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Bio-Efficacy of Different Insecticides against Soybean Leaf Folder, *Omiodes indicata* (Fabricius, 1775) (Lepidoptera: Crambidae)

Methuku Anil [a*], Shiddalingappa V Hugar [b] and Channakeshava R [c]

[a] *Department of Agricultural Entomology, College of Agriculture, Dharwad, University of Agricultural Sciences, Dharwad – 580005, Karnataka, India.*
[b] *AICRP on Groundnut, MARS, UAS Dharwad-580 005, Karnataka, India.*
[c] *AICRP on Soybean, MARS, UAS Dharwad-580 005, Karnataka, India.*

Authors' contributions

This work was carried out in collaboration among all authors. Author MA did methodology, conducted experiments, recorded observations, analyzed data, writing original draft. Author SVH Conceptualization, methodology, supervision of experiments, data curation, writing review and editing. Author CR Conceptualization, supervision of experiments, data curation, writing review and editing. All authors read and approved the final manuscript.

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ABSTRACT

A study was conducted at the Agricultural Research Station (UAS, Dharwad), Sankeshwar, Karnataka during *Kharif* 2022-23 to assess the effectiveness of different insecticides against soybean leaf folder, *Omiodes indicata*. Among five treatments, lambda cyhalothrin 4.6 % + chlorantraniliprole 9.3 % ZC @ 0.4 ml l^{-1} exhibited the lowest mean population of soybean leaf

**Corresponding author: E-mail: anilmethuku70320@gmail.com;*

folder, *Omiodes indicata* on 5th and 10th day after spray with 2.12 and 0.98 larval population per meter row length, respectively which was followed by emamectin benzoate 5 % SG @ 0.3 g l^{-1} (3.03 and 1.83 larvae per meter row length). Lambda cyhalothrin 4.6 % + chlorantraniliprole 9.3 % ZC was found to be the best effective treatment with 81.97 % reduction over control followed by emamectin benzoate 5 SG (71.61 %). Similar results were obtained with per cent defoliation.

Keywords: Insecticides; legume; leaf folder; soybean.

1. INTRODUCTION

Soybean, scientifically known as *Glycine max* (L. Merrill) (Fabaceae) has been recognized as a remarkable crop and given various titles such as wonder crop and golden bean in the 20th century [1]. Soybean seeds contain over 40 % protein and 20 % oil with 6.4 % lysine, 19.5 % fat and 20.9 % carbohydrates [2,3]. As it's having several nutrition values mentioned above, soyabean also contributes about 25 % global edible oil and 2/3rd of world's protein concentrates for livestock feeding, poultry, fish feed and soybean meal as human diet supplements for protein [4]. Soy products of wide varieties have been prepared such as roasted soybean, boiled soybean, soymilk, soy mayonnaise, miso, soy cheese, soy yogurt, tempeh, soy sauce, tamari, Textured Vegetable Protein (TVP), or Textured Soy Protein (TSP) and tofu [5,6]. In addition to the above, its oil is used in preparation of varnishes, paints, lubricants, antibiotics, adhesives *etc*. It is also abundant in mineral salts and essential amino acids, making it a promising crop for combating acute malnutrition [7].

Soybean is a significant oilseed crop in the rainfed agroecosystems of central and peninsular India. It is cultivated over a vast area of 132.26 million ha in the world. Total production is around 385.52 million ton and average productivity is about 2.88 metric ton ha^{-1}. India is the fifth-largest producing country of soybean behind China, United States, Argentina and Brazil. In India, soybean is grown on 11.44 million ha of land, yielding a total of 12.03 million ton with an average productivity of 1051 kg ha^{-1}. The prominent states in India for soybean production are Madhya Pradesh, Maharashtra, Rajasthan, Andhra Pradesh, Karnataka and Gujarat. In Karnataka, soybean is cultivated on 0.43 million ha of land, resulting in an output of 0.44 million ton and a productivity rate of 1005 kg ha^{-1} [8].

Globally, there are more than 380 species of insect pests affecting the soybean crop. In India, the number of species increased from 12 in the 1970's to 270 species, including mites, millipedes, vertebrates and snails. In Karnataka alone, 65 insect species have been found to infest soybean from its early stages to harvest [9]. Among them soybean leaf webber, *Omiodes indicata* (Fab.) (Lepidoptera: Crambidae) is an emerging pest on leguminous plants, commonly known as bean leaf webworm moth, soybean leaf folder or roller, lablab leaf webber and soybean webworm [10].

Leaf webbers, including *O. indicata*, are major insect pests in both tropical and temperate regions of the world [11]. *O. indicata* is distributed across various regions, *viz*., Africa, India, China, Japan, Hong Kong and New Guinea. It causes direct damage to the crops and it may occasionally become a serious pest on soybean, black gram, green gram, cowpea and it has been recently recorded in various regions of China and India but there is a lack of quantitative data regarding the impact of this pest on crops in these areas. The young leaves are spun together and larger leaves are rolled, starting from the tip. The larvae of *O. indicata* feed inside these rolled-up leaves. Under severe infestations, the final-instar larvae can completely skeletonize the leaves [12]. Recently, there has been a significant increase in the infestation of soybean leaf folder, causing concern to soybean farmers. With the view to manage this pest, a research study was conducted to assess the effectiveness of different insecticides in managing the soybean leaf folder.

2. MATERIALS AND METHODS

The experiment was conducted at Agricultural Research Station located at Sankeshwar, Dharwad. (16.14N, 74.30E and 698 m asl) during *Kharif* from June to October (2022). Field experiment followed a Randomized Block Design with three replications and five treatments. Plot area of 23.4 m^2 (6 × 3.9 m) and spacing of 30×10 cm was followed. The objective of the present study was to assess effectiveness of different insecticides against soybean leaf folder. The treatment includes emamectin benzoate 5 % SG

@ 0.3 g l^{-1}, quinalphos 20 % EC @ 2 ml l^{-1}, lambda cyhalothrin 5 % EC @ 0.5 ml l^{-1}, lambda cyhalothrin 4.6 % + Chlorantraniliprole 9.3 % ZC @ 0.4 ml $l^{-1}$and an untreated control.

Periodical observations were conducted to monitor the occurrence of soybean leaf folder meter row length^{-1} (mrl) and % defoliation. Treatments were imposed when the pests crossed Economic Threshold Level (ETL). Observations were recorded 24 hours before spray (pre-treatment) and on 5th and 10th days after spray (post-treatment). % leaf damage was calculated by following the mentioned formula [13],

Per cent leaf damage = Number of damaged leaves per plant/Total no. of leaves per plant ×100

% leaf damage data was transformed to arcsine values for reliable analysis and the mean larval data recorded during the field trial was transformed to √X + 0.5 values for statistical analyses and subjected to Duncan's Multiple Range Test [14]. % reduction in treatments over control plots was estimated by using the formula [15],

Population reduction over control (%) = Population in untreated check - Population in treatment / Population in untreated check × 100

3. RESULTS AND DISCUSSION

3.1 Efficacy of Different Insecticides Against Soybean Leaf Folder

At one day before spray, there was no significant difference between the treatments regarding the mean population of leaf folder larvae and the mean population ranged from 5.21 to 6.02 larvae mrl^{-1}. But there was a substantial difference between the treatments on five days after the spray. The mean population of leaf folder larvae after 5th day of spray varied from 2.12 to 8.23 larvae mrl^{-1}. Out of different treatments imposed, the treatment lambda cyhalothrin 4.6 % + chlorantraniliprole 9.3 % ZC recorded the least population of 2.12 larvae mrl^{-1} which was followed by emamectin benzoate 5 % SG (3.03 larvae mrl^{-1}). Quinalphos 20 % EC (4.01 larvae mrl^{-1}) was at par with lambda cyhalothrin 5 % EC (4.46 larvae mrl^{-1}).

A similar trend was noticed on the 10th day after spray. The data (Table 1) showed that the mean population varied from 0.98 to 8.96 larvae mrl^{-1}. Out of different treatments imposed, the treatment lambda cyhalothrin 4.6 % + chlorantraniliprole 9.3 % ZC recorded the least mean population of 0.98 larvae mrl^{-1} which was followed by emamectin benzoate 5 % SG (1.85 larvae mrl^{-1}). Quinalphos 20 % EC (2.69 larvae mrl^{-1}) and lambda cyhalothrin 5 % EC (2.93 larvae mrl^{-1}) at par with each other.

Among different treatments imposed lambda cyhalothrin 4.6 % + chlorantraniliprole 9.3 % ZC was recorded superior to other treatments with 81.97 % reduction over control followed by emamectin benzoate 5 % SG (71.61 %). Quinalphos 20 % EC (61.02 %) was comparable with lambda cyhalothrin 5 % EC (57.01 %) over control. This result is in accordance with the earlier findings of Divya et al. [16] revealed that lambda cyhalothrin 4.6 % + chlorantraniliprole 9.3 % ZC was effective treatment against *Antigastra catalaunalis* in sesamum by recording the lowest larval population (1.30 plant^{-1}) and lowest capsule damage (1.25 %) compared to all other treatments. Similarly, Swathi et al. [17] reported that lambda cyhalothrin 4.6 % + chlorantraniliprole 9.3 % ZC @ 0.5 ml l^{-1} was found to be very effective by recording 75.91 % overall mean reduction in *Maruca vitrata* larval population with lowest pod damage (7.04 %) over control (60.58 %) and also recorded highest grain yield (8.31 q ha^{-1}) followed by chlorantraniliprole 18.5 % SC at 0.0037 % and flubendiamide 39.35 % SC at 0.00787 % with 72.04 and 67.30 % overall reduction in mean larval population, respectively over untreated control in black gram. Similarly, Jakhar et al. [18] reported that two sprays of chlorantraniliprole 18.5 % SC @ 0.15 ml l^{-1} gave maximum control of *Maruca vitrata* (3.33 %) in pigeon pea with maximum grain yield (1817 kg ha^{-1}) followed by indoxacarb 15.8 EC @ 0.5 ml l^{-1} (pod borers damage of 3.83 % and grain yield 1758 kg ha^{-1}).

3.2 Effect of Different Insecticides on % Defoliation in Soybean

The mean % defoliation recorded on 5th day after spray varied from 13.78 to 35.23 %. Out of different treatments imposed, the treatment lambda cyhalothrin 4.6 + chlorantraniliprole 9.3 ZC recorded the least % defoliation with13.78 % which was followed by emamectin benzoate 5 % SG (16.05). Quinalphos 20 % EC (18.37 %) and lambda cyhalothrin 5 % EC (19.39 %) were at par with each other.

Table 1. Efficacy of different insecticides against soybean leaf folder (*Omiodes indicata*)

Tr. No.	Treatments	Number of larvae mrl^{-1}				
		1 DBS	**5 DAS**	**10 DAS**	**Mean**	**ROC (%)**
T_1	Emamectin benzoate 5 % SG @ 0.3 g l^{-1}	5.33 (2.31)	3.03 (1.74)^b	1.85 (1.36)^b	2.44 (1.56)^b	71.61
T_2	Quinalphos 20 % EC @ 2 ml l^{-1}	5.82 (2.41)	4.01 (2.00)^c	2.69 (1.64)^c	3.35 (1.83)^c	61.02
T_3	Lambda cyhalothrin 5 % EC @ 0.5 ml l^{-1}	5.96 (2.42)	4.46 (2.11)^c	2.93 (1.71)^c	3.70 (1.92)^c	57.01
T_4	Lambda cyhalothrin 4.6 % + Chlorantraniliprole 9.3 % ZC @ 0.4 ml l^{-1}	5.98 (2.44)	2.12 (1.46)^a	0.98 (0.99)^a	1.55 (1.24)^a	81.97
T_5	Control	6.02 (2.45)	8.23 (2.87)^d	8.96 (2.99)^d	8.60 (2.92)^d	-
	S.Em ±	NS	0.05	0.06	0.06	-
	C.D. (p = 0.05)		0.15	0.17	0.16	-
	C.V. (%)	9.98	8.99	9.56	8.32	-

Note: - Figures in parentheses are √x + 0.5 transformed values; Means in the columns followed by the same alphabet do not differ significantly by DMRT (p =0.05); DBS-Day before spray; DAS-Days after spray; ROC-Reduction over control; mrl- meter row length.

Table 2. Effect of different insecticides on % defoliation in soybean

Tr. No.	Treatments	Defoliation (%)				
		1 DBS	**5 DAS**	**10 DAS**	**Mean**	**ROC (%)**
T_1	Emamectin benzoate 5 % SG @ 0.3 g l^{-1}	30.03 (33.23)*	16.05 (23.62)^b	8.01 (16.44)^b	12.03 (20.29)^b	67.57
T_2	Quinalphos 20 % EC @ 2 ml l^{-1}	30.01 (33.21)	18.37 (25.38)^c	10.82 (19.20)^c	14.60 (22.46)^c	60.66
T_3	Lambda cyhalothrin 5 % EC @ 0.5 ml l^{-1}	30.56 (33.55)	19.39 (26.12)^c	11.78 (20.07)^c	15.59 (23.25)^c	57.99
T_4	Lambda cyhalothrin 4.6 % + Chlorantraniliprole 9.3 % ZC @ 0.4 ml l^{-1}	30.06 (33.24)	13.78 (21.79)^a	6.21 (14.43)^a	10.00 (18.43)^a	73.06
T_5	Control	30.59 (33.58)	35.23 (36.41)^d	38.97 (38.63)^d	37.10 (37.52)^d	-
	S.Em ±	NS	0.31	0.53	0.32	-
	C.D. (p = 0.05)		0.88	1.49	0.92	-
	C.V. (%)	8.89	7.74	8.24	8.09	-

*Note: *- Figures in parentheses are arc sine transformed values; Means followed by the same alphabet in a column indicates do not differ significantly by DMRT (p = 0.05), DBS-Day before spray; DAS-Days after spray; NS- Non significant; ROC- Reduction over control*

A similar trend was noticed on the 10th day after spray. The data (Table 2) showed that the mean population varied from 6.21 to 38.97. Among different treatments imposed, the treatment lambda cyhalothrin 4.6 + chlorantraniliprole 9.3 ZC recorded the least % defoliation of 6.21 % which was followed by emamectin benzoate 5 % SG (8.01 %). Quinalphos 20 % EC (10.82 %) and lambda cyhalothrin 5 % EC (11.78 %) were at par with each other.

Out of different treatments imposed lambda cyhalothrin 4.6 % + chlorantraniliprole 9.3 % ZC was recorded superior to other treatments with 73.06 % reduction of % defoliation over control followed by emamectin benzoate 5 % SG (67.57 %). Quinalphos 20 % EC (60.66 %) was comparable with lambda cyhalothrin 5 % EC (57.99 %) over control.

The results of the present investigation are supported by Reddy et al. [19] who reported that the Lambda cyhalothrin 4.6 % + chlorantraniliprole 9.3 % ZC @ 30 g a.i ha^{-1}, thiamethoxam 12.6 % + lambda cyhalothrin 9.5 % ZC @ 27.5 g a.i ha^{-1} and chlorantraniliprole 8.8 % + thiamethoxam 17.5 % SC @ 150 g a.i ha^{-1} were found superior in the management of *Maruca vitrata* and *Spodoptera litura* over other treatments in cowpea. Similarly, Tupe et al. [20] revealed that Lambda cyhalothrin 9.5% ZC + Chlorantraniliprole 9.30% recorded lowest shoot infestation (1.20 %) by brinjal shoot and fruit borer. This was at par with Chlorantraniliprole 18.5 SC recorded (1.33 %) and spinetoram 11.7 % SC (1.51 %). Study conducted by Kousika et al. [21] reported that chlorantraniliprole 4.3 % + abamectin 1.7 % SC @ 60 g a.i. ha^{-1} was found superior in managing *Spodoptera litura* over other treatments. However, many works have been conducted with single insecticides *viz*., chlorantraniliprole, flubendiamide *etc*. Chlorantraniliprole @ 0.006% was the effective treatment against *S.litura* in different crops *viz*., chilli Hosamani et al. [22] and groundnut Kumar et al. [23]. Similarly, evaluation of insecticides against *S.litura* under polyhouse condition in capsicum showed that chlorantraniliprole 18.5 % SC @ 0.1 ml l^{-1} was highly potent insecticide in controlling larval population and fruit damage Maruthi et al. [24]. Study conducted in Kerala revealed that chlorantraniliprole @ 30 g a.i ha^{-1} and flubendiamide @ 48 g a.i ha^{-1} were effective in controlling resistant population of *S. litura* Sreelakhsmi et al. [25].

4. CONCLUSION

The combi product lambda cyhalothrin 4.6 % + chlorantraniliprole 9.3 % ZC was found effective in managing soybean leaf folder larval population and % infestation potentially due to their complementary mode of action or synergistic effect.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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