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Residual Toxicity of Newer Insecticide Molecules against Shoot and Fruit Borer of Okra

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Authors' contributions

This work was carried out in collaboration among all authors. Authors SAD and VKK designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors SS and MD managed the analyses of the study. Author PM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Seven new molecule insecticides viz., Deltamethrin, Lambda-cyhalothrin, Emamectin benzoate, Indoxacarb, Bifenthrin, Rynaxypr and Flubendiamide were bio-assayed against okra shoot and fruit borer (*Earias vittella)* to study the residual toxicity on Okra at College of Agriculture, Raipur during the Rabi applied season(2014-15 and 2015-16)**.** On the basis of average LT_{50} values, the order of toxicity was Emamectin Benzoate > Indoxacarb > Lambda-Cyhalothrin > Rynaxypr > Flubendiamide > Deltamethrin > Bifenthrin against okra shoot and fruit borer**.**

Keywords: Okra; shoot and fruit borer (Earias vittella); new molecules insecticides; LC_{50}; LT_{50}; residual toxicity.

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1. INTRODUCTION

Okra (*Abelmoschus esculentus*) is popularly known as bhindi, lady's finger. It is the only vegetable crop of significance in the Malvaceae family and is very popular in the Indo-Pak subcontinent [1]. In India, it ranks number one in its consumption but its native rangeis Ethiopia and Sudan, and North-eastern African countries. The crop has multiple purposes including medicinal use. It is used in the treatment of catarrhal infections, dysuria and gonorrhea [2]. (Okra) is an important medicinal plant of tropical and subtropical India. Its medicinal usage has been reported in the traditional systems of medicine such as Ayurveda, Siddha and Unani. (Sathish Kumar et al.*,* 2013). Okra dry seed contains edible oil (13-22%) and protein (20-24%). The oil is used in soap, cosmetic industry and as vanaspati while protein is used for fortified feed preparations. High iodine content of fruits is used to control goitre while leaves are used in inflammation and dysentery [3].

India ranks first in the world with an area of 4, 52,500 ha with a production of 48, 03,300 mt of okra fruits with a productivity of 10.6 mt. /ha. In Chhattisgarh, the crop is grown in an area of 25,233 ha with production of 2, 49048 mt. of okra fruits and productivity is 9.86 t /ha [2]. The Chhattisgarh state is contributing approximately 4% of the total production of okra in the country. It produces approximately 0.25 million mt. of okra from an area of 0.03 million ha with productivity of 9.9 mt./ha. The major okra producing belts in the state are Raipur, Durg and Rajnandgaon [4]. To mitigate the losses inflicted by these sucking pests, a huge quantity of pesticides is used in okra lands and it is not unusual for the vegetable growers to give 10-12 sprays in okra in a season and thus the fruits harvested at short intervals are likely to retain unavoidable high level of pesticide residues which may be highly hazardous to consumers. Further, the excessive reliance on chemicals has led to the problem of resistance, resurgence, creation of environmental pollution and decimation of useful fauna & flora.

There are several constraints in the cultivation of okra and coincidentally, many of the pests affecting cotton production also affectokra crop production. As high as, 72 species of insects have been recorded on okra [5], of which, the sucking pests including Aphids, *Aphis gossypii* (Glover); leafhopper, *Amrascabiguttulabiguttula*(Ishida); whitefly, *Bemisia tabaci* (Gennadius); shoot and fruit borer, *Earias vittella* and mite *Tetranychus cinnabarinus* (Boisduval) causes significant damage to the crop.

2. MATERIALS AND METHODS

2.1 Field Trial

Field study was carried out in the experimental field of Department of Horticulture, College of Agriculture, Indira Gandhi Krishi Vishwavidyalaya (IGKV), Raipur, Chhattisgarh (C.G.) during kharif 2014-15. The research field located in the south eastern part of Chattisgarh and lies at 21- 16^{o}N latitude and 81.36^{o}E longitude with an altitude of 298 meters above sea level. The experiment was laid out in a randomized block design (RBD) with three replications. The plot size was 4.0m x 3.0m each with 0.5-meter pathway between plots. Before spraying, okra fruits in all plots/replicates were tagged and sprayed with recommended doses of insecticides and spark at 1L/ha to runoff stage.

The residual toxicity of newer molecules on okra were worked out by taking 3rd instar larvae (laboratory reared) of shoot and fruit borer at the department of Entomology, Indira Gandhi Krishi Vishvavidyalaya, Raipur during 2014-15 and 2015-16. The methodology for assessment of residual toxicity were followed as described by Shukla and Kumar, [6]. Okra fruits from every plot of experimental field were brought in the laboratory after 0 (2 hours after spray), 1st, 3rd, 5th, 7th, 10th and 14th days of treatment and were kept in three replications in Petri dishes of 15 cm diameter. In each Petri dish, ten larvae of 3rd instar larvae of shoot and fruit borer were released under feeding for 24 hours and then transferred on untreated fruits of okra. A parallel control was also run by providing untreated leaves to the larvae. The mortality counts were undertaken at 48 hours after treatment. Moribund larvae were also be considered as dead.

2.2 Test Insecticides

Commercial formulations of insecticides viz., Deltamethrin, Lambda-cyhalothrin, Emamectin benzoate, Indoxacarb, Bifenthrin, Rynaxypr and Flubendiamide were used. Full cover application of these insecticide was done to the entire plants. The required numbers of fruits receiving application of insecticides were tagged.

2.3 Collection and Rearing of Test Insect

Fruits and shoots infested by okra shoot and fruit borer (*Earias vittella*) were collected from field. The larvae were segregated and reared on healthy and untreated fruits of okra till pupation. The pupae were collected in Petri dishes and placed inside perforated aluminium cages (15 x 15 x 15 cm). The emerged moths were transferred to clean circular glass jars (20 x 15 cm) for pairing, covered with black muslin cloth and secured tightly with rubber band. The adults were supplied with the pieces of folded paper (black/purple) and cotton swabs dipped into 10 per cent honey solution were kept in Petri dish placed at the bottom of the jars for feeding the moths. Eggs were laid on the black muslin cloth as well on the folded pieces of paper. The jars were examined daily for the hatching of eggs. On hatching, neonate larvae were transferred to fresh okra fruits with the help of fine camel hairbrush and fruits were placed in the glass jars provided with filter paper at the bottom. The okra fruits were changed at periodic intervals to avoid fungal growth. The pupae formed on the filter paper were removed and placed separately in aluminium cages. The emergence of adults was examined daily to ensure continuous supply of eggs and thereafter neonates for testing. Culture was maintained in B.O.D. incubator maintained at 26±1°C temperature and 70±5% relative humidity.

2.4 Bioassay

The residual toxicity of different insecticides was studied at 0 (2 hours after spray), 1st, 3rd, 5th, 7th, 10th and 14th days after application of insecticides. Fruits from the sprayed and unsprayed plots were brought to the laboratory in polythene bags. Laboratory reared ten neonate larvae of *Earias vittella* were released on the treated fruits kept in sample containers (7.4 cm × 4.0 cm). Each treatment was replicated thrice. Treatments were kept in incubator at 26±1°C temperature and 70±5% humidity for the treatment observations. The mortality of larvae was recorded after 24 hours of treatment. The observations on mortality of test insects were converted into percentage mortality. The average percentage mortality was calculated from the observations in three replications.

2.5 Statistical Analysis

The mortality data obtained in the present studies were subjected to angular transformation and were statistically analysed using POLO-PC® software.

2.6 LT_{50} and LC_{50} Values

Per cent mortality observation for each day samplings were corrected by using Abbott`s formula [7]. Received data was subjected to probit analysis for determination of LC_{50} values [8]. The residual toxicity was calculated by comparing with untreated control as standard check.

3. RESULTS AND DISCUSSION

3.1 Insecticide Resistance Monitoring for the Evaluation of Lc_{50} against Shoot and Fruit Borer 2014-15

In the present investigation, all the target populations collected from field locations were exposed to different doses of insecticides. The doses of various concentrations of corresponding insecticides were prepared in ppm by the dilutions in tap water. The corresponding LC_{50} values and limit range of insecticides were calculated with the help of POLO-PC® software as shown in Table 1.

The lowest LC_{50} values against shoot and fruit borer were recorded for Deltamethrin (0.427 mg/kg), Lambda-cyhalothrin (2.500 mg/kg), Emamectin benzoate (2.756 mg/kg), Indoxacarb (6.340 mg/kg), Bifenthrin (7.545 mg/kg), Rynaxypr (18.389 mg/kg) and Flubendiamide (81.423 mg/kg) with the limit range of 0.268 to 0.568, 2.177 to 2.746, 2.444 to 2.978, 4.559 to 7.749, 26.977 to 8.207, 8.773 to 27.280 and78.092 to 84.346 ppm, respectively.

3.2 Insecticide Resistance Monitoring for the Evaluation of Lt_{50} against Shoot and Fruit Borer 2014-15

Under the study seven insecticides were assayed in the laboratory for assessment of residual toxicity (LT_{50} values) against 3rd instar larvae of shoot and fruit borer on okra. Results on residual toxicity of insecticides were evaluated from 0 days (2 hrs) to 14 days after treatment at different intervals against 3rd instar larvae of *Earias vittella* (Table 2).

It was observed that after two hours of spray, all the insecticides showed 100% mortality in the larvae of shoot and fruit borer.

Table 1. LC_{50} values of different insecticides against Shoot and fruit borer population 2014-15

Sl.No	Treatments	Dose (g or ml/ha)	LC_{50} (mg/kg)	Limit range (ppm)
1.	Rynaxypr 20SC	30	18.389 ppm	8.773 to 27.280
2.	Emamectin benzoate 5SG	12	2.756 ppm	2.444 to 2.978
3.	Flubendiamide 48SC	55	81.423 ppm	78.092 to 83.346
4.	Indoxacarb 14.5SC	50	6.34035 ppm	4.559 to 7.749
5.	Bifenthrin 10EC	25	7.545 ppm	6.977 to 8.207
6.	Deltamethrin 2.8EC	15	0.427 ppm	6.977 to 8.207
7.	Lambda- cyhalothrin 5EC	15	0.427 ppm	0.268 to 0.568

Emamectin benzoate 5SG @ 12g *a.i.*/ha (T_2) was the best insecticide among all the treatments with highest mortality of shoot and fruit borer population (100%) at twenty-four hours of spray andat par with Indoxacarb 14.5SC @ 50g *a.i.*/ha (T_4) (98%). Similarly, the next effective treatment was Lambda-cyhalothrin 5EC @ 15g *a.i.*/ha (T_7) (95%) on par with Chlorantraniliprole 20SC @ 30 g *a.i.*/ha (T_1) (92%), Flubendiamide 4SC @ 55 g *a.i.*/ha (T_3) (87%) and Deltamethrin 2.8EC @ 15 g *a.i.*/ha (T_6) (84%) were on par with each other. However, Bifenthrin 10EC @ 25 g *a.i.*/ha (T_5) (78%) showed the lowest mortality among all the treatments.

Emamectin benzoate 5SG @ 12 g *a.i.*/ha (T_2) was the best insecticide among all the treatments with highest mortality of shoot and fruit borer population (93%) at seventy-two hours after spray and on par with Indoxacarb 14.5SC @ 50 g *a.i.*/ha (T_4) (84%). The next effective treatments were Lambda-cyhalothrin 5EC @ 15 g *a.i.*/ha (T_7) (76%) followed by Rynaxypyr 20SC @ 30 g *a.i.*/ha (T_1) (70%), and Deltamethrin 2.8EC @ 15 g *a.i.*/ha (T_6) (68%). However, Bifenthrin 10EC @ 25 g *a.i.*/ha (T_5) (63%) was least effective treatment amongst all the treatments.

Similarly, Emamectin benzoate 5SG @ 12 g *a.i.*/ha (T_2) was also the best insecticide among all the treatments with highest mortality of shoot and fruit borer population (82%) after one hundred twenty hours of spray. It was comparable with Indoxacarb 14.5SC @ 50 g *a.i.*/ha (T_4) (72%). Lambda-cyhalothrin 5EC @ 15 g *a.i.*/ha (T_7) (66%) was the next effective treatment, on par with Rynaxypyr 20SC @ 30 g *a.i.*/ha (T_1) (53%) followed by Flubendiamide 4SC @ 55 g *a.i.*/ha (T_3) (47%) and Deltamethrin 2.8EC @ 15 g *a.i.*/ha (T_6) (43%), respectively. However, Bifenthrin 10EC @ 25 g *a.i.*/ha (T_5) (42%) again showed the lowest mortality among all the treatments.

Emamectin benzoate 5SG @ 12 g *a.i.*/ha (T_2) again was the best insecticide among all the treatments with highest mortality of shoot and fruit borerpopulation (72%) after one hundred sixty-eight hours of spray. The Indoxacarb 14.5SC @ 50 g *a.i.*/ha (T_4) (52%) was the next effective treatment, on par with Lambda-cyhalothrin 5EC @ 15 g a.i./ha (T_7) (42%), Rynaxypyr 20SC @ 30 g *a.i.*/ha (T_1) (36%), Flubendiamide 4SC @ 55 g *a.i.*/ha (T_3) (34%) and Deltamethrin 2.8EC @ 15 g *a.i.*/ha (T_6) (26%), respectively. Bifenthrin 10EC @ 25 g *a.i.*/ha (T_5) (22%) again showed the lowest mortality among all the treatments.

At the two hundred forty hours of spray, Emamectin benzoate 5SG @ 12g *a.i.*/ha (T_2) was the best insecticide among all the treatments with highest mortality of shoot and fruit borer population (42%). It was statistical no difference with Indoxacarb 14.5SC @ 50 g *a.i.*/ha (T_4) (38%) and Rynaxypyr 20SC @ 30 g *a.i.*/ha (T_1) (28%). The next effective treatment was Lambda-cyhalothrin 5EC @ 15g *a.i.*/ha (T_7) (25%) followed by Flubendiamide 4SC @ 55g *a.i.*/ha (T_3) (24%) and Deltamethrin 2.8EC @ 15g *a.i.*/ha (T_6) (18%), respectively. With the lowest mortality in Bifenthrin 10EC @ 25g *a.i.*/ha (T_5) (16%) among all the treatments.

Under the three hundred thirty-six hours after spray, Emamectin benzoate 5SG @ 12g *a.i.*/ha (T_2) was continuously the best insecticide among all the treatments with highest mortality of shoot and fruit borer population (26%). It was on par with Indoxacarb 14.5SC @ 50g *a.i.*/ha (T_4) (22%) and Lambda-cyhalothrin 5EC @ 15g *a.i.*/ha (T_7) (16%). The next effective treatment was Deltamethrin 2.8EC @ 15g *a.i.*/ha (T_6) (14%) followed by Rynaxypyr 20SC @ 30g *a.i.*/ha (T_1) (12%) and Flubendiamide 4SC @ 55g *a.i.*/ha (T_3) (10%), respectively. Bifenthrin 10EC @ 25g *a.i.*/ha (T_5) (6%) continuously showed the lowest mortality among all the treatments.

The current findings are in confirmation with Patil and Pokharkar [9] findings on the evaluation spray residues of 7 (seven) commonly used insecticides on potted okra (bhendi) plants onadults of shoot and fruit borer, *Earias vittella.* Mortality of *E.vittella* after 48 h of caging showed that endrin @ 0.04% was the most toxic compound after 1 day (giving 86.66% mortality) and with the endrin at 0.04% and Heliotox (a mixture of DDT and toxaphene) @ 0.20% were the most toxic compounds after 5 days (both giving 28.51% mortality). No mortality was recorded when adults were exposed to 10-day old residues of the compounds.

Shinde and Shetgar [10] reported residual toxicity of insecticides against *Earias vittella* on okra and order of residual efficacy on the basis of LT_{50} values, as cypermethrin 0.01% >spinosad 0.005%.

3.3 Insecticide Resistance Monitoring for the Estimation of Lc_{50} against Shoot and Fruit Borer 2015-16

In the present investigation, all the target populations collected from field locations were exposed to different doses of insecticides. The doses of various concentrations of corresponding insecticides were prepared in ppm by the dilutions in tap water. The corresponding LC_{50} values and limit range of insecticides were calculated with the help of POLO-PC® software as shown in (Table 3).

The lowest LC_{50} values against shoot and fruit borer recorded for Deltamethrin (0.422 mg/kg), Lambda-cyhalothrin (2.559 mg/kg), Emamectin benzoate (2.783 mg/kg) Indoxacarb (6.930 mg/kg), Bifenthrin (7.400 mg/kg), Chlorantraniliprole (19.740 mg/kg) and Flubendiamide (81.049 mg/kg) with the limit range of 0.212 to 0.604, 1.990 to 2.934, 2.399 to 3.043, 5.389 to 8.535, 6.863 to 7.992, 6.627 to 31.900 and 78.285 to 83.496 ppm, respectively.

3.4 Insecticide Resistance Monitoring for the Evaluation of LT_{50} against Shoot and Fruit Borer 2015-16

Under the study, seven insecticides were assayed in the laboratory for assessment of residual toxicity (LT_{50} values) against 3[rd] instar larvae of shoot and fruit borer on okra. Results on residual toxicity of insecticides were evaluated from 0 days (2 hrs) to 14 days after treatment at 7 (seven) intervals against 3[rd] instar larvae of *E. vittella* (Table 4).

It was observed that after two hours of spray, all the insecticides showed 100% mortality in the larvae of shoot and fruit borer.

Emamectin benzoate 5SG @ 12g *a.i.*/ha (T_2) was the best insecticide among all the treatments with highest mortality of shoot and fruit borer population (96%) at twenty-four hours of spray andon par with Indoxacarb 14.5SC @ 50g *a.i.*/ha (T_4) (92%) and Lambda-cyhalothrin 5EC @ 15g *a.i.*/ha (T_7) (84%). Similarly, the next effective treatment was Rynaxypyr 20SC @ 30g *a.i.*/ha (T_1) (78%), on par with Deltamethrin 2.8EC @ 15g *a.i.*/ha (T_6) (73%) and Flubendiamide 4SC @ 55g *a.i.*/ha (T_3) (65%), respectively. However, Bifenthrin 10EC @ 25g *a.i.*/ha (T_5) (62%) showed the lowest mortality among all the treatments.

Emamectin benzoate 5SG @ 12g *a.i.*/ha (T_2) was also the best insecticide among all the treatments with highest mortality of shoot and fruit borer population (84%) at seventy-two hours of spray, on par with Indoxacarb 14.5SC @ 50g *a.i.*/ha (T_4) (76%) and Lambda-cyhalothrin 5EC @ 15g *a.i.*/ha (T_7) (67%). The next effective treatments were Rynaxypyr 20SC @ 30g *a.i.*/ha (T_1) (62%), on par with Deltamethrin 2.8EC @ 15g *a.i.*/ha (T_6) (54%) and Flubendiamide 4SC @ 55g *a.i.*/ha (T_3) (47%), respectively. However, Bifenthrin 10EC @ 25g *a.i.*/ha (T_5) (38%) was least effective treatment showed the lowest mortality among all the treatments.

Similarly, Emamectin benzoate 5SG @ 12g *a.i.*/ha (T_2) was also the best insecticide among all the treatments with highest mortality of shoot and fruit borer population (76%) after one hundred twenty hours of spray. It was comparable with Indoxacarb 14.5SC @ 50g *a.i.*/ha (T_4) (63%). Lambda-cyhalothrin 5EC @ 15g *a.i.*/ha (T_7) (56%) was the next effective treatment, on par with Rynaxypyr 20SC @ 30g *a.i.*/ha (T_1) (52%) followed by Deltamethrin 2.8EC @ 15g *a.i.*/ha (T_6) (44%) and Flubendiamide 4SC @ 55g *a.i.*/ha (T_3) (41%), respectively. However, Bifenthrin 10EC @ 25g *a.i.*/ha (T_5) (32%) again showed the lowest mortality among all the treatments.

Table 2. LT_{50} values of different insecticides against shoot and fruit borer population during 2014-15

S.No		Percent mortality at various hours							Overall mean
		2	**24**	**72**	**120**	**168**	**240**	**336**	
		Treatments/ Hours							
1.	Rynaxypr 20SC	100 (90.00)	92 (73.57)	70 (56.78)	53 (46.71)	36 (36.86)	28 (31.49)	12 (20.26)	55.85 (48.35)
2.	Emamectin benzoate 5SG	100 (90.00)	100 (90.00)	93 (74.65)	82 (64.89)	72 (58.05)	42 (40.39)	26 (30.65)	73.57 (59.06)
3.	Flubendiamide 48SC	100 (90.00)	87 (68.86)	65 (53.72)	47 (43.28)	34 (35.66)	24 (29.33)	10 (18.43)	54.42 (47.53)
4.	Indoxacarb 14.5SC	100 (90.00)	98 (81.86)	84 (66.42)	72 (58.05)	52 (46.14)	38 (38.05)	22 (27.97)	66.57 (54.67)
5.	Bifenthrin 10EC	100 (90.00)	78 (62.02)	63 (52.53)	42 (40.39)	22 (27.97)	16 (23.57)	6 (14.17)	46.71 (43.11)
6.	Deltamethrin 2.8EC	100 (90.00)	84 (66.42)	68 (55.55)	43 (40.97)	26 (30.65)	18 (25.10)	14 (21.97)	50.42 (45.24)
7.	Lambda- cyhalothrin 5EC	100 (90.00)	95 (77.07)	76 (60.66)	66 (54.33)	42 (40.39)	25 (30.00)	16 (23.57)	60.00 (50.76)
	CD	NA	11.40	10.60	10.20	11.80	9.60	8.20	
	Sem		5.23	4.87	4.68	5.42	4.41	3.76	

Table 3. LC_{50} values of different insecticides against Shoot and fruit borer population 2015-16

S. no	Treatments	Dose (g or ml/ha)	LC_{50} (mg/kg)	Limit range (ppm)
1.	Rynaxypr 20SC	30	19.740 ppm	6.627 to 31.900
2.	Emamectin benzoate 5SG	12	2.783 ppm	2.399 to 3.043
3.	Flubendiamide 48SC	55	81.049 ppm	78.285 to 83.496
4.	Indoxacarb 14.5SC	50	6.930 ppm	5.389 to 8.535
5.	Bifenthrin 10EC	25	7.400 ppm	6.863 to 7.992
6.	Deltamethrin 2.8EC	15	0.422 ppm	0.212 to 0.604
7.	Lambda- cyhalothrin 5EC	15	2.559 ppm	1.990 to 2.934

Table 4. LT_{50} values of different insecticides against shoot and fruit borer population during 2015-16

S. no		Percent mortality at various hours							Overall mean
		2	**24**	**72**	**120**	**168**	**240**	**336**	
	Treatments/ Hours								
1.	Rynaxypr 20SC	100 (90.00)	78 (62.02)	62 (51.94)	52 (46.14)	32 (34.44)	23 (28.65)	16 (23.57)	51.85 (40.06)
2.	Emamectin benzoate 5SG	100 (90.00)	96 (78.46)	84 (66.42)	76(60.66)	62 (51.94)	57 (49.02)	46 (40.97)	74.42 (59.61)
3.	Flubendiamide 48SC	100 (90.00)	65 (53.72)	47 (43.28)	41(39.18)	22 (27.97)	18(25.10)	09 (17.45)	43.14 (41.05)
4.	Indoxacarb 14.5SC	100 (90.00)	92 (73.57)	76 (60.66)	63(52.53)	52 (46.14)	45 (42.13)	35 (36.27)	66.14 (54.41)
5.	Bifenthrin 10EC	100 (90.00)	62 (51.94)	38 (38.05)	32(34.44)	20 (26.56)	14 (21.97)	04 (11.53)	38.57 (38.39)
6.	Deltamethrin 2.8EC	100 (90.00)	73 (58.69)	54 (47.29)	44(41.55)	27 (31.3)	20 (26.56)	12 (20.26)	47.14 (43.36)
7.	Lambda- cyhalothrin 5EC	100 (90.00)	84 (66.42)	67 (54.93)	56(48.44)	34(35.66)	26 (30.65)	21 (27.27)	55.42 (48.11)
	CD	NA	12.32	14.2	11.52	11.2	13.3	13.86	
	Sem		5.65	6.51	5.28	5.14	6.10	6.36	

Emamectin benzoate 5SG @ 12g *a.i.*/ha (T_2) was again the best insecticide among all the treatments with highest mortality of shoot and fruit borer population (62%) after one hundred sixty-eight hours of spray, on par with Indoxacarb 14.5SC @ 50g *a.i.*/ha (T_4) (52%). The Lambda-cyhalothrin 5EC @ 15g *a.i.*/ha (T_7) (34%) was the next effective treatment, on par with Rynaxypyr 20SC @ 30g *a.i.*/ha (T_1) (32%) followed by Deltamethrin 2.8EC @ 15g *a.i.*/ha (T_6) (27%) and Flubendiamide 4SC @ 55g *a.i.*/ha (T_3) (22%), respectively. Bifenthrin 10EC @ 25g *a.i.*/ha (T_5) (20%) again showed the lowest mortality among all the treatments.

At the two hundred forty hours of spray, Emamectin benzoate 5SG @ 12g *a.i.*/ha (T_2) was the best insecticide among all the treatments with highest mortality of shoot and fruit borer population (57%) and was on par with Indoxacarb 14.5SC @ 50g *a.i.*/ha (T_4) (45%). The next effective treatment was Lambda-cyhalothrin 5EC @ 15g *a.i.*/ha (T_7) (26%), on par with Rynaxypyr 20SC @ 30g *a.i.*/ha (T_1) (23%) followed by Deltamethrin 2.8EC @ 15g *a.i.*/ha (T_6) (20%) and Flubendiamide 4SC @ 55g *a.i.*/ha (T_3) (18%), respectively. Bifenthrin 10EC @ 25g *a.i.*/ha (T_5) (14%) was the least effective treatment among all the treatments showed the lowest mortality of shoot and fruit borer.

Under the three hundred thirty-six hours of spray, Emamectin benzoate 5SG @ 12g a.i./ha (T_2) showed continuously the best insecticide among all the treatments with highest of shoot and fruit borer mortality population (46%). It was on par with Indoxacarb 14.5SC @ 50g *a.i.*/ha (T_4) (35%) and Lambda-cyhalothrin 5EC @ 15g *a.i.*/ha (T_7) (21%). The next effective treatment was Rynaxypyr 20SC @ 30g *a.i.*/ha (T_1) (16%) followed byDeltamethrin 2.8EC @ 15g *a.i.*/ha (T_6) (12%) and Flubendiamide 4SC @ 55g *a.i.*/ha (T_3) (09%), respectively. Bifenthrin 10EC @ 25g *a.i.*/ha (T_5) (04%) was least effective showed continuously the lowest mortality among all the treatments.

Similar, findings are in confirmation with the present findings of Patil and Pokharkar [9] evaluated spray residues of 7 (seven) commonly used insecticides on potted okra (bhendi) plants to adults of shoot and fruit borer, *Earias vittella* (F.) caged at 1, 5 and 10 days after application for the determination in laboratory tests in India. Shinde and Shetgar (2011) reported residual toxicity of insecticides against *Earias vittella* on okra and order of residual efficacy on the basis of LT50 values, as cypermethrin 0.01% >spinosad 0.005%.

4. CONCLUSION

The lowest LC_{50} values against shoot and fruit borer were recorded for Deltamethrin (0.427 mg/kg), with the limit range of 0.268 to 0.568, 0.212 to 0.604, Emamectin benzoate 5SG @ 12g *a.i.*/ha (T_2) was the best insecticide among all the treatments with highest mortality of shoot and fruit borer population (100 %) at twenty four hours of spray.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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