheat, rice, sorghum, maize, millets, cocoa beans etc. While feeding, the larvae leave silken threads which produce dense webbing containing their faecal matter and cast skin which contaminate the grains. The webbing formed is observably dense and hard, adding to the damage caused [4, 2]. The use of chemical pesticides still play a dominant role in the control of these insects as it the most quickest and simplest way to keep check on its infestation without foreseeing its adverse effects on living organisms and ecosystem. Insecticides have serious drawbacks such as pest resurgence and resistance, hazardous to non-target organisms, the risk of user's contamination, residual effects and environmental pollution [5, 6]. Moreover, botanical insecticides or biopesticides which are derived from plants, have been touted as potential alternatives to conventional synthetic insecticides, presumably because the natural products would have lesser environmental and human health impacts than many of the older conventional pesticides that have had demonstrable adverse effects on human health and ecosystems [7]. In the last two decades, considerable efforts have been directed at screening plants in order to develop new botanical insecticides as alternatives to the existing insecticides [8, 9]. Recently, the study was conducted to investigate the lethal and ovicidal effects of fifteen different combinations of six commonly available essential oils against the larvae of *C. cephalonica* [10]. Shukla & Tiwari [11] reported the insecticidal effects of D. felix-mas root and rhizome's ethanolic extract to control the rice moth. Thus, in spite of the hundreds of research reports on the effects of plant extracts to pest insects in the laboratory published, only two new botanical insecticides have been commercialized in the past 15 years [12]. These are the neem-based products, with the limonoid azadirachtin as their active ingredient [13], and those based on plant essential oils [14]. In accordance with this trend, we evaluated the comparative bioefficacy in terms of antifeedant activity and larval mortality of commercial formulations of biopesticides with selected plant extracts against *C. cephalonica* in an environmentally safe manner.

MATERIALS AND METHODS

Test insect

The eggs of *C. cephalonica* were obtained from Tropical Forest Research Institute, Jabalpur. The culture is maintained in laboratory on a dietary medium composed of coarsely ground maize, streytomycin, 5% (w/w) powdered yeast in large glass containers at 26±1ºC and 75±5% RH. After continued rearing, last instar larvae were separated out and used for the desired experiment.

Biopesticides used

The experimental biopesticides, Margosom® 0.3%EC (3000 ppm), Derisom® 2%EC (20,000 ppm) and Anosom® 1%EC (10,000 ppm) are commercial formulations of *Azadirachtin indica*, *Pongamia glabra* and *Annona squamosa* botanical extracts respectively obtained from Agri Life, SOM Phytopharma (India) Limited, Bollaram, Medak Dist. Hyderabad-AP, India.

Besides the above listed commercial biopesticides, ethanolic leaf extraction of *Argemone mexicana*, *Nerium oleander* and *Parthenium hysterophorus* were performed in the laboratory using soxhlet extraction apparatus.

Preparation of plant extract

The plant materials were collected in and around the campus of AMU, Aligarh. The leaves were thoroughly washed with tap water and shade dried under room temperature (28.0˚C±2˚C). After complete drying the plant materials were pulverized using electrical blender. The powdered materials (50 g) were then put into the thimble of the Soxhlet and extractions were carried out with ethanol (200 ml, Merck) until exhaustion (48 hrs) and filtered through Whatman's No. 1 filter paper. The obtained extracts were concentrated in water-bath at 60ºC and the residue obtained called as crude extract was stored at 4ºC as stock solution.

Preparations of different concentrations of the Biopesticides used

Five concentrations each of Anosom (An), Derisom (De) and Margosom (Ma) *viz.* 0.100%, 0.075%, 0.05%, 0.025% and 0.01% were prepared from the stock solutions in desired solvents (distilled water) by serial dilution.

Similarly, five concentrations each of leaf extract of *A. mexicana* (Ar), *N. oleander* (Ne) and *P. hysterophorus* (Pa) *viz.* 10.0%, 7.5%, 5.0%, 2.5% and 1.0% were prepared from the stock solutions in desired solvents (distilled water) by serial dilution.

Feeding bioassay

Crushed rice were soaked overnight in each concentrations of An, De, Ma (0.100%, 0.075%, 0.05%, 0.025% and 0.01%) and leaf extracts of Ar, Ne, Pa (10.0%, 7.5%, 5.0%, 2.5% and 1.0%) along with control wherein crushed rice were soaked only in water. The next morning soaked crushed rice were sieved and kept on filter paper to evaporate excess water. Five replicates for each treatment and 20 last instar larvae for each replicates were used.

Antifeedant assay

The larvae to be used for antifeedant assay were left without feeding during 24 hrs, the individual petridishes of starved larvae (5 larvae in each petridish) were kept in freezer for few min to inactivate the larvae and collective weight of 5 larvae were recorded. The larvae were then fed on the treated rice along with control and reweighted after 24 hrs.

Percentage of starvation was calculated according to the formula by Moustafa [15] and Abdel- Mageed *et al.* [16].

% Starvation = (C-E)/(C-S) x 100

Where:
C = Mean weight gain of control larvae within 24 hours

E = Mean weight gain of treated larvae at each tested concentration within 24 hours
S = Mean weight gain of starved control larvae within 24 hours

Statistical Analysis
The mortality was corrected using Schneider-Orelli's formula [17] and LC_{50} values were determined by Probit analysis [17]. Mortality data were expressed as Means±SE and data were submitted to analysis of variance (one way ANOVA). Significant difference between treatments were determined by Tukey's multiple range test (P≤0.05). Statistical analysis was performed using the software GraphPad Prism and SPSS, the graphs were produced accordingly.

RESULTS

Antifeedant Assay
The antifeedant activity of biopesticides was assessed on the basis of percent starvation of larvae of *C. cephalonica*. Figure 1 shows the percent starvation of Anosom, Derisom and Margosom at 0.01%, 0.025%, 0.05%, 0.075% and 0.1% after 24 hrs of treatment. Among the commercial formulations, highest concentration i.e. 0.1% of Derisom exhibited maximum percent starvation (85.76%) whereas its lowest concentration (0.01%) also showed fairly higher rate of antifeedancy which is (53.75%). Likewise, Anosom and Margosom at different concentrations showed moderate rate of antifeedant activity (67.34% and 68.27% at 0.10% concentration, respectively).

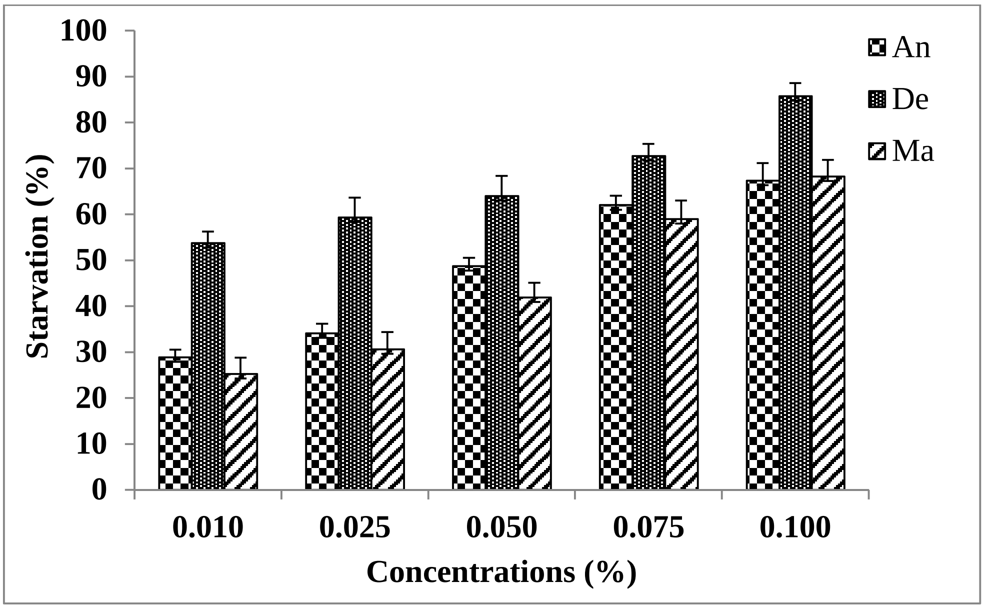

Figure 1 Starvation (%) of *C. cephalonica* larvae treated with commercial formulations of different biopesticides at various concentrations after 24 hrs of treatment

Percent starvation of plant extracts of *A. mexicana*, *N. oleander* and *P. hysterophorus* were also evaluated after 24 hrs of treatment (Figure 2). The maximum starvation of 65.26% was noted at 10.0% of *N. oleander* extract followed by *A. mexicana* (57.53%) and *P. hysterophorus* (55.19%) at the same concentration. The middle and least concentrations (5.0% and 1.0%) of the plant extracts also showed significant rate of antifeedant activity which is depicted in Figure 2. Higher percent starvation indicate decreased rate of feeding and thereby, increase in antifeedant activity.

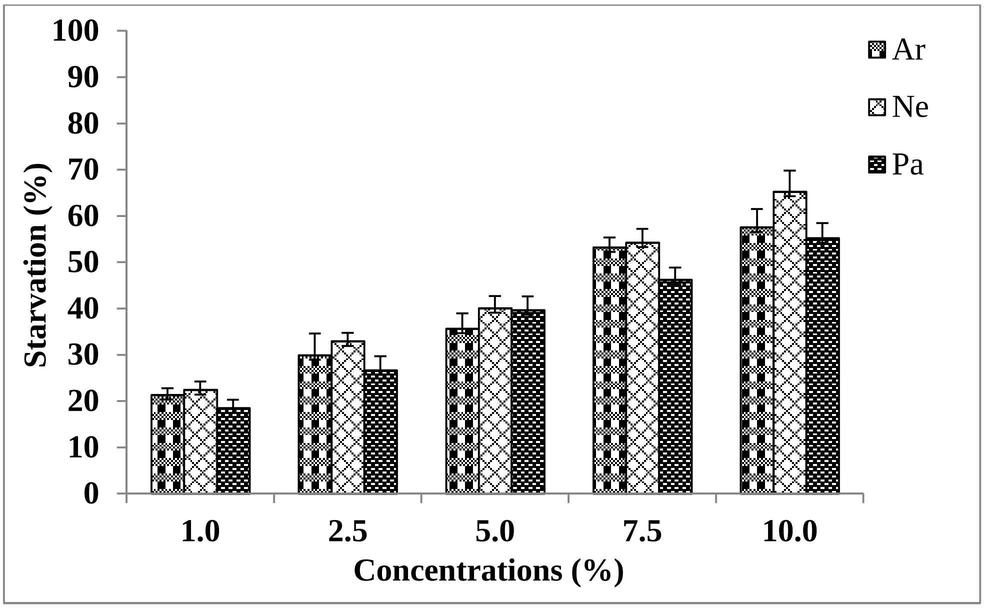

Figure 2 Starvation (%) of *C. cephalonica* larvae treated with different plant extracts at various concentrations after 24 hrs of treatment

Mortality and Toxicity Bioassay

In the present investigation, the toxicity of commercial biopesticides as well as soxhlet extracted ethanolic leaf extracts were tested against the last instar larvae of rice moth. Derisom resulted in 72.73% of corrected mortality at 0.1% concentration followed by Margosom (56.57%) and Anosom (41.41%) after 24 hrs of treatment (Figure 3) whereas the highest percent corrected mortality was found in plant extract of *N. oleander* (44.44%) followed by *A. mexicana* (43.43%) and *P. hysterophorus* (40.40%) at 10.0% (Figure 4). Furthermore, after 48 hrs of treatment Derisom and Margosom exceeded in causing more than 90% of the corrected mortality (95.92%) followed by Margosom (90.82%), Anosom (85.71%) (Figure 5). In case of plant extracts, *N. oleander* exhibited highest corrected mortality (82.65%), next in the series is *P. hysterophorus* (80.61%) and least mortality showed in *A. mexicana* (75.51%), at the highest concentration i.e. 10.0% (Figure 6). Linear regression for percent corrected mortality (Figure 3-6) clearly revealed that all of the tested biopesticides either commercial formulations or non-commercial plant extracts exhibited concentration dependent larvicidal activity against *C. cephalonica* after 24 and 48 hrs of treatment.

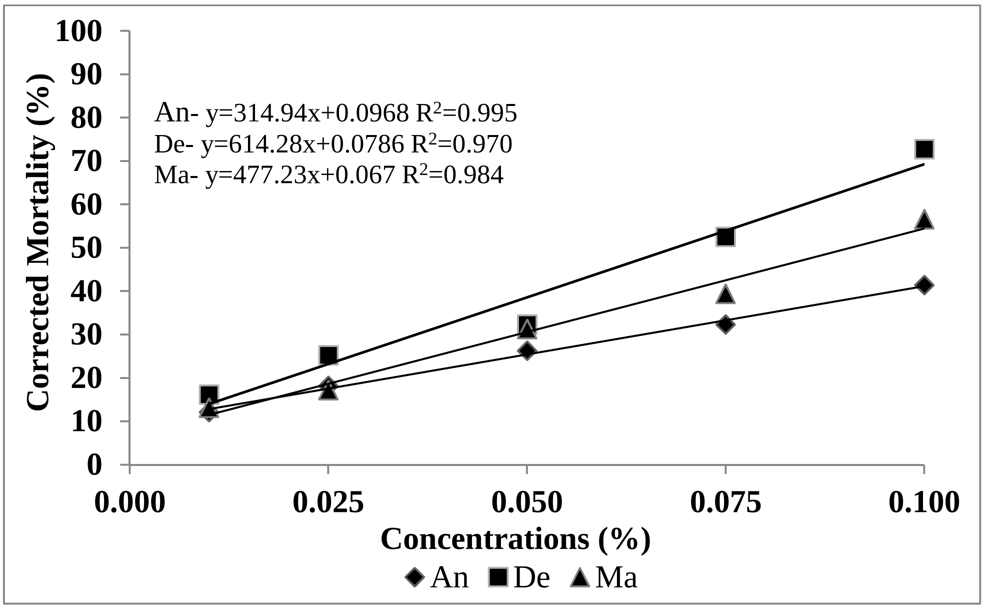

Figure 3 Corrected mortality (%) of *C. cephalonica* larvae treated with commercial formulations of different biopesticides at various concentrations after 24 hrs of treatment

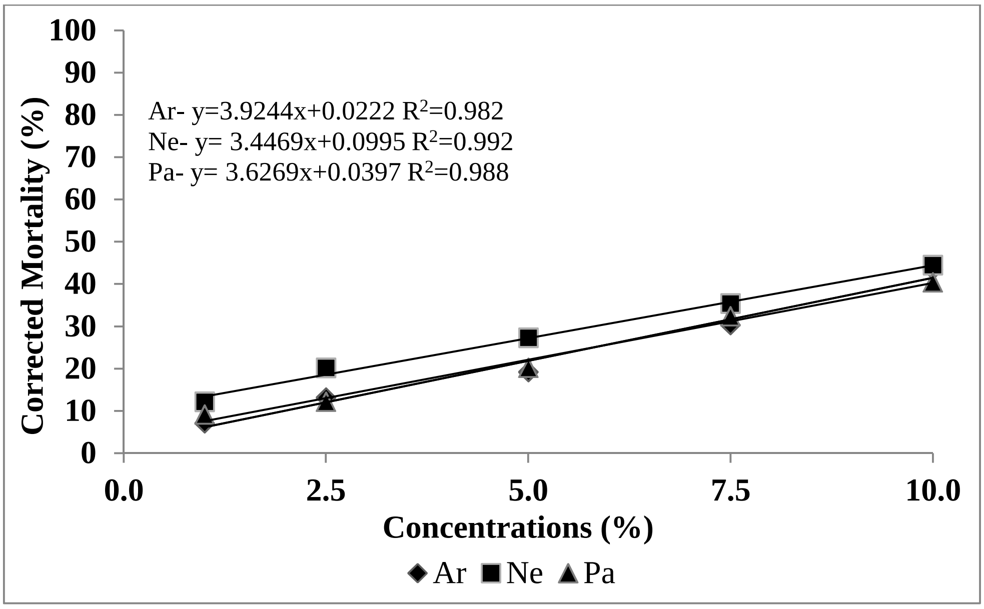

Figure 4 Corrected mortality (%) of *C. cephalonica* larvae treated with different plant extracts at various concentrations after 24 hrs of treatment

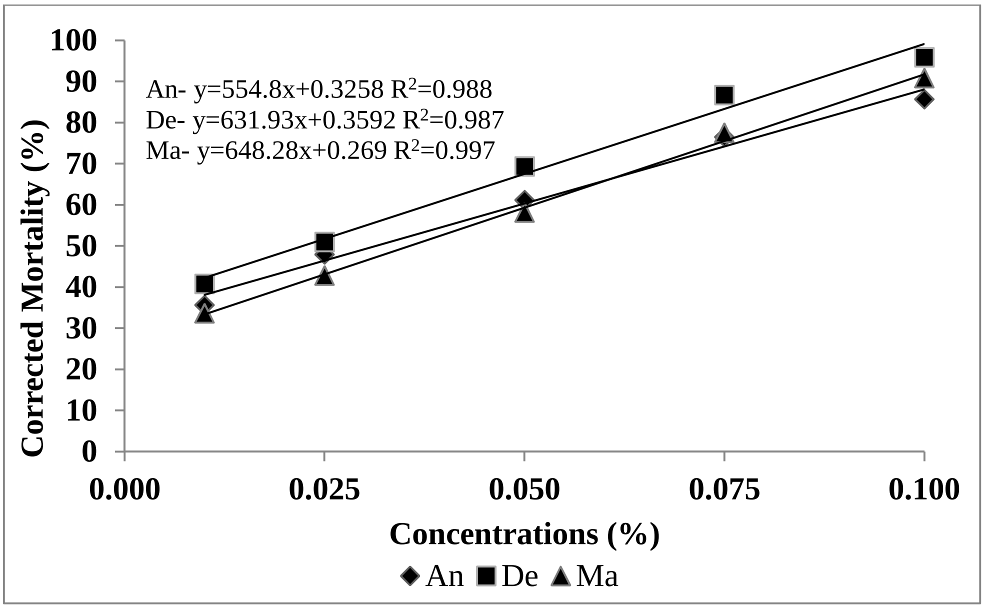

Figure 5 Corrected mortality (%) of *C. cephalonica* larvae treated with commercial formulations of different biopesticides at various concentrations after 48 hrs of treatment

The toxicity of commercial biopesticides Anosom, Derisom and Margosom and leaf extracts of *A. mexicana*, *N. oleander* and *P. hysterophorus* at different concentrations were tested against the larvae of *C. cephalonica* after 48 hrs of treatment (Table 1 and Table 2). Mean±SE of percent mortality data were recorded and LC_{50} and LC_{90} values were calculated. The LC_{50} values of Anosom, Derisom and Margosom were found to be 0.031%, 0.022% and 0.037% respectively whereas the LC_{90} of Derisom and Margosom were estimated to be 0.086% and 0.097% respectively. In case of plant extracts, the LC_{50} values of *A. mexicana*, *N. oleander* and *P. hysterophorus* were calculated to be 5.54%, 4.54% and 4.49% respectively. The analysis of variance where means were compared by tukey's multiple range test and 95% lower and upper confidence limit were significant at P<0.05% level. The mortality values at different concentrations were significantly greater than that of control.

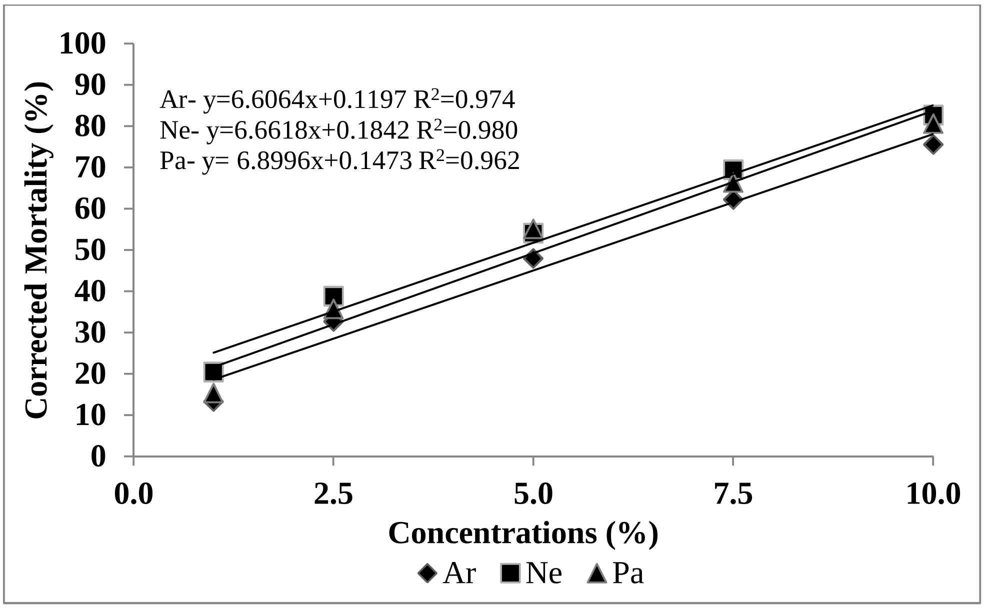

Figure 6 Corrected mortality (%) of *C. cephalonica* larvae treated with different plant extracts at various concentrations after 48 hrs of treatment

Table 1 Mortality and Toxicity of *C. cephalonica* larvae treated with commercial formulations of different biopesticides at various concentrations after 48 hrs of treatment

Biopesticides	Conc. (%)	% Larval Mortality (Mean±SE)	LC_{50}	LC_{90}	95% Confidence Interval		Variance (F)
					Lower	Upper	
Anosom	0.010	37.0±2.54^{b}	0.031	-	29.921	44.078	80.499
	0.025	49.0±2.91^{bcd}			40.905	57.094	
	0.050	62.0±3.39^{de}			52.584	71.415	
	0.075	77.0±3.39^{fg}			67.584	86.415	
	0.100	86.0±2.91^{gh}			77.905	94.094	
Derisom	0.010	42.0±2.54^{bc}	0.022	0.086	34.921	49.094	
	0.025	52.0±2.54^{cd}			44.921	59.078	
	0.050	70.0±3.53^{ef}			60.183	79.816	
	0.075	87.0±3.39^{gh}			77.584	96.415	
	0.100	96.00±1.87^{h}			90.805	101.19	
Margosom	0.010	35.0±2.23^{b}	0.037	0.097	28.791	41.208	
	0.025	44.0±2.91^{bc}			35.905	52.094	
	0.050	59.0±3.31^{de}			49.791	68.208	
	0.075	78.0±2.54^{fg}			70.921	85.078	
	0.100	91.0±2.91^{gh}			82.905	99.094	
Control		2.0±1.22^{a}			-1.400	5.400	

Means followed by the same letters are not significantly different at P<0.05 (Tukey's Multiple Comparison Test); LC_{50} =lethal concentration that kills 50% of the treated insects; LC_{90}= lethal concentration that kills 90% of the treated insects; 100 insects (5 replicates of 20 each) were treated at each concentrations.

Table 2 Mortality and Toxicity of *C. cephalonica* larvae treated with different plant extracts at various concentrations after 48 hrs of treatment

Plant extracts	Conc. (%)	% Larval Mortality (Mean±SE)	LC_{50}	95% Confidence Interval		Variance (F)
				Lower	Upper	
Argemone mexicana	1.0	15.0 ± 2.23^{b}	5.54	8.791	21.208	115.211
	2.5	34.0 ± 2.44^{c}		27.199	40.800	
	5.0	49.0 ± 1.87^{de}		43.805	54.194	
	7.5	63.0 ± 2.54^{fgh}		55.921	70.078	
	10.0	76.0 ± 2.91^{ijk}		67.905	84.094	
Nerium oleander	1.0	22.0 ± 3.00^{b}	4.54	13.670	30.329	
	2.5	40.0 ± 2.23^{cd}		33.791	46.208	
	5.0	55.0 ± 2.73^{ef}		47.396	62.603	
	7.5	70.0 ± 1.58^{hij}		65.610	74.389	
	10.0	83.00 ± 2.54^{k}		75.921	90.078	
Parthenium hysterophorus	1.0	17.0 ± 2.00^{b}	4.49	11.447	22.552	
	2.5	37.0 ± 1.22^{c}		33.599	40.400	
	5.0	56.0 ± 2.91^{efg}		47.905	64.094	
	7.5	67.0 ± 2.54^{ghi}		59.921	74.078	
	10.0	81.0 ± 2.44^{jk}		74.199	87.800	
Control		2.0 ± 1.22^{a}		-1.400	5.400	

Means followed by the same letters are not significantly different at P<0.05 (Tukey's Multiple Comparison Test); LC_{50} =lethal concentration that kills 50% of the treated insects; 100 insects (5 replicates of 20 each) were treated at each concentrations.

DISCUSSION

Eco-friendly pest management strategies can be achieved by using plants products as a suitable substitute to chemical insecticides as plants are the rich source of bioactive compounds. Moreover, utilization of phytochemicals as botanical insecticides and/or antifeedants is gaining momentum nowadays. In the present investigation, screening of the plant extracts along with the commercial formulations of biopesticides showed that both possess feeding deterrent and toxic effects against the larvae of *C. cephalonica*. From the results obtained, all the three plant extracts *viz.*, *A. mexicana*, *N. oleander*, *P. hysterophorus* and commercial formulations of biopesticides *viz.*, Anosom, Derisom and Margosom exhibited viable percent starvation/antifeedant activity. These botanicals induced reduced feeding when compared to that of control. Our results are comparable to those of other scientists who worked on petroleum ether extracts of black pepper, *Piper nigrum* and physic nut, *Jatropha curcus* and found that both extracts showed high bioactivity at all doses against *C. cephalonica* [19, 20]. Individual and joint toxicity of botanical and microbial pesticides *viz.*, Anosom®, Derisom®, Margosom®, Lipel® MVP II and XenTari® against diamondback moth, *Plutella xylostella* was lately investigated [21]. Pathak & Tiwari [22] reported that different doses of acetone extract of neem seed exerted a depressive effect on the developmental stages of *C. cephalonica*, they also depicted that the toxicity increases significantly with the increase in concentrations which is in accordance with the present findings of Margosom containing azadirachtin as an active ingredient. Besides the plant extracts investigated in the present study, other plant-based products also revealed similar toxic effects that play a positive role in pest population inhibition of *C. cephalonica* [20, 23, 24]. Currently, the control of pest insects is mainly dependent upon synthetic insecticides which cause ecological disruption and development of resistance. Therefore, there is a need to explore, develop and commercialize newer potential insect management products with a minimum environmental impact.

CONCLUSION

These findings together with the results of previous studies, suggest that plant extracts have high prospective to put back the indiscriminate use of synthetic harmful insecticides in saving the environment. Based on the comparable bioefficacy of soxhlet extracted plant products and commercial formulations of biopesticides they have potential for development as commercial insecticides with broad-spectrum activity and lesser adverse effects on human health and the ecosystem.

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