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Bio-efficacy of eco-friendly pesticides against major predators of lac insect, *Kerria lacca* Hemiptera: Kerriidae

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Abstract
The field experiment was conducted to assess the botanicals and insecticide molecules for bio efficacy against predators of lac insect on ber plants (*Ziziphus mauritiana* Lam) at lac gene bank, Department of Entomology, Rajasthan College of Agriculture, Udaipur during *Katki* season 2018. The insecticidal sprays were applied at 45 days (time that coincides with the most critical stage of the predatory caterpillars) or 7-8 weeks after the inoculation of brood lac on the completion of male emergence. The first spray application was applied at 7 days after the completion of male emergence followed by a second application at 30 days after the first spray. The insecticidal application was applied on lac bearing Twigs of the ber plants to cover the encrustation of lac insect. Among the insecticides evaluated, the most effective treatment was spinosad 2.5% EC against Predators *viz*., *Eublemma amabilis* and *Pseudohypatopa pulverea* with 84.85 and 78.95 mean per cent reduction in the population over control, respectively. Application of spinosad 2.5% EC was also recorded as the most effective treatment in terms of survival percentage of lac insect. Emamectin benzoate 5% SG was found next effective treatment, whereas, Neem oil was found least effective treatment in reducing the population of predators of lac insect as well as in terms of survival percentage of lac insect.

Keywords: Bio-efficacy, pesticides, predators, lac insect

1. Introduction
The lac insect *Kerria lacca* (Hemiptera: Kerriidae) is scale insect which occurs naturally as parasites on various host plants. The specific host trees of lac insects are palas (*Butea monosperma* Loun), ber (*Ziziphus mauritiana* Lam), kusum (*Schleichera oleosa* Loun), semialata (*Flemingia semialata* Roxb). It secretes lac, a layer of red resin on branches of host-trees on which it settles. Lac resin is a natural, biodegradable, non-toxic, and the only animal originates resin which is used as food, textiles industries and pharmaceutical industries. It is also used as surface coating, electrical component manufacturing, and other fields. The distribution range of lac is tropical and subtropical areas of south and south-east Asia. Lac culture is useful as resin, dye, wax and having tremendous export potential. In India, two species of lac strains namely *Rangeeni* and *Kusumi* are known to prevail dominantly. Of the two strains *i.e*., *Kusumi* and *Rangeeni* of lac insect, *Aghani* crop of *Kusmi* contribute the most with the contribution of 32 % followed by *Jethwi* (26 %) of *Kusmi* strain and *Baisakhi* (24 %) and *Katki* (18 %) of *Rangeeni* strain in total lac production [1]. It is a highly remunerative crop, paying high economic returns to the farmers and also foreign exchange to the country through its export. In spite of the wide distribution of the lac insect through the country on different hosts, lac production is limited in the country because of many biotic and abiotic factors; Among biotic factors are predators and parasitoids, while adverse climatic factors create abiotic stresses causing hinderance in lac production. Among the natural enemies *Eublemma amabilis* Moore (Lepidoptera; Noctuidae), *Psuedohypatopa pulverea* Meyr (Lepidoptera; Blastobesidae), *Chrysopa lacciperda* Kimmins and *Chrysopa madestes* Banks (Chrysopidae; Neuroptera) are the major predators of regular occurrence causing severe losses to lac production [2].Predators have been estimated to cause around 35 to 40 per cent loss of lac production [3, 4], and these are in regular occurrence but their incidence may vary from season to season, place to place and crop to crop. The first, second and third instar larvae of *Chrysopa madestes* can consume 20, 24 and 74 mature females of lac insect per day, respectively [5]. As many as 30 different species of parasites have been reported on lac insect [6]. Earlier studies indicated a parasitisation level of only 5-10 percent [7], but with changing times and climatic

scenario an increased patriotization level of about 20-37 percent has been reported [8], which have been notice d as one of the major limiting factors in complete failure of crop during last few years. *Rangeeni* crop is more vulnerable to pest attack and the damage is more in the rainy season crop which sometimes destroys the whole crop. In Rajasthan, lac insect has been noticed to prevail naturally on as many as in different hosts [9]. In spite of its high natural occurrence and wide availability of hosts, the lac cultivation is not in practice and yet not adopted by the farmers of the region. Among various factors, the lack of knowledge about practices of lac cultivation, the incidence and management of major predators of lac insect is one of important the factor responsible for the hindering lac production in the region.

2. Materials and Methods

2.1 Bio-efficacy of eco-friendly pesticides against major predators of lac insect, *Kerria lacca* (Kerr).

The field experiment was conducted to evaluate the bio-efficacy of eco-friendly pesticides against major predators of lac insect and their safety response for the lac insect on ber plants (*Ziziphus mauritiana* Lam) at lac gene bank, Department of Entomology, Rajasthan College of Agriculture, Udaipur during *Katki* season 2018. The experiment was conducted in Randomized Block Design with seven treatments replicated three times on the ber plants. The ber plants were pruned during March 2018 and were utilized for the study during *Katki* 2018. The ber plants were inoculated with locally collected brood lac after the appearance of new shoots of ber. The brood lac having fully mature female cells on the appearance of the yellow spot was tied on the ber plants in July 2018 for the emergence and settlement of lac insects. There were seven different treatments that were applied to evaluate the response of different botanicals and insecticides against the major predators of lac insect. The insecticidal sprays were applied at 45 days (time that coincides with the most critical stage of the predatory caterpillars) or 7-8 weeks after the inoculation of brood lac on the completion of male emergence. The first spray application was applied at 7 days after the completion of male emergence followed by a second application at 30 days after the first spray. The insecticidal application was applied on lac bearing twigs of the ber plants to cover the encrustation of lac insect. The treatment details are given in table 1. The observation on the efficacy of different treatments were recorded in terms of living/dead cells at harvest. The mature lac stick samples for each treatment in each replication were harvested and observed to count the numbers of mature live and dead cells per 4 square centimeters by placing the graph paper. The samples were collected from the upper, middle and lower portion of the treated plants for each treatment and kept in 60 mesh nylon cages for the emergence of predators. The numbers of living and dead larvae as well as adults of lac predators emerging from the caged samples (per meter lac stick) were counted, and the percentage reduction in the incidence of predators over control was worked out.

Table: 1 Treatment Detail

Sl. No.	Treatments	Dose or Concentration
1.	Neem Seed Kernel Extract (5%)	5.0 ml/lit
2.	Karanj Oil (2%)	2.0 ml/lit
3.	Neem Oil (2%)	2.0 ml/lit
4.	Spinosad 2.5% SC	2.0 ml/lit
5.	Emamectin benzoate 5% SG	0.4 gm/lit
6.	Cartap hydrochloride 50% SP	2 gm/lit
7.	Control (water only)	-

2.2 Statistical analysis

The data recorded for efficacy of different treatments were statistically analyzed using standard procedure for analysis of variance (ANOVA) of Randomized Block Design in order to test the significance of experiment. The survival percentage of lac insect was worked out using the formula given below.

$$\text{Survival percentage} = \frac{\text{No.of live cells/cm}^2}{\text{Total no.of cells/cm}^2} \text{x} 100$$

3. Results

3.1 Bio-efficacy of eco-friendly pesticides against major predators of lac insect, *Kerria lacca* (Kerr)

The bio-efficacy of different insecticides and botanical extracts was evaluated against major natural enemies of lac insect. The first spray was done at 45 days after brood lac inoculation and the subsequent spray was done at 30 days after first spray. The observation on the efficacy of the eco-friendly pesticide on major predators of lac insect was recorded by counting the number of individuals that emerged from the caged samples from each treatment, collected at harvest. All the treatments were significantly superior over control in reducing the population of the major predators of lac insect *viz., Eublemma amabilis* and *Pseudohypatopa pulverea.*

The results presented in table 2 revealed that the spray application of spinosad 2.5% EC @ 2.0 ml/litre of water proved to be most effective with maximum per cent reduction of the mean population of predators *i.e. E. amabilis* (84.85%) and *P. pulverea* (78.95) over control with the minimum mean population of 3.33 and 1.33 per meter lac stick. Emamectin benzoate 5% SG and @ 0.4 gm/lit, cartap hydrochloride 50% SP @ 2 gm/lit were recorded as the next effective treatments with 80.30, 73.68 and 74.24, 63.16 mean per cent reduction of *E. amabilis* and *P. pulverea* over control with 4.33, 1.67 and 5.67, 2.33 mean population per meter lac stick respectively.

The treatment of spinosad 2.5% EC and emamectin benzoate 5% SG were recorded significantly at par to each other. The treatment of neem oil 2% @ 2.0 ml/lit was recorded as the least effective against *E. amabilis* and *P. pulverea* with minimum 45.45 and 47.37 mean per cent reduction over the control with 12.00 and 3.33 mean population of predators respectively. Highest mean percentage population of *E. amabilis* and *P. pulverea* 22.00 and 6.33 were recorded in control.

3.2 Survival percentage of lac insect

The observation on the survival of lac insects to ascertain the safety of different treatments based on a number of living and dead cells 4 square centimeters at harvest of lac crop during 2018 are presented in Table 2. The treatment of spinosad 2.5% EC @ 2.0 ml/lit was recorded as the most effective treatment with the highest (78.57%) mean survival percentage of lac insect and hence proved to be the safest insecticide among all treatments. Treatments of emamectin benzoate 5% SG, cartap hydrochloride 50% SP were the next best treatments with respect to mean survival of lac insect, 75.00, 66.67 per cent respectively. The mean survival percentage of lac insect at harvest was 61.54, 58.33 and 53.85 per cent was recorded from the treatments of Neem Seed Kernel Extract 5%, Karanj oil 2% and Neem oil 2 %, respectively. Significantly, minimum (48.00%) mean survival percentage of lac insect was recorded from the control.

4. Discussion

The lac insect is a sluggish and soft-bodied insect hence it is a preferred host for natural enemies and attacked by numerous predators and parasitoids during the crop cycle. The Predator *Eublemma amabilis*, *Pseudohypatopa pulverea* and *Chrysopa sp.* are major predators and their attack starts after one month of brood lac inoculation whereas primary parasitoids belonging to family Encyrtidae, and Eulopidae are the major parasitoids of lac insect.

Seven treatments *viz.*, spinosad 2.5% EC @ 2.0 ml/lit, emamectin benzoate 5% SG @ 0.4 gm/lit, cartap hydrochloride 50% SP @ 2.0 gm/lit, karanj oil 2% @ 2.0 ml/lit, Neem Seed Kernel Extract 5% @ 5.0 ml/lit and neem oil 2% @ 2.0 ml/lit, were applied at one week after the completion of male emergence and was 30 days after the first application for the management of major predators associated with lac insect during of the present study during *Katki* season 2018. The treatment application of spinosad 2.5% EC @ 2.0 ml/lit effectively reduced the population of *E. amabilbis* and *P. pulverea* followed by emamectin benzoate 5 SG @ 0.4 gm/lit and cartap hydrochloride 50 SP @ 2.0 gm/lit and these both treatments were found at par with spinosad 2.5% EC. The findings of the present investigation are in full support with the results of [10]and [11] who have reported the higher efficacy of spinosad 2.5% SC against *E.amabilbis* and *P. pulverea* of lac insect. Similarly, [12] have also reported spinosad (0.005, 0.007 and 0.01%) as most promising with significant reduction cent per cent the population of *E. amabilbis* infesting of lac during rainy and summer crops. The present findings are in close agreement with the study of [13] who reported overall higher impact of emamectin benzoate @ 0.002 per cent management the population of lac predator, *E. amabilis.*

4.1 Survival percentage of lac insect

The data recorded on the survival of lac insect after the application of various treatments, to ascertain their safety responses against lac insect reveals that treatment of spinosad 2.5% EC was recorded as the most effective in terms of survival percentage of lac insect and hence proved to be the safest insecticide. Emamectin benzoate 5% SG and cartap hydrochloride 50% SP were recorded as the next effective treatments with respect to survival percentage of lac insect. However, the mean survival percentage of lac insect at harvest was recorded lower in Neem Seed Kernel Extract 5%, Karanj oil 2% and Neem oil 2% treatment, respectively. Significantly, the minimum mean survival percentage of lac insect was recorded from the control. The present results are in full agreement with the findings of [11] who recoded higher fecundity and superior quality brood lac was obtained from treated crops.

Table 2: Efficacy of insecticides on the population of major predators of *Rangeeni* rainy season lac crop during 2018.

Treatments	Doses/Conc.	*E. amabilbis*		*P. pulverea*		Survival of lac insect (%)
		Mean population at time of harvest	Reduction over control (%)	Mean population at time of harvest	Reduction over control (%)	
Neem Seed Kernel Extract (5%)	5.0 ml/lit	3.47*(11.67)	46.97	1.87(3.00)	52.63	58.33(49.81)**
Karanj oil (2%)	2.0 ml/lit	3.39(11.00)	50.00	1.76(2.67)	57.89	50.00(45.00)
Neem oil (2%)	20 ml/lit	3.53(12.00)	45.45	1.94(3.33)	47.37	53.85(47.21)
Spinosad 2.5 EC	2.0 ml/lit	1.95(3.33)	84.85	1.34(1.33)	78.95	75.00(60.02)
Emamectin benzoate 5 SG	0.4 gm/lit	2.20(4.33)	80.30	1.46(1.67)	73.68	66.67(54.75)
Cartap hydrochloride 50 SP	2 gm/lit	2.48(5.67)	74.24	1.68(2.33)	63.16	61.54(51.67)
Control (Water only)	-	4.74(22.00)	-	2.61(6.33)	-	78.57(62.44)
S. Em. ±		0.83	-	0.33		1.89
CD at 5%		2.51	-	0.99		5.68

*Square root √ (X + 0.5) transformations values and figures in parenthesis are retransformed values, ** figures in parenthesis are arc sine transformed % values.

5. Conclusion

The results reveal that two major Predators *viz.*, *E. amabilbis* and *P. pulverea* have been recorded as natural enemies of the lac insect. The results of bio-efficacy of insecticides and plant products on the population of major predator of *Rangeeni* lac insect during *Katki* season 2018 shows that all the treatments were superior over control. The results showed that among six treatments botanicals and insecticidal treatments proved superior in reducing the predator population. Taking the above facts into consideration the spray schedules were formulated for the effective management of these natural enemies as well as their safety responses towards lac insect.

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