Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(3): 380-383

Received: 04-03-2019
Accepted: 06-04-2019

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Field efficacy of selected bio-agent and insecticide against shoot and fruit borer, *Earias vittella* (Noctuidae: Lepidoptera) on okra

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Abstract
Earias vittella is the major pest of okra. It has been reported to cause 24.6 to 26.0 per cent damage to okra shoots and 40 to 100 per cent loss to fruits. In recent years, increased interest has been shown towards biological control following unsatisfactory results with the application of conventional insecticides. Hence, investigations were carried out to assess the potential of *Trichogramma* parasitoids and insecticide control against okra fruit borers, the results suggested that significant differences were observed between the treatments. The fruit infestation ranged from 5.47 to 15.57 per cent, highest fruit infestation was recorded in control (15.57 %), which was significantly more over rest of the treatments, followed by *T. chilonis* (10.58 %), chlorantraniliprole treatment (8.58 %). However, minimum fruit infestation was recorded in *T. chilonis* + chlorantraniliprole treatment (5.47 %).

Keywords: *Earias vittella, T. chilonis,* chlorantraniliprole, control *and* okra

Introduction
Okra is a major economically important vegetable crop which alone accounts for 21 per cent of total exchange earnings from export of vegetables from India. One of the major impediment in successful production of okra is insect pests. Amongst them shoot and fruit borer, *E. vittella* (Fabricius) is a major pest is the most important pest because it damages okra, particularly young growing shoots and fruits (pods), and decrease okra fruit yield significantly both in terms of quality and quantity[1]. The borer has been reported to cause 24.6 to 26.0 per cent damage to okra shoots [2] and 40 to 100 per cent loss to fruits [3,4]. Farmers heavily rely on the use of synthetic insecticides for the control of this pest [5].but an indiscriminate use of chemical insecticides for the suppression of this pest has generated the development of insecticide resistance [6].

There is a need to explore alternatives, encompassing available pest control methods and techniques in order to reduce the sole dependence to insecticides. For this purpose, integrated pest management seems to be the most appropriate approach to achieve sustainability in okra production. *Trichogramma* spp. is more or less universal parasites of eggs of the Lepidoptera and is recommended as an important component of IPM programme of okra against *Earias* spp [7] they offer economically compatible and ecologically viable alternatives in managing the insects.

Materials and Methods
The experiment was conducted at NBAIR (National Bureau of Agricultural Insect Resources), Research Farm, Attur campus, Yelahanka, Bengaluru during *Rabi* season 2014. Okra seeds of variety 'Arka Anamika' were sown on 25th November (*Rabi*) with a spacing of 60 cm × 30 cm. Experiment was laid out in a Randomized Block Design (RBD) with 4 treatments including untreated control. The plot was divided into four blocks of equal size, *i.e.*, 100 sq. m for each treatment, which was divided into sub-plots of 20 m^2 (5×4 m) with bunds all round and irrigation channels in between the replications, each treatment consisted of five replications. 10 m space was left between each treatment to avoid the effect of insecticidal drift on other treatment and also the movement of *T. chilonis* from one plot to another. All the recommended agronomic practices (irrigation, fertilizer etc.) were strictly followed in case of all treatments while conducting the trial.

Treatments

S. No.	Treatment	Dosage / 100 sq. mtr plot
1	Chlorantraniliprole 18.5%	1.5 ml /5 lit
2	*T. chilonis*+ Chlorantraniliprole 18.5%	1500 adults + 1.5 ml /5 lit
3	*T. chilonis*	1500 adults
4	Control	-

The chemical insecticide was selected against *E. vittella* from resistance studies and most commonly used insecticide in farmer's field, *i.e*., Chlorantraniliprole 18.5% SC @ 0.3 ml/lit. The selected chemical was sprayed in blocks separately by using knapsack sprayer at 12 days intervals once the imposition of treatments was started and *T. chilonis* was released 2 days after insecticide spray.

Field observation

The observations on pest incidence and their number were recorded one day before spraying as pre-treatment count. Post-treatment count was taken and recorded at four days interval after each treatment and spraying takes place once in 12 days.

The number of healthy and damaged fruits from each treatment was recorded at each picking. All the fruits in each sub-plot were plucked, kept separately and carefully examined. Those fruits having exit holes were easily separated, whereas some fruits, that the entry point of caterpillars in the form of minute plugged holes surrounded by small-decolorized patches were seen after careful examination of the fruits, were cut open to confirm the damage. After sorting out the fruits as healthy and damaged ones, they were counted and also weighed separately

Fruit infestation

Total number of fruits and number of fruits damaged per ten plant due to fruit borer damage were counted and per cent fruit damage was worked out per plot

$$\text{\% Fruit damage} = \frac{\text{Number of damaged fruits}}{\text{Total number of fruits}} \times 100$$

$$\text{\% Reduction in fruit infestation} = \frac{\text{\% fruit infestation in control - \% fruit infestation in treatment}}{\text{\% Fruit infestation in control}} \times 100$$

$$\text{\% Increase in yield over control} = \frac{\text{Yield in treatment plot - yield in control plot}}{\text{Yield in treatment plot}} \times 100$$

Observations on number of damaged fruits per plot were recorded at four days intervals. The data on fruit damage by the pest was converted into per cent values and transformed to arc sine transformation before analysis by two-way ANOVA [8].

Results and Discussion

During pre-application of treatments, % fruit damage by *E. vittella* larvae on okra was non-significant during Rabi. It ranges from 10.68 to 13.23 % (Table 1).

After first application

There was significant difference of per cent fruit damage was noticed among the treatments. Lowest per cent fruit damage was recorded in T2 plot (5.84 %) among the treatments. The next best treatment is T1 (10.53 %) which was on par with T3 (12.25 %) Highest fruit damage were noticed in T4 (18.18 %). The per cent reduction of fruit damage was high in *T. chilonis* + chlorantraniliprole treatment (67.87 %) and in chlorantraniliprole and *T. chilonis* treatments, it was (42.07 and 32.61 %) over control (Table 1).

After second application

The results revealed that there was a significant difference between the treatments. The per cent fruit damage was significantly lowest in chlorantraniliprole + *T. chilonis* (4.40 %) compared to rest of treatments. It was followed by (T_1) Insecticide spray (9.80 %), (T_3) *T. chilonis* (20.91 %) and (T_4) Control (17.89 %). The per cent reduction of fruit damage was high in *T. chilonis* + chlorantraniliprole treatment (75.40 %) and in chlorantraniliprole and *T. chilonis* treatments, it was (49.24 and 27.83 %) over control) (Table 1).

After third application

Significant difference of per cent fruit damage was noticed among the treatments. Lowest per cent fruit damage was recorded in T_2 (chlorantraniliprole + *T. chilonis*) treated plot (5.31 %) compared to the rest of the treatments. Further, T_1 (chlorantraniliprole) (6.95 %) showed on par with T_3, (*T. chilonis*) (8.75 %). Highest fruit damage was noticed in T_4 (12.70 %). The per cent reduction of fruit damage was high in T_2 (58.18 %) and in T_1 & T_3 was 45.27 and 31.10 per cent over control. (Table 1).

After fourth application

Lowest per cent fruit damage was recorded in T_2 plot (4.14 %) compared to rest of the treatments. It was followed by T_1 (4.99 %), showed on par with T_3 (6.75 %). Highest fruit damage was noticed in T_4 (14.47 %).The per cent reduction of fruit damage was high in *T. chilonis* + chlorantraniliprole treatment (75.38 %) and in chlorantraniliprole and *T. chilonis* treatments, it was 65.51 and 53.35 per cent over control (Table 1).

Overall mean % fruit damage

Among mean values over different days after imposing treatments, the results suggested that significant differences were observed between the treatments. The results suggested that significant differences was observed between the treatments in overall mean. The fruit infestation ranged from 5.47 to 15.57 per cent, highest fruit infestation was recorded in control (15.57 %), which was significantly more over rest of the treatments, followed by *T. chilonis* (10.58 %), chlorantraniliprole treatment (8.58 %). However, minimum fruit infestation was recorded in *T. chilonis* + chlorantraniliprole treatment (5.47 %) (Table 1). The overall season mean indicated significant differences in reduction of fruit infestation over control. The highest reduction in fruit infestation was recorded *T. chilonis* + chlorantraniliprole (64.86 %), followed by chlorantraniliprole treatment (44.89 %) and the lowest reduction of fruit infestation was recorded *T. chilonis* in (32.04 %) over control (Table 1).

Fruit yield/ha

The significant fruit yield ranged between 33.57 to 92.58 q/ha. Highest fruit yield was recorded in T_2 (92.58 ton/ha) which was significantly more over rest of the treatments, followed by T_1 (70.51 q/ha), (T_3) (48.70 q/ha). However, low fruits yield was recorded in T_4 (33.57 q/ha) (CD=4.05, P=0.05) (Table 1).

Table 1: Effect of application of selected bioagent and insecticide against fruit damage by *E. vittella* on okra during Rabi

Treatments	% Fruit damage (Number basis)										
		1st application					2nd application				
	Pre-pray	4 DAA	8 DAA	12 DAA	Mean	% ROC	4 DAA	8 DAA	12 DAA	Mean	% ROC control over control
Insecticide	13.23 (21.16)	9.14 (17.43)^{b}	10.38 (18.74)^{b}	12.06 (20.23)^{b}	10.53 (18.80)^{c}	42.07	9.61 (17.99)^{b}	8.23 (16.40)^{b}	9.41 (17.79)^{b}	9.08 (17.39)^{c}	49.24
Insecticide + *T. chilonis*	10.68 (18.87)	6.90 (15.07)^{c}	5.22 (10.29)^{c}	5.40 (11.93)^{c}	5.84 (12.51)^{d}	67.87	4.12 (11.14)^{c}	4.77 (8.52)^{c}	3.68 (11.05)^{c}	4.40 (10.34^{d}	75.40
T.chilonis	11.62 (19.85)	10.99 (19.24)^{b}	12.32 (20.43)^{a}	13.46 (21.44)^{ab}	12.25 (20.37)^{bc}	32.61	14.87 (22.55)^{a}	12.60 (20.64)^{ab}	11.27 (19.35)^{ab}	12.91 (20.85)^{b}	27.83
Control	11.57 (19.75)	18.73 (25.56)^{a}	17.25 (24.42)^{a}	18.57 (24.40)^{a}	18.18 (25.13)^{a}		19.80 (26.36)^{a}	16.72 (24.04)^{a}	17.15 (24.16)^{a}	17.89 (24.86)^{a}	
Mean		11.44 (19.33)	11.29 (18.51)	12.37 (19.77)			12.26 (19.53)	10.30 (17.44)^{a}	10.64 (18.11)^{a}		
					S.Em±	CD @ 5%				S.Em±	CD @ 5%
A Factor					0.27	2.98	A Factor			0.29	3.26
B Factor					0.20	NS	B Factor			0.22	NS
A X B Factor					0.33	3.45	A X B Factor			0.37	5.65

Table 1 Contd….

Treatments	% Fruit damage (Number basis)									Overall mean % fruit damage	% reduction of fruit damage over control
	3rd application					4th application					
	4 DAA	8 DAA	12 DAA	Mean	% ROC	4 DAA	8 DAA	Mean	% ROC		
Insecticide	7.04 (15.23)^{a}	7.39 (15.57)^{a}	6.45 (14.56)^{c}	6.95 (15.12)^{c}	45.27	5.69 (13.52)^{b}	4.29 (10.58)^{b}	4.99 (12.09)^{b}	65.51	8.58 (16.60)^{c}	44.89
Insecticide + *T. chilonis*	4.75 (13.19)^{b}	5.34 (13.96)^{b}	6.02 (11.01)^{b}	5.31 (12.74)^{b}	58.18	4.59 (9.89)^{c}	3.74 (10.86)^{b}	4.14 (10.47)^{c}	75.38	5.47 (12.15)^{d}	64.86
T. chilonis	7.95 (16.26)^{a}	8.37 (16.59)^{a}	9.95 (18.26)^{d}	8.75 (17.04)^{a}	31.10	7.01 (14.92)^{b}	6.51 (12.89)^{b}	6.75 (13.95)^{b}	53.35	10.58 (18.53) ^{b}	32.04
Control	14.08 (21.93)^{a}	8.81 (17.18)^{a}	15.21 (22.92)^{a}	12.70 (20.68)^{a}		15.21 (22.92)^{a}	13.74 (21.72)^{a}	14.47 (22.33)^{a}		15.57 (23.03) ^{a}	44.89
Mean	6.60 (16.66)	7.64 (15.82)	9.04 (16.71)			7.91 (15.34)	7.26 (14.08)				
				S.Em±	CD @ 5%					S.Em±	CD @ 5%
A Factor				0.20	2.20	A Factor				0.33	4.63
B Factor				0.15	NS	B Factor				0.25	NS
A X B Factor				0.25	3.82	A X B Factor				0.42	6.55

Cost: Benefit Ratio

The increase of fruit yield and cost-benefit(C: B) ratio over control showed significant differences between treatments which were ranged from 31.06 to 63.73 per cent. The highest increase of healthy fruit yield was recorded *T. chilonis* + chlorantraniliprole (63.73 %) (C: B-1: 2.06), followed by chlorantraniliprole treatment (52.38 %) (C: B -1.49), and the lowest increase of healthy fruit yield were recorded in *T. chilonis* (31.06 %) (C: B-1:0.68), (Table 2).

In the present study, *T. chilonis* was used for field studies against *E. vittella* as significantly higher parasitism was observed dosage @ 150000/ha and it was found to be significantly superior to other species, *T. achaea*. The present findings were in agreement with the selection of *T. chilonis* for field trial [9]. but it was contrary with dosage used by them for the control of *E. vittella*. Similarly *T. chilonis* reduced the fruit borer damage up to 55.7%, when parasitoids were released inundatively at the rate of 2 lakh adult ha^{-1} at 10 days interval [10]. *T. pretiosum* was recorded to parasitize eggs of *E. vittella* and *H. armigera* to the extent of 64 and 70 per cent, respectively, under laboratory conditions but when released under field conditions at Parbhani (Maharashtra) proved less efficient [11]. However, in the earlier studies revealed that *T. achaea* was reported to be parasitise 27.2 per cent of eggs of *E. vittella* in Punjab [12]. Karnataka and Gujarat [13]. Similarly Varma [9].reported that *Trichogrammatoidea* and *T. Chilonis* sps were common egg parasitoids of *Earias spp* in Punjab with average parasitism of 30.0 per cent. Thontadarya [14]. reported natural parasitism of 8.0 per cent by *T. chilonis* in okra crop. However Sumathi [15].*T. chilonis* release at Coimbatore (Tamil Nadu) against *E. vittella* and *E. insulana* on okra crop at the rate of 50000 / ha reported to be highly effective & cause lowest fruit damage stage. Similarly sprays of Cypermethrin (159 a.i/ha) at an interval of 14 days could be relied up on for reducing the losses due to *E. vittella* on okra [16]., whereas application of emamectin benzoate 5 SG @ 0.2 g/ l was the most superior treatment by recording the least per cent fruit damage (7.82%) and resulted in highest good fruit yield (47.02 q/ha) [17]. Bheemanna [18] reported that emamectin benzoate @ 8.50 g.a.i/ha recorded lower fruit damage and higher fruit yield and was found to be highly promising insecticide against okra fruit borer complex, whereas Latif [19] reported that spraying of flubendamide reduced the highest percent of shoot (87.46%) and fruit (81.43%) infestation of okra fruit and shoot borer over control and also produced the highest total fruit yield.

Table 3: Effect of different treatments on fruit yield of okra against E. vittella during Rabi

Treatments	Healthy yield (q/ha)	% increased of fruit yield over control	C:B ratio
Rabi			
Insecticide	70.51	52.38	1: 1.49
Insecticide +*T. chilonis*	92.58	63.73	1: 2.06
T. chilonis	48.70	31.06	1: 0.68
Control	33.57		
SEm±	1.31		
CD (5 %)	4.05		

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