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RESPONSE OF BROODLAC TREATMENT WITH INSECTICIDES ON PREDATORS AND PARASITOIDS OF LAC INSECT, *KERRIA LACCA* (KERR) HARBOURING BROODLAC

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ABSTRACT

Treatment of broodlac (lac encrusted host sticks with fully mature living mother lac cells ready to produce young ones) is ecofriendly and cost effective tool for managing the biotic stress harbouring seed material. This study aims to bring down the pest population harbouring broodlac by treating the seed material. Response of insecticides on emergence of predators and parasitoids from treated broodlac was assessed under laboratory conditions by dipping *kusmi* broodlac in insecticidal formulations and subsequent inoculation of treated broodlac on lac host, *Flemingia semialata* in field. Broodlac obtained from summer season *kusmi* lac crop raised on *Schleichera oleosa* (*kusum*) was dipped in insecticidal solution of indoxacarb (0.007, 0.014 and 0.021%), spinosad (0.005, 0.007 and 0.01%), fipronil (0.007, 0.014 and 0.02%) and ethofenprox (0.02, 0.03 and 0.04%) for 15 min. No detrimental effect of insecticides on emergence and survival were noticed. Normal emergence and settlement on lac host *Flemingia semialata* seen clearly indicating the safety of insecticides. Significant reduction in lepidopteran predators and hymenopteran parasitoids population was observed from the treated broodlac. Maximum reduction in *Eublemma amabilis* emergence was observed with spinosad (100%) followed by indoxacarb (97.92 to 100%), ethofenprox (75 to 93.75%) and fipronil (72.92 to 91.67%). All the insecticides have shown very good response on *Pseudohypatopa pulverea*. Emergence of parasitoids of lac insect *viz.*, *Tachardiaephagus tachardiae*, *Aprostocetus purpureus* and *Eupelmus tachardiae* was significantly low from treated broodlac. Reduction in population of *T. tachardiae* in different treatments varied from 47.06 to 89.71%, *A. purpureus* from 61.54 to 100%, *E. tachardiae* (male) from 38.46 to 100% and *E. tachardiae* (female) from 45.45 to 100%. Study clearly indicates that the treatment of broodlac prior to inoculation can be safely and effectively used as a tool in IPM programmes selective insecticides namely indoxacarb, fipronil, spinosad and ethofenprox can be safely and effectively used.

Key words: Broodlac, insecticides, *Aprostocetus purpureus, Tachardiaephagus tachardiae, Eupelmus tachardiae, Eublemma amabilis* and *Pseudohypatopa pulverea.*

Lac is the natural resinous secretion of Indian lac insect *Kerria lacca* (Kerr) which finds application in many industrial sectors *viz.*, food, pharmaceutical, cosmetic and jewellery, varnish, lacquer and paint, electrical and electronic, adhesive, automobiles and textile etc. Lac insect thrives on more than 400 tree species (Varshney and Teotia, 1967; Varshney, 1986). *Schleichera oleosa* (*kusum*), *Butea monosperma* (*palas*) and *Ziziphus mauritiana* (*ber*) are the major known tree species along with *Flemingia semialata*, a bushy host, that have been established as commercial lac host species. Twenty-two insect predators, 30 primary parasitoids and 45 secondary parasitoids associated with lac insect had been reported so far (Varshney, 1976; Das, 1990). Among the predators, two key lepidopteran predators *viz.*, *Eublemma amabilis* Moore (Noctuidae) and *Pseudohypatopa pulverea* Meyr (Blastobasidae) cause damage to lac crops to the tune of 30 to 40% annually (Malhotra and Katiyar, 1979). The relative abundance of different species of hymenopteran parasitoids had been studied and *Aprostocetus purpureus* (Cameron) (Eulophidae), *Tachardiaephagus tachardiae* Howard (Encyrtidae) and *Eupelmus tachardiae* reported to be the most prevalent (Srivastava *et al.*, 1976; Srivastava and Mehra, 1980). Most of the parasitoids belong to chalcid group and inflict damage to lac crop upto the extent of 8 to 10% annually, in some lac growing areas the damage caused by the parasitoids is as high as 50% (Teotia, 1964). In recent past total *rangeeni* lac crop failure has been reported due to parasitoids. The

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broodlac is one of the major sources for the infestation of these predators and parasitoids on new lac crops. Mechanical means are available for trapping the predators and parasitoids of lac insect by inoculating the broodlac in 60 mesh nylon broodlac containers.

Treatment of broodlac with insecticides had been tried and reported by earlier workers, but some of the insecticides evaluated by earlier workers have been either banned or outdated (Malhotra and Bhattacharya, 1988; Bhattacharya *et al.*, 1994). In recent past, some new insecticides had been evaluated on lac cultures which are safe to lac insect and effective against predators (Singh *et al.*, 2009; 2011). The safe and effective treatments of *rangeeni* broodlac with newer insecticides have been reported (Singh *et al.*, 2013). The crop cycles, settlement pattern, thickness of lac encrustation, resin quality and productivity of *rangeeni* and *kusmi* strains are different. Due to high settlement density and more resin productivity of *kusmi* strain, the thickness of lac encrustation is more than the *rangeeni* strain. The *kusmi* strain produces resin of better quality which fetches more prices in market than the *rangeeni* strain. In the present study, some newer insecticides have been evaluated to assess their safety and efficacy for the treatment of *kusmi* broodlac to minimize the source of infestation on new standing lac crops.

MATERIALS AND METHODS

Summer season *kusmi* lac crop was raised on *S. oleosa* trees at Research Farm of Indian Institute of Natural Resins and Gums, Ranchi, Jharkhand. For raising the crop, the *kusmi* broodlac was inoculated on host trees during January and crop matured during July. The *kusmi* broodlac harvested from summer season lac crop (January to July) in July, 2012 was used for bio-efficacy studies of various insecticides on predators and parasitoids by treating the broodlac in insecticidal formulations. The broodlac was in a stage of ready to emergence of young lac insect crawlers. The broodlac sticks were cut into pieces of around 15 cm lengths and grouped into 50 g each by weight. Randomly selected group of 50 g broodlac was taken for each treatment. There were 12 treatments of insecticides and a control with four replicates in each. The commercial formulations evaluated were indoxacarb 14.5% SC (0.007, 0.014 and 0.021%) (Dupont India Ltd), spinosad 2.5% SC (0.005, 0.007 and 0.010%) (Dow Agro Sciences India Ltd), fipronil 5% SC (0.007, 0.014 and 0.021%) (Bayer Crop Science), and ethofenprox 10% EC (0.02, 0.03 and 0.04%) (Northern Minerals Ltd). Each replication having 50 g broodlac was tagged with rubber band and submerged in insecticidal solution for 15 minutes.

After the treatment, the broodlac sticks were spread under ceiling fan for half an hour for air drying. After drying these broodlac sticks were transferred in 60 mesh nylon net bag and mouth was tied up with plastic string and the treated broodlac was inoculated on bushy lac host, *Flemingia semialata* as treatment wise. The emergence from treated broodlac and its settlement on lac host *F. semialata* was closely monitored throughout the experimental period. The lac host sticks containing settled lac insect were collected one month after inoculation and survival/ mortality of lac insects (sq cm^{-1}) were counted from four randomly selected spots. The net bags containing treated broodlac were collected from the lac host after the complete emergence and settlement of lac crawlers was over. Thereafter these bags were kept in the laboratory for another 35-40 days to facilitate complete emergence of natural enemies before quantification of predators and parasitoids which emerged out in net bag and trapped inside. The predators and parasitoids emerged from treated broodlac were quantified. The data on number of predators and parasitoids emerged out from treated broodlac were subjected to analysis of variance under Randomized Block Design (RBD) after transformation to $\sqrt{n+0.5}$. The survival status of emerging lac insect was also recorded at regular interval for assessment of detrimental effect of insecticides.

RESULTS AND DISCUSSION

The data pertaining to the response of insecticides as broodlac treatment on safety of lac culture and efficacy as population reduction of predators and parasitoids of lac insect are presented in Tables 1, 2 and 3.

All the treatments were found safe to lac culture as there was no significant difference in settlement and survival of lac insect on lac host plant *F. semialata* (Table 1). The emergence of crawlers from the treated broodlac and settlement on lac host was quite normal. The survival of lac insect on lac host in different treatments varied from 74.78 to 91.63% as compared to 78.96% in control which were statistically at par ($p < 0.05$) with each other clearly indicating the safety of broodlac treatment with these selective insecticides.

All the treatments were found to be significantly effective ($P < 0.05$) as compared to control in reducing the population of *E. amabilis* from treated broodlac

Table 1. Survival of *kusmi* lac insect after treatment of broodlac with insecticidal formulations

Insecticide	Conc (%)	Mean number of insects settled (sq cm^{-1})	Mean number of insects survived (sq cm^{-1})	Survival of lac insect (%)*
Indoxacarb	0.007	62.75	58.25 ± 12.33	88.27 ± 3.64(9.45)
	0.014	66.50	61.50 ± 6.95	91.63 ± 3.48(9.62)
	0.021	57.50	51.50 ± 18.57	88.11 ± 10.08 (9.43)
Fipronil	0.007	51.50	43.00 ± 11.80	88.45 ± 5.30(9.45)
	0.014	57.00	44.25 ± 6.70	89.47 ± 3.92(9.51)
	0.021	46.75	40.00 ± 4.55	87.69 ± 4.08(9.42)
Spinosad	0.005	37.50	33.00 ± 8.27	87.09 ± 8.08 (9.38)
	0.007	75.25	49.75 ± 11.09	87.73 ± 2.87 (9.42)
	0.010	64.00	38.25 ± 5.12	84.93 ± 4.62 (9.27)
Ethofenprox	0.02	62.75	47.75 ± 6.23	90.86 ± 3.19 (9.58)
	0.03	46.75	24.75 ± 4.65	77.57 ± 5.25 (8.86)
	0.04	36.25	19.75 ± 5.38	74.78 ± 4.36 (8.70)
Control	-	40.00	42.00 ± 11.94	78.96 ± 9.093 (8.70)
CD (5%)			NS	NS

*Figures in parentheses are transformed values to √n+1

Table 2. Effect of *kusmi* broodlac treatment with insecticidal formulations on lepidopteran predators

Insecticide	Conc(%)	*Eublemma amabilis*		*Pseudohypatopa pulverea*	
		Mean number	% reduction over control	Mean number	% reduction over control
Indoxacarb	0.007	0.33(0.91)^{ab}	97.92	0(0.71)^{a}	100
	0.014	0.00(0.71)^{a}	100	0(0.71)^{a}	100
	0.021	0.00(0.71)^{a}	100	0(0.71)^{a}	100
Fipronil	0.007	4.33(2.20)^{c}	72.92	0(0.71)^{a}	100
	0.014	1.67b(1.47)	89.58	0(0.71)^{a}	100
	0.021	1.33(1.35)^{ab}	91.67	0(0.71)^{a}	100
Spinosad	0.005	0.00(0.71)^{a}	100	0(0.71)^{a}	100
	0.007	0.00(0.71)^{a}	100	0(0.71)^{a}	100
	0.010	0.00(0.71)^{a}	100	0(0.71)^{a}	100
Ethofenprox	0.02	4.00(2.12)^{c}	75.00	0(0.71)^{a}	100
	0.03	1.67(1.47)^{b}	89.58	0(0.71)^{a}	100
	0.04	1.00(1.22)^{ab}	93.75	0(0.71)^{a}	100
Control	0	16.00(4.06)^{d}	0.00	2.67(1.78)^{b}	0
SEd±		0.286		0.0379	
F value		21.94		121.0	

*Figures in parentheses are transformed values to √n+0.5
Means marked with different letters within same column are significantly different ($P<0.05$)

(Table 2). Spinosad was found to be the best followed by indoxacarb. The treatment of broodlac with fipronil resulted in 72.92 to 91.67% population reduction of *E. amabilis* whereas with ethofenprox it was 75.00 to 93.75%. Wherever no significant response between lower and higher concentrations were observed, then lower concentrations should be treated as suitable concentration. In this respect, spinosad (0.005%), indoxacarb (0.007%), fipronil (0.014%) and ethofenprox (0.03%) can be safely and effectively used

Table 3. Effect of *kusmi* broodlac treatment with insecticidal formulations on major parasitoids

Insecticide	Conc(%)	*Tachardiaephagus tachardiae*		*Aprostocetus purpureus*		*Eupelmus tachardiae* (male)		*Eupelmus tachardiae* (female)	
		Mean number	% reduction over control	Mean number	% reduction over control	Mean number	% reduction over control	Mean number	% reduction over control
Indoxacarb	0.007	2.17 (1.63)^{cde}	80.88	0.67 (0.71)^{abc}	92.31	1.33 (1.35)^{abcd}	84.62	1.00(1.22)^{ab}	86.36
	0.014	3.33 (1.96)^{cde}	70.59	0.00 (0.71)^{a}	100	1.00 (1.22)^{abc}	88.46	1.33(1.35)^{ab}	81.82
	0.021	1.17 (1.29)^{abc}	89.71	0.00 (1.96)^{a}	100	0.33 (0.91)^{ab}	96.15	0.00(0.71)^{a}	100
Fipronil	0.007	6.00 (2.55)^{ef}	47.06	3.33 (1.87)^{d}	61.54	5.33 (2.42)^{fg}	38.46	4.00(2.12)^{c}	45.45
	0.014	3.67 (2.04)^{def}	67.65	3.00 (1.87)^{cd}	65.38	3.33 (1.96)^{def}	61.54	2.00(1.58)^{bc}	72.73
	0.021	3.00 (1.87)^{bcde}	73.53	3.00 (1.87)^{cd}	65.38	2.33 (1.68)^{cde}	73.08	2.00(1.58)^{bc}	72.73
Spinosad	0.005	4.67 (2.27)^{bcd}	58.82	3.00 (1.58)^{bcd}	65.38	4.33 (2.20)^{ef}	50.00	2.67(1.78)^{bc}	63.63
	0.007	2.67 (1.78)^{bcd}	76.47	2.00 (0.91)^{abcd}	76.92	2.00 (1.58)^{bcd}	76.92	1.33(1.35)^{ab}	81.82
	0.010	2.33 (1.68)^{ab}	79.41	0.33 (1.96)^{ab}	96.15	0.00 (0.71)^{a}	100	0.00(0.71)^{a}	100
Ethofenprox	0.02	1.33 (1.35)^{ab}	88.24	3.33 (1.58)^{cd}	61.54	3.67 (2.04)^{bef}	57.69	2.33(1.68)^{bc}	68.18
	0.03	1.33 (1.35)^{ab}	88.24	2.00 (1.47)^{abcd}	76.92	2.33 (1.68)^{cde}	73.08	1.00(1.22)^{ab}	86.36
	0.04	1.33 (1.35)^{a}	88.24	1.67 (3.03)^{abcd}	80.77	1.00(1.22)^{abc}	88.46	0.33(0.91)^{a}	95.45
Control	0	11.33 (3.44)^{f}	0.00	8.67 (0.71)^{e}	0.00	8.67 (3.03)^{g}	0.00	7.33(2.80)^{d}	0.00
SEd±		0.500		0.410		0.311		0.311	
F value		5.07		4.64		8.45		6.87	

*Figures in parentheses are transformed values to $\sqrt{n+0.5}$

Means marked with different letters within same column are significantly different P<0.05) for the treatment of broodlac before inoculation on the host plants to suppress the predator population harboring in broodlac. All the insecticides were found to be very much effective in reducing the population of *P. pulverea* as cent per cent population reduction was achieved with the treatment of broodlac in insecticidal formulations for 15 min (Table 2).

All the insecticidal treatments were found to be significantly superior over control ($P<0.05$) in reducing the population of *T. tachardiae* except lower concentrations (0.007 and 0.014%) of fipronil (Table 3). Ethofenprox was found to be the best treatment with 88.24% population reduction followed by indoxacarb in which population reduction ranged between 70.59 to 89.71%. The population reduction of *T. tachardiae* with spinosad and fipronil ranged from 58.82 to 79.41% and 47.06 to 73.53%, respectively.

The mean values and per cent reduction of *A. purpureus* in all the treatments differed significantly. Indoxacarb was the best treatment with population reduction in range of 92.31 to 100% followed by spinosad (65.38 to 96.15%) and ethofenprox (61.54 to 80.77%). Fipronil was observed to be the least effective treatment (Table 3).

All the treatments were found to be significantly more effective than the control ($P<0.05$) in reducing the male population of *E. tachardiae* except lower concentrations (0.007%) of fipronil. Maximum (100%) population reduction was observed with spinosad (0.01%) followed by indoxacarb (Table 3). Ethofenprox was found to be more effective than the fipronil.

All the treatments were found to be significantly more superior in reducing the female population of *E. tachardiae* ($P<0.05$). Indoxacarb was found to be best treatment followed by spinosad (Table 3). As in case of male, ethofenprox was found to be more effective than the fipronil. Study indicated that the female population was observed to be relatively more sensitive to insecticides than the male.

The treatment of broodlac by dipping it in insecticidal formulation of endosulfan has been carried out to reduce the population of lepidopteran predators viz., *E. amabilis* and *P. pulverea* (Malhotra and Bhattacharya 1988; Bhattacharya *et al.*, 2005). In view of ban imposed on the use of endosulfan by Supreme Court of India (effective from 13.5.2011), its use can not be further recommended in lac production system.

The present finding differed from earlier report where ethofenprox and endosulfan treatment were found ineffective on population of *T. tachardiae* and *Aprostocetus purpureus*. This difference might be attributed due to the fact that the dipping period was relatively short (Bhattacharya *et al.*, 2005). In our earlier experimentation of broodlac treatment with *rangeeni* strain of lac insect, there was duration dependent relationship in pest reduction and was time proportionate. There was non-significant reduction in pest population below 10 min dipping period whereas 15 min dipping showed better results as evident by higher pest reduction. Significant reduction in predators and parasitoids population with treatments of *rangeeni* broodlac with these insecticides had been achieved (Singh *et al.*, 2013).

Therefore, in present study with *kusmi* strain, 15 min dipping time periods were considered based on initial trials. The more prolonged duration in dipping time may be detrimental to lac insect. It should also be ensured before broodlac treatment that the larvae of lac insect are not emerging from the broodlac. The treatments of broodlac significantly enhanced the quality of broodlac by reducing the pest population of treated broodlac which is one of the major sources of pest infestation for subsequent crop. Treatment of broodlac with these insecticides can be used as a tool for devising integrated pest management programmes in lac production system for minimizing the incidence of predators and parasitoids.

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