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Response of some selected insecticides on neuropteran predator (*Chrysopa lacciperda*) of lac insect (*Kerria lacca*)

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ABSTRACT

Laboratory bioassay was carried out during 2008 to evaluate some insecticides against larval instar of lac insect predator (*Chrysopa lacciperda* Kimmins) to develop suitable strategy for management of this serious neuropteran pest of Indian lac insect [*Kerria lacca* (Kerr)]. Seven safer insecticides, viz lambdacyhalothrin, carbosulfan, spinosad, indoxacarb, fipronil, alphamethrin and ethofenprox against lac insect, were evaluated for their bioefficacy against *C. lacciperda* Kimmins by topical application and exposing the insect on residual film of insecticides. Topical application of lambdacyhalothrin (0.005 and 0.008%), carbosulfan (0.02 and 0.03%), fipronil (0.005 and 0.01%), alphamethrin (0.005 and 0.01%), spinosad (0.02%), indoxacarb (0.02%), and ethofenprox (0.02%) exhibited 100% mortality of *C. lacciperda* within 24 hr of treatment. Fipronil (0.005 and 0.01%) and indoxacarb (0.02%) were found to be equally effective as cent per cent mortality was observed within 24 hr of treatment with both modes of treatment. In most of the treatments topical application of insecticides was found to be more effective as compared to exposure of insect on residual films. Hence, lambdacyhalothrin, carbosulfan, indoxacarb, spinosad, fipronil, alphamethrin and ethofenprox can be incorporated in IPM programmes while formulating strategy for effective management of this neuropteran predator of lac insect without having any adverse effect on lac insect. Fipronil is highly water soluble and hence may be cautiously used. Supervisory control of predators of lac is generally recommended.

Key words: *Chrysopa lacciperda*, Insecticides, *Kerria lacca*, Lac insect, Predator

Lac culture is seen as a cash crop of commercial importance providing valuable income to resource-constrained growers inhabiting tribal-dominated forest and sub-forest regions of the country. The lac crop is a low input high value crop and returns from lac cultivation are much higher, especially in drought situations when other major agricultural crops fail. The Indian lac insect [*Kerria lacca* (Kerr)] (Homoptera: Tachardiidae) is cultivated for commercial value of its products namely resin, dye and wax. The lac insect is sedentary, phytosuccivorous and feeds on phloem sap of specific host plants namely, *Schleichera oleosa* (*kusum*), *Butea monosperma* (*palas*), *Zizyphus mauritiana* (*ber*) and *Flemingia semialata* which are being exploited for commercial lac production in India. Lac crop is prone to attack by a hoard of enemies that include insect parasitoids and predators. Among the inimical insect fauna, the two lepidopteran predators *Eublemma amabilis* Moore (Lepidoptera : Noctuidae) and *Pseudohypatopa pulverea* Meyr (Lepidoptera: Blastobasidae) are the key pests causing a loss of around 30–40% to lac crop. Besides the lepidopteran predators, two neuropteran predators, *Chrysopa lacciperda* Kimmins and *Chrysopa madestes* Banks (Chrysopidae : Neuroptera) are the most prevalent predators in lac ecosystem which cause considerable damage, especially to the winter season (*aghani*) *kusmi* lac crop. In case of severe infestation by *Chrysopa* spp, whole winter season *kusmi* lac crop may be lost, if not managed properly. The larvae of *E. amabilis* and *P. pulverea* bore into the lac encrustations and feed on the lac insects and remain confined within the encrustation. While the larvae of *C. lacciperda* and *C. madestes* is a surface feeder and move over the lac colonies and suck the body fluids from different developmental stages of lac insect with the help of large pincers. The lac insect predators have wide distribution in all the lac-growing areas of the country. The first, second and third instar larvae of *C. madestes* can destroy up to 20, 24 and 74 mature females of lac insect/day. Two critical periods of *Chrysopa* infestation has been observed during August-September and March-April, which normally coincides with the period of 25–30 days after crop inoculation in the winter and summer season crops of *kusmi* lac insect.

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The critical period can extend up to 15 days of completion of mating period of lac insects. Hence, the management of this insect predator is of paramount significance for successful lac cultivation and increased production. Hand picking and shaking of lac insect settled branches are simple method to contain the population of predators but difficult for adoption on large scale due to large tree size and also labour intensive. Some chemical pesticides like HCH/ Chlordane have been recommended by Chaudhary (1983) and dichlorvos by Mishra *et al.* (1996) for the management of *Chrysopa*, but the use of Benzene Hexachloride/Chlordane has been banned in India and dichlorvos has been categorized in highly hazardous category of insecticide by WHO. Ethofenprox recommended by Jaiswal *et al*. (2007) is currently in practice to control this pest. In IPM programmes, it is not advisable to use a single insecticide over a period of time because it will lead to development of resistance in the insects. It is imperative, therefore to search for some more safer and eco-friendly insecticides for managing the predators of lac insect. Keeping in view the severity of damage caused by this neuropteran predator to lac crop and very limited number of options available to contain the menace of this pest, efforts have been made to evaluate the bioefficacy of some eco-friendly newer and selective insecticides (safe to lac insect) under laboratory conditions and to develop suitable strategy for managing the neuropteran predator (*C. lacciperda*) of lac insect under field conditions. Preliminary studies showed these insecticides safer to the lac insects based on that they were selected for bioassay studies against neuropteran predator (*C. lacciperda*) of lac insect for subsequent application in the field condition.

MATERIALS AND METHODS

Laboratory bioassay of some selected insecticides was carried out to evaluate the bioefficacy of 7 commercially available insecticides against field collected population of neuropteran predator (*C. lacciperda* Kimmins) during 2008 by topical application of insecticides on insects and by exposing the insects on residual film of insecticides. The two methods were tried with the perception that it might be possible that some predators may escape direct contact of insecticidal treatments at the time of spraying as they are mobile in nature so it was felt desirable to also assess the residual effect of such insecticides against this predator. The experiments consisted of 7 insecticides, viz indoxacarb 14.5% SC, carbosulfan 25% EC, spinosad 2.5% SC, fipronil 5% SC, lambdacyhalothrin 5% EC, alphamethrin 10% EC, ethofenprox 10% EC, including control (water only) and replicated thrice. All these insecticides and their doses have been evaluated for their safety towards lac insect and the insecticides were selected on the basis of their safety, as safety of lac insect is of prime importance for lac growers. Third instar larvae of *C. lacciperda* was collected from the Indian Institute of Natural Resins and Gums Research Farm, Ranchi, India from *Schleichera oleosa* (*kusum*) infested trees in April 2008 and brought to the laboratory and kept for 2 hr for starvation and conditioning. The commercial formulations of insecticides available in the market were evaluated for their bioefficacy against this pest of lac insect. Six selected insecticides, viz lambdacyhalothrin (0.005 and 0.008%), carbosulfan (0.02 and 0.03%), spinosad (0.01 and 0.02%), indoxacarb (0.01 and 0.02%), fipronil (0.005 and 0.01%), alphamethrin (0.005 and 0.01%) based on their safety to lac insect (*K. lacca* Kerr) were evaluated at two different concentrations and ethofenprox was evaluated at the recommended concentration (0.02%) for their bioefficacy against penultimate larval instar of *C. lacciperda*. There were two sets of experiment, in one set, the various concentrations of insecticides were directly sprayed on the insects with an atomizer and in the other set, residual film of different concentrations of insecticides were made in Petri-dishes and allowed to air dry under ceiling fan. Twenty larvae of test insects were sorted out for each replication and kept in Petri-dishes and the different insecticides in desired concentration were sprayed directly on the insects with an atomizer. After drying of insecticides on the insect body, the treated insects were transferred in separate glass jars containing twigs of *kusum* with living lac insect colony for feeding as natural food. In the other set of experiment, the different concentrations of insecticides were sprayed on the Petri-dishes and were allowed to air dry under ceiling fan. After drying, 20 test insect larvae were released on the residual film of insecticides and insects were exposed for half an hour, thereafter the treated insects were transferred in a separate jar containing fresh living lac insect settled twigs of *kusum* for feeding as natural food. In untreated control, insets were sprayed with water and reared on fresh living lac insect settled twigs of *kusum*. Mortality of insects was recorded after 2 hr, 24 hr and 48 hr of treatments and per cent mortality was calculated accordingly. Moribund insets were counted as dead. Data obtained were subjected to statistical analysis in completely randomized design after arc sine transformation before analysis of variance (ANOVA). The per cent data were transformed after adding 0.5 to the original value.

RESULTS AND DISCUSSION

The test insect (*C. lacciperda*) exhibited differential response to different insecticides in relation to their doses and mode of applications (Table 1). All the treatments were significantly superior over control in exerting mortality of lac insect predator. The larval mortality of insect was dose-responsive and relatively more mortality was observed with higher dose of insecticides. Topical application of insecticides was relatively more effective in comparison to exposure of insects on residual film of insecticides.

Topical application of insecticides

The observation on percentage larval mortality of *C.*

Table 1 Per cent larval mortality of lac insect predator (*Chrysopa lacciperda*) in different treatments of insecticides

Insecticide	Concentration (%)	Topical application of insecticides on insects			Exposure of insects on residual film of insecticides		
		Per cent mortality after			Per cent mortality after		
		2 hr	24 hr	48 hr	2 hr	24 hr	48 hr
Lambdacyhalothrin	0.005	63.33	100.00		33.33	56.67	90.00
		(53.01)	(90.00)		(35.55)	(49.14)	(72.05)
	0.008	76.67	100.00		46.67	70.00	100.00
		(61.48)	(90.00)		(43.39)	(57.10)	(90.00)
Carbosulfan	0.02	56.67	100.00		36.67	66.67	83.33
		(49.14)	(90.00)		(37.58)	(55.06)	(66.27)
	0.03	70.00	100.00		43.33	73.33	100.00
		(57.10)	(90.00)		(41.44)	(59.21)	(90.00)
Spinosad	0.01	23.33	73.33	100.00	0.00	0.00	36.67
		(29.20)	(59.21)	(90.00)	(4.05)	(4.05)	(37.58)
	0.02	30.00	100.00		0.00	33.33	90.00
		(33.52)	(90.00)		(4.05)	(35.55)	(72.05)
Indoxacarb	0.01	13.33	90.00	100.00	13.33	76.67	100.00
		(21.81)	(72.05)	(90.00)	(21.81)	(61.48)	(90.00)
	0.02	56.67	100.00		53.33	100.00	
		(49.14)	(90.00)		(47.18)	(90.00)	
Fipronil	0.005	43.33	100.00		23.33	100.00	
		(41.44)	(90.00)		(29.20)	(90.00)	
	0.01	76.67	100.00		73.33	100.00	
		(61.48)	(90.00)		(59.21)	(90.00)	
Alphamethrin	0.005	76.67	100.00		36.67	63.33	80.00
		(61.48)	(9000)		(37.58)	(53.01)	(63.79)
	0.01	90.00	100.00		56.67	83.33	86.67
		(72.05)	(90.00)		(49.14)	(66.19)	(69.04)
Ethofenprox	0.02	50.00	100.00		0.00	56.67	80.00
		(45.29)	(90.00)		(4.05)	(49.14)	(63.79)
Control		0.00	0.00	0.00	0.00	0.00	0.00
		(4.05)	(4.05)	(4.05)	(4.05)	(4.05)	(4.05)
S Em. (±)		3.69	1.13		3.60	2.32	3.25
CD (*P*=0.05)		11.28	3.46		10.99	7.09	10.26
CD (*P*=0.01)		15.71	4.83		15.32	9.87	14.58

Figures in parentheses are arc sine transformed values

lacciperda with the topical application of insecticides indicated that lambdacyhalothrin (0.005 and 0.008%), carbosulfan (0.02 and 0.03%) fipronil (0.005 and 0.01%), alphamethrin (0.005 and 0.01%), ethofenprox (0.02%), indoxacarb (0.02%) and spinosad (0.02%) caused cent per cent insect mortality within 24 hr of treatment, whereas spinosad (0.01%) and indoxacarb (0.01%) exerted cent per cent mortality after 48 hr of treatment. There was significant difference between 2 hr and 24 hr of treatment with both concentrations and insecticides evaluated. No significant difference between two (lower and higher) concentrations was observed in case of lambdacyhalothrin, carbosulfan, spinosad and alphamethrin, indicating that lower concentrations of all these insecticides are equally effective against *C. lacciperda* larvae. However, lower and higher concentrations of indoxacarb and fipronil showed significant difference in larval mortality indicating suitability of higher concentration for quick knock-down effect. The results in respect of larval mortality within 2 hr of treatment indicated that maximum larval mortality (90%) was observed with the treatment of alphamethrin (0.01%), followed by 76.67% with lambdacyhalothrin (0.008%), fipronil (0.01%) and alphamethrin (0.005%) which did not differ significantly between themselves. Similarly, there was no significant difference in mortality between lambdacyhalothrin (0.005%), carbosulfan (0.02%), indoxacarb (0.02%) and ethofenprox (0.02%), indicating all the insecticides are equally effective as the presently recommended insecticide ethofenprox (0.02%) which causes 50% larval mortality within 2 hr of treatment. However, significantly more larval mortality to the tune of 76.67% was observed with the treatment of fipronil (0.01%) and alphamethrin (0.005%) as compared to

above mentioned 4 insecticides. Indoxacarb and spinosad are slow acting insecticides and caused 13.33 and 23.33% mortality at 0.01% concentration and 56.67 and 30% mortality at 0.02% concentration, respectively within 2 hr of treatment. Treatment of indoxacarb and spinosad @ 0.01% caused larval mortality to the tune of 90.00 and 73.33%, respectively within 24 hr of treatments. The toxic activity of spinosad and indoxacarb at lower doses (0.01%) was slow but consistent and caused cent per cent larval morality of test insect after 48 hr of treatment with topical application. Gupta and Bhattacharya (2007) evaluated the toxicity of naturalyte compound against *Spilarctia oblique* and reported that spinosad was more active after 48 hr of treatment. Insecticides fipronil (0.005 and 0.01%) and indoxacarb (0.02%) are equally effective as they cause cent per cent larval mortality within 24 hr of treatment with both mode of application (topical application and residual exposure).

On the basis of results obtained within 2 hr of topical treatment, it can be inferred that the screened insecticides can be divided into 3 categories in terms of performance on mortality *vis-à-vis* ethofenprox. Spinosad, a naturalyte synthetic analogue compound in less effective than ethofenprox, insecticides lambdacyhalothrin, carbosulfan and indoxacarb are equally effective as ethofenprox and compound fipronil and alphamethrin are relatively more effective than ethofenprox.

Exposure of insect on residual film of insecticides

Out of 7 insecticides evaluated, only indoxacarb (0.02%) and fipronil (0.005 and 0.01%) caused cent per cent larval mortality within 24 hr of treatment, whereas, indoxacarb (0.01%), lambdacyhalothrin (0.008%) and carbosulfan (0.03%) caused cent per cent mortality after 48 hr of treatment. Spinosad, alphamethrin and ethofenprox however did not show cent per cent mortality even after 48 hr of treatment. There was a significant difference in per cent mortality between two concentrations of indoxacarb, fipronil and alphamethrin within 2 hr of treatment. Significant differences in per cent mortality were also observed within 2 hr and 24 hr as well as between 24 hr and 48 hr ($P_{0.05}$: CD=9.74) except in case of alphamethrin 0.01%. Based on the mortality within 2 hr of treatment, no significant difference between two concentrations was observed in case of lambdacyhalothrin, carbosulfan and spinosad, whereas fipronil and alphamethrin showed significant differences indicating suitability of latter with higher concentration for residual effect. Based on results of larval mortality within 2 hr of treatment and significance of two concentrations, it was observed that the response of ethofenprox and spinosad was similar where no mortality occurred but rest of the insecticides showed significantly higher mortality. The exposure of insect on residual film of fipronil (0.01%) causes significantly higher mortality (73.33%) of test insect as compared to other insecticides within 2 hr of exposure. No significant difference in larval mortality was observed with the treatment of alphamethrin (0.01%), indoxacarb (0.02%) and lambdacyhalothrin (0.008%) as it causes 56.67, 53.33 and 46.67% mortality, respectively within 2 hr of exposure. Residual exposure of alphamethrin (0.01%) exerted 83.33% larval mortality after 24 hr of treatment, followed by 76.67% with indoxacarb (0.01%), 73.33% with carbosulfan (0.03%) and 70.00% with lambdacyhalothrin (0.008%) which did not differ significantly between themselves. Residual exposure of insect on lambdacyhalothrin (0.008%), carbosulfan (0.03%) and indoxacarb (0.01%) resulted in cent per cent larval mortality after 48 hr of exposure. Exposure of insect on residual film of lambdacyhalothrin (0.005%), carbosulfan (0.02%), spinosad (0.02%), alphamethrin (0.005 and 0.01%) and ethofenprox (0.02%) resulted 90.00, 83.33, 90.00, 80.00, 86.67 and 80.00% larval mortality of test insect, respectively after 48 hr of treatment. After exposure of larvae or residual film of insecticides, especially spinosad, indoxacarb and ethofenprox, *C. lacciperda* larvae which escaped the lethal dose started pupating but adult emergence did not takes place in most of the cases and in a case of spinosad few deformed adults emerged probably due to chronic effect of insecticides. Adult deformity may also be attributed due to insect growth regulator activity of the spinosad. When response of other insecticides were compared with ethofenprox, all the insecticides were found superior than ethofenprox in respect to quick knock-down effect except spinosad. Assessment of insecticides in respect of quick mortality is important, especially during rainy season which may result into washing of insecticides from the treated surface.

Jaiswal *et al*. (2007) have evaluated ethofenprox on *C. madestes* under laboratory and field conditions and reported that ethofenprox (0.02%) was most suitable for protecting the lac crop at critical stage against *C. madestes* under field conditions without harming lac culture. The safety of ethofenprox against lac insect culture has been established up to 0.04% by field application (Jaiswal *et al*. 2004) and also by dipping broodlac (Bhattacharya *et al*. 2005). Mishra *et al*. (1996) evaluated the efficacy of selected organophosphorus insecticides for the control of *C. madestes* and reported that dichlorvos at 0.03% was most suitable for the control of predator. Toxicity of ethofenprox against first instar larvae of *Chrysoperla carnea* has been reported by Toda and Kashio (1997).

C. lacciperda is sporadic in nature and its incidence is more pronounced on *kusmi* lac culture. Leaving even a smaller population of this predator is harmful due to their voracious feeding behaviour, besides devouring large population of lac insect, its life-cycle will continue and next generation will also be harmful to lac insect. There is a critical period in lac insect development when application of chemical insecticides is restricted. This period pertains to 4–5 day prior to male emergence and up to completion of adult male emergence. Mortality of male lac insect will

hamper the fertilization of female and subsequently reduction in lac yield as female insect secretes lac resin in large quantity rapidly only after fertilization and female insect with high fecundity secretes more resin. Besides due to virgin female in the population, the resultant mature lac crop cannot be utilized as broodlac to continue the lac crop cycle. Keeping in mind the safety parameters of insecticides to lac insect, it is suggested that the insecticides alphamethrin (0.005%), fipronil (0.005%), lambdacyhalothrin (0.005%), carbosulfan (0.02%), indoxacarb (0.02%), ethofenprox (0.02%) and spinosad (0.02%) can be safely incorporated in pest management programme for effective management of *C. lacciperda*. All these insecticides were found to be toxic and have residual impact also on this pest. The use of these insecticides will not be harmful to lac insect because safety of these insecticides has been established under field conditions by the authors (unpublished data). Such compounds can be incorporated in pest management strategy to achieve the desired suppression of neuropteran lac insect predators and the best strategy would be using all the effective compound in rotation along with other pest management tactics under field conditions to avoid the development of resistance in insect to insecticides.

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