Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2019; 8(1): 2564-2567
Received: 09-11-2018
Accepted: 12-12-2018

Thara KT
Department of Agricultural Entomology. College of Agriculture, UAHS Shivamogga, Karnataka, India

Sharanabasappa
Department of Agricultural Entomology. College of Agriculture, UAHS Shivamogga, Karnataka, India

Narasa Reddy G
Department of Agricultural Entomology. College of Agriculture, UAHS Shivamogga, Karnataka, India

Kalleshwara Swamy CM
Department of Agricultural Entomology. College of Agriculture, UAHS Shivamogga, Karnataka, India

Sandeep AR
Department of Agricultural Entomology. College of Agriculture, UAHS Shivamogga, Karnataka, India

Correspondence
Thara KT
Department of Agricultural Entomology. College of Agriculture, UAHS Shivamogga, Karnataka, India

Bio-efficacy of newer insecticide molecules against okra fruit borer, *Helicoverpa armigera*

Thara KT, Sharanabasappa, Narasa Reddy G, Kalleshwara Swamy CM and Sandeep AR

Abstract
To evaluate the effectiveness of newer insecticides in management of okra fruit borer, *Helicoverpa armigera.* A field experiment was conducted at Zonal Agricultural and Horticultural Research Station Navile, Shivamogga, Karnataka, India during *kharif* of 2015 to know the efficacy of various newer insecticides against Bhendi fruit borer, *Helicoverpa armigera* (Hub.) Among all the insecticides, the lowest mean larval number and fruit damage was noticed in Chlorantraniliprole 18.5 % SC (0.27 larvae/plant, 3.3%,) followed by Emamectin benzoate @0.36g/L(0.65 larvae/plant, 5.8%) and flubendiamide 480 SC(0.98 larvae/plant, 7.2%) respectively. Spinosad 45 SC and cyantraniliprole 10.26 OD were statistically on par with each other and all other treatments showed significantly superior over untreated check. Significant maximum yield of okra fruit was recorded from the plot sprayed with chlorantraniliprole 18.5%SC (89.25 q/ha) followed by Emamectin benzoate (85.06q/ha) and flubendiamide 81.25q/ha With respect to cost benefit ratio maximum was obtained from plot treated with chlorantraniliprole (1:3.56 followed by Emamectin benzoate (1:3.52).

Keywords: Bhendi, fruit damage, *Helicoverpa* armigera, chlorantraniliprole, flubendiamide

Introduction
Okra (*Abelmoschus esculentus* L.) is an important vegetable in India. It is also known as lady's finger and locally called "bhendi" It contains large quantities of carbohydrate, protein and vitamin C. Okra is a nutritious vegetable which plays an important role to meet the demand of vegetables of the country when vegetable are scanty in the market (Anon., 2015) [1]. Okra mucilage is suitable for medicinal and industrial application.
causes of poor production are the attack of various pests and lack of knowledge about cultural practices [5]. Okra is susceptible to the attack of various insects from seedling to fruiting stage such as okra fruit borer *Helicoverpa* armigera, okra shoot and fruit borer *Earias vittella*, okra jassid, white fly, aphids etc. Among these okra fruit borer *Helicoverpa* armigera is the most serious pest which cause direct damage to tender fruits. It is reported that about 69% losses in marketable yield due to attack of this insect pest (Kanwar and Ameta, 2007) [5]. The adult f fruit borer, *Helicoverpa* armigera lays eggs individually on floral buds and on tender fruits. Small b caterpillars bore into the fruit and feeds inside the fruit by thursting its head into the fruit as a result the infested plant bears smaller and deformed pods. A larva attacks a number of fruits one after another. Damaged plant tissues serve as entrance for disease causing microorganisms such as fungi. Conventionally farmers are using various types of synthetic chemical insecticides to control okra fruit borer. But due to the unconscious and unjustified use of synthetic pesticides create several problems in agro-ecosystem such as direct toxicity to beneficial insects, fishes, and man [8]. Therefore, it is now urgently need to use safe and effective biodegradable pesticides with less toxic effects on non-target organisms. The newer and safer insecticides may play a significant role in this regard. Newer insecticides are broad spectrum in pest management and many are safe to apply, unique in action and can easily be processed and used. Therefore, the experiment was conducted to find out the efficient way of management of okra fruit borer using newer insecticide molecules.

Material and Methods
The trial was conducted in field condition during *kharif* 2015 at Zonal Agricultural and Horticultural Research Station Navile, Shivamogga, Karnataka, India. The experiment was laid out in Randomized Complete Block Design (RCBD) with nine treatments replicated thrice in 4m x 3m plot size with a spacing of 60 cm x 30 cm. The variety Arka anamika was raised as per the recommended package of practices except plant protection measures. The treatments were imposed by using Knapsack sprayer @ 450-500 litres of spray solution/ha depending on

stage of the crop. The crop received a total of 2 sprays, the first being given when the fruit borer infestation was recorded and the second spray 15 days after the first on need basis. To compare the efficacy of treatments, both recommended insecticides as well as untreated control were maintained. Observations were recorded on the number of larvae per plant and per cent fruit damage per plant on 5 randomly selected plants per plot on one day before, 3, 7 and 15 days after each spray. The data were converted to square root and arc sin transformation before statistical analysis.

Table 1: List of different newer insecticides used for management of *Helicoverpa armigera*

Treatment	Chemicals	Dose ml/l
T_1	Cyantraniliprole 10.26 OD	1.80
T_2	Azadiractin 1 EC	2.00
T_3	Chlorantraniliprole 18.5 SC	0.25
T_4	Flubendiamide 480 SC	0.25
T_5	Indoxacarb 14.5 SC	0.30
T_6	Profenophos 50 EC	2.00
T_7	Emamectin benzoate 5 SG	0.30
T_8	Spinosad 45 SC	0.25
T_9	Untreated check	----

Results and Discussion

The newer insecticides were tested for their efficacy against H.armigera on okra under field condition revealed that all the insecticidal treatments were significantly superior to untreated control in checking the larval population and per cent fruit damage. Among chemicals the lowest mean larval number was noticed in flubendiamide 480 SC (0.70 larva /plant), chlorantraniliprole 18.5 SC (0.73larva /plant), cyantraniliprole 10.26 OD (0.80 larva /plant), spinosad 45 SC (0.87 larvae/ plant) and indaxocarb 14.5 SC (0.24 larva /plant) were statistically on par with each other. The plot received without any treatment was recorded significantly higher larval load with 3.16 (Table 1).

The per cent larval reduction over control was also calculated over untreated control. The result shows that highest larval reduction in per cent was recorded in chlorantraniliprole 18.5 SC (73 %), flubendiamide 480SC (72.6 %), emamectin benzoate 5% SG (71.6 %), cyantraniliprole 10.26OD (69.0 %), spinosad 45SC (68 %), indaxocarb 14.5SC (64.66 %), profenophos 50 EC (60.66%) and azadiractin 1 EC (60 %). They found least effective in reducing the larval population.

Data pertaining to fruit damage caused by borer infestation during 2015 has been presented in table 2). The plot which received chlorantraniliprole 18.5 SC had significant least damage the next best treatments reducing the lower per cent fruit damage was emamectin benzoate 5 SG, flubendiamide 480 SC (being on par with spinosad 45 SC found to be superior over untreated control. Data pertaining to fruit yield (q/ha) is presented in table 3. Application of chlorantraniliprole 18.5 SC registered significantly highest yield of 86.24 q/ha being on par with flubendiamide 480 SC (81.36 q/ha). Emamectin benzoate 5 SG (79.80 q/ha) recorded the next best treatment being statistically on par with spinosad 45 SC with 75.0 q/ha fruit yield. The treatments cyantraniliprole 10.26 OD (74.00 q/ha), indaxocarb 14.5 SC (71.56 q/ha) and azadiractin 1 EC (64.50 q/ha), found superior over the untreated control. The plot received without any treatment recorded significantly lower fruit yield of 25.42 q/ha being statistically inferior over other treatments.

However, the B:C ratio was high in chlorantraniliprole 18.5 SC (3.56) which was followed by emamectin benzoate 5 SG, flubendiamide 480 SC, spinosad 45 SC indaxocarb 14.5 SC (3.52, 3.23, 3.33 and 3.02 respectively. cyantraniliprole 10.26 OD and profenophos recorded lower B:C ratio (1.93 and 2.49 respectively). However, lowest B: C ratio was observed in cyantraniliprole 10.26 OD (1.93) over untreated control (Table 4)

Table 2: Efficacy of insecticides against *Helicoverpa armigera* on okra during *kharif*, 2015

Tr. No.	Treatments	Dose	Number of larvae per plant											Per cent reduction over control
			First spray				Mean	Per cent reduction over control		Second Spray			Mean	
			DBFS	3 DAFS	7 DAFS	15 DAFS			DBSS	3DASS	7 DASS	15DASS		
T_1	Cyantraniliprole 10.26OD	1.80 ml/l	2.73 (1.80)	1.20 (1.30)^{def}	0.73 (1.11)^{def}	0.80 (1.14)^{de}	0.91	69.00	2.90 (1.84)	1.00 (1.22)^{ef}	0.43 (0.96)^{ef}	0.57 (1.03)^{ef}	0.66	81.76
T_2	Azadiractin 1 EC	2.00 ml/l	2.80 (1.82)	1.47 (1.40)^{bc}	1.03 (1.24)^{c}	1.10 (1.26)^{c}	1.20	60.00	2.86 (1.83)	1.23 (1.32b)^{c}	0.70 (1.09)^{bc}	0.83 (1.15)^{bc}	0.92	74.58
T_3	Chlorantraniliprole 18.5 SC	0.25ml/l	2.73 (1.79)	1.07 (1.25)^{e}	0.63 (1.06)^{f}	0.73 (1.11)^{ef}	0.81	73.00	2.80 (1.82)	0.93 (1.20)^{f}	0.33 (0.91)^{f}	0.47 (0.98)^{f}	0.57	84.25
T_4	Flubendiamide 480SC	0.25ml/l	2.93 (1.85)	1.17 (1.29)^{ef}	0.58 (1.03)^{f}	0.70 (1.11)^{ef}	0.82	72.66	2.86 (1.83	0.97 (1.21)^{ef}	0.37 (0.93)^{f}	0.50 (1.00)^{f}	0.61	83.14
T_5	Indaxocarb 14.5SC	0.30ml/l	2.66 (1.78)	1.33 (1.35)^{cd}	0.90 (1.18)^{cd}	0.97 (1.21)^{cd}	1.06	64.66	2.93 (1.85)	1.17 (1.29)^{bcd}	0.60 (1.05)^{bcd}	0.73 (1.11)^{bcd}	0.83	77.07
T_6	Profenophos 50 EC	2.00ml/l	2.73 (1.80)	1.43 (1.39)^{bc}	1.03 (1.24)^{c}	1.10 (1.26)^{c}	1.18	60.66	2.93 (1.85)	1.30 (1.34)^{b}	0.73 (1.11)^{b}	0.87 (1.17)^{b}	0.96	73.48
T_7	Emamectin benzoate 5 SG	0.30ml/l	2.66 (1.78)	1.13 (1.28)^{ef}	0.70 (1.09)^{ef}	0.73 (1.09)^{ef}	0.85	71.66	2.93 (1.85)	1.00 (1.22)^{ef}	0.40 (0.95)^{f}	0.53 (1.02)^{f}	0.64	82.32
T_8	Spinosad 45SC	0.25ml/l	2.66 (1.78)	1.23 (1.32)^{de}	0.80 (1.14)^{cd}	0.87 (1.17)^{de}	0.96	68.00	2.80 (1.82)	1.03 (1.24)^{ef}	0.47 (0.98)^{def}	0.60 (1.05)^{def}	0.70	80.66
T9	Untreated control		2.73 (1.80)	2.86 (1.83)^{a}	3.00 (1.89)^{a}	3.16 (1.87)^{a}	3.00		3.33 (1.90)^{a}	3.40 (1.89)^{a}	3..62 (1.94)^{a}	3.84 (1.90)^{a}	3.62	
	SEm +		---	0.01	0.02	0.02			----	0.02	0.02	0.02	-	
	CD @ 5%		NS	0.05	0.08	0.06			NS	0.06	0.07	0.07	-	
	CV%		7.68	10.56	7.42	13.5			7.21	10.9	11.7	9.68		

Observations: 5 plants per treatment; Figures in parenthesis are $\sqrt{X+0.5}$ are transformed values; Means followed by same letters do not differ significantly by DMRT (P=0.05); DBFS- Days before first spray: DAFS- Days after first spray; DBSS- Day before second spray; DASS-Days after second spray

Table 3: Efficacy of insecticides against fruit borer damage on okra during *kharif*, 2015-16

Tr. No.	Treatments	Percent fruit damage per plant											Per cent reduction over control
		First Spray				Mean	Per cent reduction over control	Second Spray				Mean	
		DBFS	3 DAFS	7 DAFS	15 DAFS			DBSS	3DASS	7 DASS	15DASS		
T_1	Cyantraniliprole 10.26OD	21.68 (27.74)	19.66 (26.29)^{ab}	15.26 (22.92)^{b}	16.10 (23.62)^{bc}	17.00	35.36	22.36 (28.21)	18.3 (25.24)^{bc}	10.5 (18.89)^{c}	10.00 (18.39)^{cde}	12.93	65.08
T_2	Azadiractin 1 EC	20.60 (26.94)	17.00 (24.33)^{bcd}	16.13 (23.65)^{b}	17.00 (24.32)^{b}	16.71	36.46	22.76 (28.45)	20.56 (26.95)^{b}	14.78 (22.58)^{b}	15.20 (22.91)^{b}	16.84	54.52
T_3	Chlorantraniliprole 18.5 SC	22.02 (27.97)	14.30 (22.18)^{d}	6.30 (14.25)^{e}	8.50 (16.77)^{e}	9.7	63.11	21.73 (27.77)	13.33 (21.34)^{d}	6.00 (14.10)^{e}	8.00 (16.28)^{e}	9.11	75.39
T_4	Flubendiamide 480SC	20.86 (27.16)	16.00 (23.47)^{bcd}	10.0 (18.34)^{cd}	12.0 (20.22)^{cde}	12.66	51.86	22.42 (28.24)	17.20 (24.47)^{bcd}	9.68 (18.05)^{cd}	10.00 (18.19)^{cde}	12.29	66.81
T_5	Indaxocarb 14.5SC	21.09 (27.30)	20.20 (26.69)^{ab}	15.53 (23.18)^{b}	18.0 (25.10)^{b}	17.91	31.90	21.08 (27.31)	19.28 (26.00)^{bc}	14.43 (22.29)^{b}	14.83 (22.60)^{bc}	16.18	56.30
T_6	Profenophos 50 EC	20.86 (27.16)	19.20 (25.98)^{bc}	13.60 (21.42)^{bc}	15.16 (22.88)^{bc}	15.98	39.23	21.68 (27.72)	17.50 (24.67)^{bcd}	11.40 (19.67)^{bc}	13.05 (21.09)^{bcd}	13.98	62.24
T_7	Emamectin benzoate 5 SG	20.16 (26.64)	15.20 (22.93)^{cd}	8.33 (16.71)^{de}	10.16 (18.50)^{de}	11.23	57.30	23.21 (28.77)	15.50 (23.15)^{cd}	7.30 (15.57)^{de}	9.08 (17.47)^{de}	10.62	71.32
T_8	Spinosad 45SC	20.11 (26.58)	18.36 (25.33)^{bcd}	12.26 (20.45)^{bc}	14.16 (22.02)^{bcd}	14.92	43.26	22.56 (28.34)	19.40 (26.11)^{bc}	10.25 (18.41)^{cd}	12.03 (20.11)^{bcd}	13.89	62.48
T9	Untreated control	22.19 (28.10)	24.38 (29.54)^{a}	24.27 (29.44)^{a}	30.25 (33.35)^{a}	26.30		22.10 (20.09)	30.23 (33.34)^{a}	38.23 (38.19)^{a}	42.63 (40.75)^{a}	37.03	
	SEm +	1.43	1.58	1.54	1.72			1.29	1.65	1.41	2.12		
	CD @ 5%	NS	3.36	3.30	3.66			NS	3.52	3.01	4.50		
	CV%	6.45	7.68	8.93	9.20			5.65	7.90	8.31	11.82		

Observations: 5 plants per treatment; Figures in parenthesis arc sine transformed values; Means followed by same letters do not differ significantly by DMRT (P=0.05); DBFS- Days before first spray: DAFS- Days after first spray; DBSS- Days before second spray; DASS-Days after second spray.

Table 4: Cost Economics of newer insecticide on fruit yield of okra during, *kharif* 2015 (Fruit borers)

Tr. No.	Treatments	Dosage	Fruit Yield (Q/ha)	Cost of protection (Rs/ha)	Total cost of production (Rs/ha)	Gross returns (Rs/ha)	Net returns (Rs/ha)	B:C ratio
T_1	Cyantraniliprole 10.26 OD	1.80 ml/l	74.00^{cd}	17500	50500	148000	97500	1.93
T_2	Azadiractin 1 EC	2.00 ml/l	64.50^{e}	3940	36940	129000	92060	2.49
T_3	Chlorantraniliprole 18.5 SC	0.25 ml/l	86.24^{a}	4813.33	37813	172480	134667	3.56
T_4	Flubendiamide 480 SC	0.25 ml/l	81.36 ^{ab}	5445	38445	162720	124275	3.23
T_5	Indoxacarb 14.5 SC	0.30 ml/l	71.56^{d}	2159	35159	143120	107961	3.07
T_6	Profenophos 50EC	2.00 ml/l	65.38 ^{e}	2100	36100	130760	94660	2.62
T_7	Emamectin benzoate 5 SG	0.30 g /l	79.80^{bc}	1940	34940	159600	124660	3.52
T_8	Spinosad 45 SC	0.25 ml/l	75.00^{cd}	1638.25	34638	150000	115362	3.33
T_9	Untreated Check		25.42 ^{f}		33000	50840	17840	
	CD @ 5%		1.18					
	SEm ±		0.65					
	CV (%)		10.35					

Note: cost of insecticides

T_1Cyantraniliprole 10.26% OD	1868Rs/180ml
T_2Azadiractin 1 EC	1570 Rs /l
T_3Chlorantraniliprole 18.5 SC	16053. 33Rs /l
T_4Flubendiamide 480 SC	18580Rs /l
T_5Indoxacarb 14.5 SC	4530Rs /l
T_6 Profenophos 50EC	650 Rs /l
T_7Emamectin benzoate 5 SG	3800 Rs/kg
T_8Spinosad 45 SC	3353Rs/l

T_9Untreated Chec Cost of labour: Rs 200/day, Number of labourers required per spray /ha = 2, Market price of Bhendi Rs.20/kg

In the present findings, among chemicals the lowest mean larval number was noticed in flubendiamide 480 SC (0.70 larva /plant), chlorantraniliprole 18.5 SC (0.73larva /plant), cyantraniliprole 10.26 OD (0.80 larva /plant), spinosad 45 SC (0.87 larva /plant) and indaxocarb 14.5 SC (0.24 larva /plant) were statistically on par with each other. In the present findings, *H. armige*ra larval mortality was high with new molecules than rest of chemicals is mainly due to resistance developed against many older insecticides. The present findings were supported by Sharma and Bhati (2008), who reported indoxacarb 75 g.a.i/ha was quite effective treatment against okra fruit borer, *H armigera*. Similarly, Parmar and Borad (2009) [8] also reported that, the new molecule indoxacarb as effective chemical against fruit borers of okra next to emamectin benzoate.

The present study is in accordance with Mansoor-Ul- Hasan *et al.* (2001) [6] who reported higher effectiveness of spinosad against *H. armigera* in chickpea ecosystem. Similarly Chowdary *et al*., (2010) [4] tested the newer insecticide molecules and reported chlorantraniliprole 20 SC @ 30 g. a.i/ha and 20 g. a.i/ha were superior in recording less *H. armigera* larval populations followed by spinosad @ 56 g. a.i/ha, emamectin benzoate @15 g. a.i/ha and flubendiamide @ 45 g. a.i/ha.

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