



Safety evaluation of some newer pesticides against lac insect (*Kerria lacca*) for managing predators

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ABSTRACT

Seven newer insecticides, viz indoxacarb, spinosad, fipronil, lambda-cyhalothrin, alphasulphathion, bifenthrin and carbosulfan along with two recommended insecticides namely ethofenprox and endosulfan have been evaluated against first and second larval stages of lac insect for its safety, so that it can be further assessed for their bioefficacy against harmful biotic fauna associated with lac insect. Insecticides namely spinosad (0.0025, 0.005, 0.01 and 0.02%), indoxacarb (0.003, 0.005, 0.007, 0.01 and 0.02%), fipronil (0.0025, 0.005 and 0.01%) and carbosulfan (0.01 and 0.02%) have been found safe against first and second instar larvae of both *kusmi* and *rangeeni* strain of lac insect under field conditions. Lambda-cyhalothrin, alphasulphathion and bifenthrin were found safe to lac insect at lower concentrations, but detrimental effect on survival of lac insect was observed with increase in dosages, hence may not be suitable for application at the initial stage of crop development (first application) in lac production system. It is suggested that newer compounds like spinosad (0.005%) which is a natural synthetic analogue compound produced by fermentation of a rare bacterium, *Sacharopolyspora spinosa*, indoxacarb (0.005%), fipronil (0.005%) and carbosulfan (0.01%), with different mode of action and whose safety against lac insect has been evaluated and established at some higher concentrations also, can be incorporated in pest management programme to achieve the desired control of lac insect predators in lac production system without harming lac culture.

Key words: *Kerria lacca*, Lac insect, Pesticides, Safety evaluation

The Indian lac insect [*Kerria lacca* (Kerr)] (Homoptera: Tachardiidae) is prone to attack by many insect predators and parasitoids, causing substantial damage to lac crop qualitatively and quantitatively. It has been estimated that two lepidopteran predators namely *Eublemma amabilis* and *Pseudohypatopa pulverea* cause 30–40% damage to lac crop (Jaiswal *et al.* 2008), whereas the sporadic neuropteran predator, *Chrysopa* spp are the most prevalent predators in lac ecosystems causing considerable damage, especially in the winter season *kusmi* lac crop. A severe infestation by *Chrysopa* spp may lead to the loss of the whole winter season *kusmi* lac crop if not managed properly. The pest loss in lac is thus far greater than what is usually met with in other agricultural crops and consequently invites serious attention. The chemical control which is a palliative measure and can immediately be applied with advantage in other agriculture crops during epizootics, has been considered of doubtful utility in case of lac pests as both the lac insect and immature

stages of its pests-complex share the same habitat in such an intimate association. Screening and evaluation of a series of insecticides for their suitability in lac ecosystem resulted in the selection of endosulfan as a safe insecticide against lac insect. The use of endosulfan currently in practice to control the lac insect predators, has been banned in most of the developed countries and also in some parts of India like Kerala due to its carcinogenic effect (Arora *et al.* 2009). The use of dichlorvos recommended by earlier workers in lac ecosystem for the management of lac insect predators after establishing its safety to lac insect, has been categorized in highly hazardous category of pesticide by WHO (FAO/WHO 1994, Arora *et al.* 2009). Ethofenprox has been identified by Jaiswal *et al.* (2004) as a safe and potential pesticide for use in lac ecosystem. In IPM programme, it is not advisable to use a single pesticide over a period of time because it will lead to development of resistance in insect to insecticide. So, it is imperative to search some more new and relatively safer molecules for managing the predator of lac insect, nevertheless the safety of lac insect is of prime importance for lac growers. Keeping in view the severity of damage caused by the predators to lac crop and very limited number

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of options available to contain the menace of pests in lac ecosystem, efforts have been made to find out other eco-friendly and newer pesticides, safe to lac insect, while controlling its predators and to minimize the chances of developing resistance following repeated usages of only few insecticides.

MATERIALS AND METHODS

Field evaluation of nine commercially available chemical pesticides was carried out on first and second instar larvae of *kusmi* and *rangeeni* lac insect culture at Institute Research Farm (IRF), Ranchi, Jharkhand and Farmers' field at Putidih

in district Purulia of West Bengal. First instar larvae belongs to summer crop of both *rangeeni* (*baisakhi*) and *kusmi* (*jethwi*) strain, whereas second instar larvae belongs to rainy season (*katki*) and winter season (*aghani*) lac crop, respectively. For the evaluation of bioefficacy of chemical pesticides for their safety towards lac insect, *rangeeni* rainy season crop was raised on *Butea monosperma* by inoculating the broodlac in July 2007, 2008 and 2009, whereas summer season crop was inoculated in October 2008, 2009 and 2010 on same host at IRF Ranchi and simultaneously in farmers' field at Putidih. Similarly, *kusmi* summer and winter season crops were raised on *Ziziphus mauritana*, *Schleichera oleosa* and *Albizia lucida*

Table 1. Response of insecticidal spray on survival of *rangeeni* and *kusmi* lac insect

Insecticide	Concentration (%)	Survival of lac insect (%)			
		<i>Rangeeni</i>		<i>Kusmi</i>	
		Early first instar larvae (summer crop)	Late second instar larvae (rainy crop)	Late first instar larvae (summer crop)	Late second instar larvae (winter crop)
Carbosulfan (25% EC)	0.01	88.98 (70.63)	78.87 (62.65)	68.45 (55.86)	87.77 (69.56)
	0.02	87.95 (69.73)	76.99 (61.34)	52.16 (46.26)	90.02 (71.56)
	0.05	83.94* (66.34)	71.32* (57.61)	39.33* (38.82)	
Indoxacarb (14.5% SC)	0.003	89.38 (71.00)	82.62 (65.35)		
	0.005	91.36 (72.95)	92.08 (73.68)	62.81 (52.42)	89.36 (71.00)
	0.007	87.72 (69.47)	83.53 (66.03)		89.62 (71.19)
	0.01	91.31 (72.84)	83.55 (66.11)	56.40 (48.68)	88.71 (70.36)
	0.02	86.62 (68.53)	76.06 (60.73)		88.99 (70.63)
Spinosad (2.5% SC)	0.001		97.58 (81.09)		
	0.0025	88.15 (69.82)	84.92 (67.13)		90.47 (72.05)
	0.005	89.06 (70.72)	83.38 (65.96)	73.43 (58.96)	90.45 (72.05)
	0.01	87.14 (68.95)	83.16 (65.80)	54.77 (47.75)	89.93 (71.47)
	0.02	87.23 (69.04)	77.71 (61.82)		89.05 (70.72)
Fipronil (5% SC)	0.0025		78.05 (62.10)		
	0.005	88.53 (70.18)	80.62 (63.87)	66.29 (54.51)	88.65 (70.27)
	0.01	86.46 (68.44)		53.26 (46.89)	89.14 (70.72)
	0.02	75.00* (60.00)			
Lambdacyhalothrin (5% EC)	0.001	88.82 (70.45)	78.62 (62.44)		
	0.002	91.08 (72.64)	78.24 (62.17)	64.55 (53.49)	88.90 (70.54)
	0.005	86.00 (68.03)	76.33 (60.87)	51.99 (46.15)	89.85 (71.47)
	0.008	83.77* (66.27)	69.47* (56.48)		
	0.01		24.77* (29.87)		
Alphamethrin (10% EC)	0.002	86.55 (68.53)	76.97 (61.34)		
	0.005	88.62 (70.27)	76.60 (61.07)	60.71 (51.18)	
	0.01	80.71* (63.94)	72.09* (58.12)	39.33* (38.82)	
	0.02		48.84* (44.51)		
Bifenthrin (10% EC)	0.001	88.93 (70.54)			
	0.002	87.31 (69.12)	75.92 (60.60)		90.42 (71.95)
	0.005	82.86* (65.42)			81.20* (64.30)
Ethofenprox (10% EC)	0.02	93.28 (75.00)	83.41 (65.96)	53.89 (47.24)	90.06 (71.66)
Endosulfan (35% EC)	0.05	87.41 (69.21)	82.93 (65.57)	50.98 (45.57)	90.78 (72.34)
Control	(Water)	90.38 (71.95)	82.86 (65.57)	53.91 (47.24)	92.58 (74.21)
SEm ±	1.53	2.72	3.88	1.58	
CD (P = 0.05)	4.28	7.46	11.09	4.43	

Figures in parentheses are arc sine transformed values

*Concentrations have shown detrimental effect on survival of lac insect

(*galwang*) by inoculating the broodlac in February 2008, 2009 and July 2008, 2009 and 2010 at both the locations. Commercial formulations of insecticides available in the market, viz carbosulfan 25% EC, indoxacarb 14.5% SC, spinosad 2.5% SC, fipronil 5% SC, lambdacyhalothrin 5% EC, alphamethrin 10% EC, bifenthrin 10% EC, ethofenprox 10% EC, endosulfan 35% EC, imidacloprid 17.8% SL, thiamethoxam 25% WG and acetamiprid 20% SP were evaluated in present study at different concentrations (Table 1). Keeping in mind the safety towards lac insect, some lower doses of insecticides were also evaluated along with recommended concentrations of insecticides for various field crops. During preliminary trial in July 2007, neonicotinoids, viz imidacloprid, thiamethoxam and acetamiprid were also evaluated at @ 0.003, 0.006 and 0.01% along with other insecticides but due to their detrimental effect on survival of lac insect, the further evaluation of these pesticides was discontinued. The experiment was laid in a randomized block design comprising nine insecticides besides control and replicated ten times. The insecticide formulations were applied on lac culture with the help of Gator sprayer after 30–35 days after inoculation (because this period coincides with the most critical stage of the predatory caterpillars, ie peak period of its eggs hatching) which corresponds to first instar larvae of summer season crop of both *rangeeni* and *kusmi* strain and second instar larvae of *rangeeni* rainy season crop and *kusmi* winter season crop. While spraying, the spray fluid was targeted towards lac encrustations on the host plants.

For recording post-treatment observations on survival/mortality of treated lac insect, samples (two lac sticks each of 30 cm shoot length) from each treatment were collected after 10 days of first application of pesticides by following the method of stratified destructive random sampling. Settlement of lac insect larvae and mortality of the lac insects were recorded to assess safety of the pesticides towards lac insect. Living and dead cells of lac insect were counted in 1cm² area per spot from three spots (upper, lower and middle portion). Number of living and dead lac insect cells were counted and converted into percentage survival of lac insects. Each crop season data obtained from Institute research farm (IRF) and farmers' fields with respect to *rangeeni* and *kusmi* lac crops and stages of lac insect were pooled together and subjected to statistical analysis after arc sine transformation before analysis of variance (ANOVA).

RESULTS AND DISCUSSION

Effect of insecticides on survival of rangeeni lac insect

Out of nine insecticides evaluated on summer season *rangeeni* lac crop for their safety to first instar larvae of lac insect, insecticides, viz carbosulfan (0.01 and 0.02%), indoxacarb (0.003, 0.005, 0.007, 0.01 and 0.02%), spinosad (0.0025, 0.005, 0.01 and 0.02%), fipronil (0.005 and 0.01%), ethofenprox (0.02%) and endosulfan (0.05%) were found safe

to lac insect and did not show any detrimental effect on lac culture wherein the survival of lac insect varied between 86.46 and 91.36% and showed non-significant differences with control (90.38%). The survival of lac insect in recommended insecticides, ethofenprox and endosulfan were 93.28 and 87.41%, respectively and was at par with the newer insecticides (Table 1). Significant reduction in survival of lac insect was observed with the application of carbosulfan (0.05%) and fipronil (0.02%) indicating its detrimental effect on lac culture, hence cannot be recommended at the initial stage of crop development (first application). Whereas, same concentration of carbosulfan (0.05%) and fipronil (0.02%) did not show any detrimental effect on surviving population of lac insect at the later stage of crop development (second application after 60 days of inoculation). Lambdacyhalothrin was evaluated at various concentrations (0.001, 0.002, 0.005, 0.008 and 0.01%) and showed non-toxic effect up to 0.005%. However, at higher concentrations (0.008 and 0.01%) detrimental effect was noticed on the survival of lac culture. Alphamethrin evaluated at four different concentrations (0.002, 0.005, 0.01 and 0.02%) in which lower concentrations (0.002 and 0.005%) was found safe as survival of lac insect was significantly at par with the control. Bifenthrin was regarded as safe up to 0.002% but toxic at higher concentration (0.005%).

Seven newer insecticides, viz indoxacarb, spinosad, fipronil, lambdacyhalothrin, alphamethrin, bifenthrin and carbosulfan along with two recommended insecticides namely ethofenprox and endosulfan were evaluated on rainy season *rangeeni* lac crop. Almost similar trend of insecticidal bioefficacy was observed against second instar larvae of lac insect in which survival of lac insect in safer insecticides with safer dose ranged between 75.92 and 97.58% as compared to 82.86% in control which were significantly at par with each other indicating the safety of these insecticides towards lac culture (Table 1). Significantly lower percentage survival of lac insect was observed at 0.008% and 0.01% concentrations of lambdacyhalothrin which were 69.47 and 24.77%, respectively. The latter dose was highly toxic and only 24.77% insect survived against 82.86% in control. Similar trend was also observed with alphamethrin in which 72.09 and 48.84% survival was recorded at 0.01 and 0.02%, respectively. Significant reduction in survival of lac insect at higher dose indicating the detrimental effect of particular insecticides on lac culture, hence cannot be recommended for application in lac production system. In present study, the recommended concentrations of endosulfan (0.05%) and ethofenprox (0.02%) were found safe to lac culture confirming the earlier findings. The preliminary studies carried out in July 2007 on *rangeeni* rainy season lac crop revealed the detrimental effect of neonicotinoids (imidacloprid, thiamethoxam and acetamiprid) as they were toxic to lac insect culture, and causing heavy mortality in lac insect, hence further evaluation of these insecticides were

discontinued. The toxicity of these neonicotinoids to lac insect might be attributed to the systemic nature of these pesticides which gets translocated into plant system during the course of sap feeding by lac insect and exerted detrimental effect.

Effect of insecticides on survival of kusmi lac insect

Only selected concentrations of new insecticides namely carbosulfan (0.01, 0.02 and 0.05%) indoxacarb (0.005 and 0.01%), spinosad (0.005 and 0.01%), fipronil (0.005 and 0.01%), lambdacyhalothrin (0.003 and 0.005%) and alphamethrin (0.005 and 0.01%) along with recommended ethofenprox (0.02%) and endosulfan (0.05%) were evaluated against first instar larvae of *kusmi* lac insect of summer season crop. All the evaluated newer insecticides were found safe to lac insect where survival ranged between 51.99 and 73.43% as against 53.91% lac insect survival in control and showed similar trends as in case of first instar *rangeeni* lac culture (Table 1). Carbosulfan (0.05%) and alphamethrin (0.01%) have shown detrimental effect on lac culture in which survival of lac insect was recorded to the tune of 39.33% and significantly lower than the control. The survival of lac insect in ethofenprox and endosulfan treatment was recorded as 53.89 and 50.98%, respectively and significantly at par with other safer insecticides and control.

The effect of different concentrations of newer insecticides was evaluated against second instar lac insect on winter season *kusmi* lac crop. All the newer insecticides were found safe to lac insect at the evaluated concentrations in which survival of lac insect ranged from 88.71 to 90.47% as against 92.58% in control and were statistically at par with each other, except bifenthrin (0.005%) which showed significantly lower survival (81.20%) in comparison to control. The survival of lac insect in endosulfan and ethofenprox treatment was 90.78 and 90.06%, respectively which are in conformity with the findings of Jaiswal *et al.* (2004). In general, the survival of *kusmi* lac insect was relatively higher on winter season crop as compared to summer season crop.

The lac insect associated fauna have complex ecosystem comprising direct association of three major insect predators; two lepidopteran, ie *Eublemma amabilis* and *Pseudohypatopa pulvereana* and one sporadic neuropteran predator *Chrysopa* spp in which lepidopteran are highly specific to lac insect and remains with lac throughout the crop period. Any insecticide applied for management of these predators may also show some detrimental effect on survival of lac insect. Hence, evaluation of insecticides for their safety towards lac insect is of prime importance. Several chemical insecticides have been evaluated by the earlier workers for safety against lac insects which are inadequate as either they have been banned or in restricted use. The endosulfan has been popularised in view of its toxic effect on both major lepidopteran predators. However, endosulfan was not effective against *Chrysopa* spp which is these, days are more

prevalent on *kusmi* lac crop. Most of the lac growers are still using endosulfan though it has been banned in several countries due to its carcinogenic effect (Arora *et al.* 2009). The use of dichlorvos (0.03%) in lac ecosystem for the management of neuropteran lac insect predators, establishing its safety up to 0.04%, has been categorised as highly hazardous category of pesticides by WHO (FAO/WHO 1994, Arora *et al.* 2009). Ethofenprox, a non-ester pyrethroid molecule falls under the category of GRAS (generally recognized as safe) has been found as a safe and potential pesticide for use in lac ecosystem for the management of both lepidopteran (Jaiswal *et al.* 2004) and neuropteran (Jaiswal *et al.* 2007) predators. Bhattacharya *et al.* (2005) evaluated the safety of cartap hydrochloride on rainy season *rangeeni* lac crop to manage the *E. amabilis* and reported that cartap hydrochloride (0.05, 0.075 and 0.1%) was safe to lac insect, hence recommended the use of cartap hydrochloride @ 0.05% in lac ecosystem for the control of lac insect predator, *E. amabilis* without causing any adverse effect on lac insect. The present findings are in conformity with the findings of Jaiswal *et al.* (2004) where endosulfan 0.05% and ethofenprox upto 0.02% were reported to be safe to lac insect. Our findings regarding imidacloprid and bifenthrin are in conformity with the findings of Howard and Steinberg (2005) in which they have recommended the application of imidacloprid and bifenthrin for the successful control of the pest lobate lac scale, *Paratachardina lobata*. Singh *et al.* (2009) have evaluated the response of all these insecticides against neuropteran predator, *C. lacciperda* of lac insect under laboratory conditions and advocated the spray of these newer insecticides for reducing the incidence of *Chrysopa* spp in lac production system. The efficacy of these insecticides against lepidopteran predators has been evaluated and established (personal communication, unpublished).

Based on the present findings against first and second instar larvae of lac insect, chemical pesticides, viz indoxacarb, a naturalyte compound spinosad, fipronil and carbosulfan did not exhibit any adverse effect and proved safer to lac culture when applied on standing lac crop. So these pesticides can be safely and effectively integrated in lac pest management programme. Lambdacyhalothrin, alphamethrin and bifenthrin was found to be safe to lac insect if applied at an advanced stage of crop development (second application), otherwise detrimental effect may occur when applied at initial stage of lac insect settlement (first application). With the increase in concentration and quantum of spray fluid of lambdacyhalothrin, alphamethrin and bifenthrin, these pesticides have shown detrimental effect on lac culture. So keeping in mind the overall impact of these insecticides on growth and survival of lac insect, these pesticides cannot be recommended for first application but can be used as second spray with adhering on recommended dose. The benchmark of highest dose for different

insecticides, viz indoxacarb (0.02%), spinosad (0.02%), fipronil (0.01%), carbosulfan (0.02%) and bifenthrin (0.002%) has been finalized. The safety and toxicity of these insecticides towards lac insect and their dosages provide basic information for its possible application in lac insect pest management programme. So these pesticides can be incorporated in pest management programme to achieve the desired control of lac insect predators and subsequently sustained quality broodlac and lac production. To manage the development of resistance in insect to insecticides in lac production system, these newer compounds may be applied in rotation along with other pest management tactics.

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