Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

J E Z S Journal of Entomology and Zoology Studies

E-ISSN: 2320-7078
P-ISSN: 2349-6800
www.entomoljournal.com
JEZS 2020; 8(2): 1098-1103

Received: 07-01-2020
Accepted: 09-02-2020

Anirban Sakar
AICRP on Potato, Directorate of Research, B.C.K.V., Kalyani, Nadia, West Bengal, India

Moumita Chakraborty
Department of Agricultural Entomology, B.C.K.V., Mohanpur, Nadia, West Bengal, India

Lakshman Chandra Patel
College of Agriculture (Extended Campus of Bidhan Chandra Krishi Viswavidyalaya), Agricultural Farm, Farm Gate 1, Kalna Road, Burdwan, West Bengal, India

Anjan Kumar Nayak
Department of Agricultural Entomology, B.C.K.V., Mohanpur, Nadia, West Bengal, India

Corresponding Author:
Anirban Sakar
AICRP on Potato, Directorate of Research, B.C.K.V., Kalyani, Nadia, West Bengal, India

Studies on bio-efficacy of flubendiamide 90% + deltamethrin 60% w/v against the fruit borer *Earias vitella* infesting Okra and its effect on natural enemies

Anirban Sakar, Moumita Chakraborty, Lakshman Chandra Patel and Anjan Kumar Nayak

Abstract
An experiment was conducted at 'C' unit Farm, BCKV, Kalyani, West Bengal on okra to study the Bio-efficacy of Flubendiamide 90% + Deltamethrin 60% w/v against the Fruit Borer and its effect on naural enemies during the *pre kharif* season of 2017 & 2018. Three doses of Flubendiamide 90% + Deltamethrin 60% SC @ 250, 300 and 400 ml/ha along with some other insecticides were sprayed to work out their efficacy against this menace of okra. The effect of various doses of Flubendiamide 90% + Deltamethrin 60% SC along with other chemical treatments on natural enemies was also studied. The study revealed that Flubendiamide 90% + Deltamethrin 60% SC @ 400 ml/ha was the most effective for controlling fruit borer and recorded the highest yield during both year. The application of Flubendiamide 90% + Deltamethrin 60% SC has no adverse effects on natural enemies. Hence could be suggested to control its infestation in okra crop.

Keywords: Bio efficacy, flubendiamide 90% + deltamethrin 60% w/v, *Earias vitella*, okra

1. Introduction
Okra (*Abelmoschus esculentus* L. Moench), also known as lady's finger or bhendi, belongs to family Malvaceae and is an important vegetable crop grown in many tropical and subtropical parts of the world. India is the leading producer and cultivator of okra. In India 0.53 mha of total cropped area is under okra cultivation with production and productivity of 6.35 MT and 11.91 t/ha respectively [8]. Okra is a nutritious vegetable, which provides an important source of vitamins, calcium, potassium and other mineral matters which are often lacking in the diet of developing countries [3]. Insect pests are one of the major biotic stresses in okra growing regions in both developing and developed counties. As many as 72 insect pests of different groups have been recorded damaging the okra crop from germination to maturity [9]. It has been reported that in India fruit borer (*Earias vitella*) responsible for 49-74 % losses in okra production [2]. The loss, which can be avoided, due to this pest in yield and fruit damage have been estimated from 36% to 90% [7]. Reports are there where it is said that this pest alone can cause fruit infestation to the extent of 57.1% and total yield loss to the tune of 54.04% in okra [1]. Injudicious use of insecticides as a control strategy against these insect pests has resulted in several undesirable effects like pesticide pollution, resurgence of secondary pests, insecticide resistance and human health hazards Etc. [6]. To tackle this pest menace, a number of chemical insecticides are liberally sprayed on this vegetable crop, which leads to undesirable loads of residue in marketable vegetables [5]. Due to the presence of pesticidal residues in the final commodity, there is a risk of rejection of whole consignments during export. To overcome these problems, identification of safe molecules with better insecticidal properties, low mammalian toxicity, safe to natural enemies, which fit well in the IPM concept, is the need of the hour. A number of new molecules are on the scene, therefore periodical evaluation for their comparative effectiveness, specificity, selectivity and economics of control operations is essential. Hence the current investigation was conducted to find out the efficacy of Flubendiamide 90% + Deltamethrin 60% w/v to manage fruit borer infestation in okra.

2. Materials and Methods

A. Location of study

Field experiments were carried out at District Seed Farm–C Unit, Bidhan Chandra Krishi Viswavidyalaya, West Bengal, India (22_580 N latitude, 88_250 E longitude, 9 m above mean sea level) in *Pre-kharif* season 2017 and 2018.

B. Treatment details

The experiment was laid out in a randomised block design using tomato variety, "Pusa Sawani". Total nine treatments including the untreated control are considered to evaluate the bio-efficacy of above mentioned formulation. Each treatment is replicated three times. The details of the treatments are presented in Table 1.

C. Experimental practices

The crop was sown at 4th week of April during both the consecutive years in 27 different plots of 5 x 5 m^2 area with 60 cm x 45 cm spacing. Fertilizers were applied @ 80:50:50 kg/ha of NPK in the form of urea, single super phosphate and muriate of potash in all the plots followed by recommended horticultural practices. Two rounds of spraying were done for both the year of the crop season.

D. Methods of observation

The observations on number of healthy and infested okra fruits were recorded from ten randomly selected and tagged plants from the net area of each plot before 24 hours of each spraying. Subsequently, the observations on infested and healthy okra fruits were also recorded 5 days and 10 days after each spraying. On the basis of number of damaged and healthy okra fruits, the percent infestation was calculated and the data were statistically analyzed. The population of spider and other predatory insects (coccinellids and others) were counted per square meter area and the impact of different treatments on them was recorded before spray and 1,3,5,7 and 10 days after spaying. The okra yield from each plot was pooled and expressed as tonnes/ha.

E. Statistical analysis

The data were subjected to analysis using "Randomized Block Design ANOVA" in excel after making necessary transformations.

3. Results and Discussion

3. A. Efficacy of Flubendiamide 90% + Deltamethrin 60% SC on Fruit Borer, *Earias vitella*

The efficacy of different treatment schedule against *Earias vitella* after 1st and 2nd round of spray during *pre-kharif*, 2017 and *pre-kharif*, 2018 of the experiment has been presented in table 2 and table 3 (Fig. 1 and Fig. 2). Results from first year study revealed that after first round of spray all the treatments were effective in reducing the population of *Earias vitella* over control. Among the various insecticides tested, the lowest infestation (7.33%) due to fruit borer was recorded in the treatment T_4 i.e. Flubendiamide 90% + Deltamethrin 60% SC @ 400 ml/ha after 10 DAS (days after spray). However, it was at par with treatments T_7 i.e. Flubendiamide 480 SC @ 100 ml/ha which showed 8.33% fruit infestation. The next best result was obtained from T_3 i.e. Flubendiamide 90% + Deltamethrin 60% w/v SC @ 300 ml/ha after 10 days of spraying (11.33%). Treatment T_2 i.e. Flubendiamide 90 + Deltamethrin 60 w/v SC @ 250 ml/ha recorded 16.33% fruit infestation which also statistically at par with T_5 i.e. Flubendiamide 480 SC @ 75 ml/ha. Treatment of deltamethrin 100 EC (T_6) @ 240 ml/ha, lambda cyhalothrin 4.9% CS (T_8) @ 300 ml/ha and imidacloprid 200 Sl (T_9) @ 100 ml/ha encountered 22.33%, 21.33% and 19.67% fruit infestation respectively. Almost similar trend was observed in 2nd round spray. During 2nd year of the experiment also the best results obtained from T_4 i.e. Flubendiamide 90% + Deltamethrin 60% SC @ 400 ml/ha after 10 DAS which recorded 9% fruit infestation after 10 DAS of first spray. Field bio-effectiveness of flubendiamide against okra shoot and fruit borer was conducted and reported that all the dosages of flubendiamide found very much effective over conventional synthetic molecules [4].

B. Impact of Flubendiamide 90% + Deltamethrin 60% SC on predator populations after two round of spraying during *pre-kharif* season of 2017 and 2018

The data obtained during *pre-kharif*, 2017 and *pre-kharif*, 2018 after 2 (two) round of spraying on the percent reduction of predator population at different days after spray has been presented in table 4 and table 5. The per cent reduction of predator population was maximum at 2nd to 3rd days after spray. The highest percent of population reduction was observed in case of T_6 i.e. Deltamethrin 100 EC @ 240 ml/ha (Table 4 and Table 5). The rest of the treatments had negligible or a very less effect on the population reduction of spider population recorded around 10% mean mortality of the same. [4]Katti and Surpur reported negligible non-target toxicity of flubendiamide against prevailing predatory fauna in okra ecosystem.

C. Yield (t/ha)

The mean yield of okra plots treated with different insecticides has been presented in table 6 (Fig. 3) which revealed that the highest yield of 11.53 t/ha and 11.39 t/ha were registered by Flubendiamide 90% + Deltamethrin 60% SC at 400 ml/ha during *pre-kharif* 2017 and *pre-kharif* 2018 respectively followed by Flubendiamide 480 SC w/v @ 100 ml/ha which yielded 11.18 t/ha and 11.25 t/ha during *pre-kharif* 2017 and *pre-kharif* 2018 respectively but these two treatments were statistically at par with each other. Yield obtained from the other treatments were comparatively low. The next best result was obtained from T_3 i.e. Flubendiamide 90% + Deltamethrin 60% SC at 300 ml/ha yielding 9.75 t/ha and 9.50 t/ha during *pre-kharif* 2017 and *pre-kharif* 2018 respectively. Among the other treatments T_2 i.e. Flubendiamide 90% + Deltamethrin 60% SC at 250 ml/ha, T_5 i.e. Flubendiamide 480 SC w/v @ 75 ml/ha and T_9 i.e. Imidacloprid 200 SL @ 100/ha gave more than 8.5 t/ha yield during both the year of study. The lowest yield was obtained from the untreated check plots (4.45 t/ha 5.42 t/ha in 1st year and 2nd year respectively) during both the year of the experiment.

Table 1: Different Treatments for Bio-efficacy study

Sl. No	Treatments	Dosage (g a.i./ha)	Dosage Formulation g or ml per ha
1.	T_1= Untreated control	----	----
2.	T_2= Flubendiamide 90 + Deltamethrin 60 w/v SC	22.5 + 15	250
3.	T_3= Flubendiamide90 + Deltamethrin 60 w/v SC	27 + 18	300
4.	T_4= Flubendiamide 90 + Deltamethrin 60 w/v SC	36 + 24	400
5.	T_5= Flubendiamide 480 SC w/v	36	75
6.	T_6= Deltamethrin 100 EC	24	240
7.	T_7= Flubendiamide 480 SC w/v	48	100
8.	T_8= Lambda-Cyhalothrin 4.9% CS	15	300
9.	T_9= Imidachloprid 200 SL	20	100

Table 2: Bio- Efficacy of Flubendiamide 90% + Deltamethrin 60% SC on Fruit Borer, *Earias vitella* during *pre-kharif* 2017

Treatment	Chemicals	Dosage (gm or ml) /ha)	Pre spray count of damaged fruit % per plant	Percentage of damaged fruit after 1st round Spray			Percentage of damaged fruit after 2nd round Spray		
				5 DAS	10 DAS	Mean percentage	5 DAS	10 DAS	Mean Percentage
T_1	Untreated control	--	29.67	38.33 (38.24)*	56.67 (48.82)	46.50 (43.53)	59.33 (50.36)	68.33 (57.76)	63.83 (53.04)
T_2	Flubendiamide 90 + Deltamethrin 60 w/v SC	250	27.33	19.33 (26.03)	16.33 (23.75)	17.83 (24.95)	18.67 (25.58)	16.33 (23.81)	17.50 (24.71)
T_3	Flubendiamide 90 + Deltamethrin 60 w/v SC	300	28.33	19.67 (26.29)	11.33 (19.61)	15.50 (22.99)	18.33 (25.28)	12.33 (20.53)	15.33 (22.94)
T_4	Flubendiamide 90 + Deltamethrin 60 w/v SC	400	31.33	13.33 (21.37)	7.33 (15.56)	10.33 (19.09)	11.33 (19.61)	8.00 (16.34)	9.67 (18.04)
T_5	Flubendiamide 480 SC w/v	75	27.67	23.33 (28.86)	16.33 (23.75)	19.83 (26.35)	21.67 (27.71)	16.33 (23.79)	19.00 (25.78)
T_6	Deltamethrin 100 EC	240	30.67	26.67 (31.06)	22.33 (28.15)	24.50 (29.63)	24.00 (29.30)	21.33 (27.45)	22.67 (28.41)
T_7	Flubendiamide 480 SC w/v	100	22.33	15.67 (23.29)	8.33 (16.73)	12.00 (19.51)	14.67 (22.46)	7.00 (15.31)	10.83 (18.92)
T_8	Lambda-Cyhalothrin 4.9% CS	300	29.67	25.00 (29.96)	21.33 (27.49)	23.17 (28.74)	24.67 (29.73)	19.33 (26.04)	22.00 (27.92)
T_9	Imidachloprid 200 SL	100	26.67	21.67 (27.72)	19.67 (26.30)	20.67 (27.03)	19.67 (26.29)	18.67 (25.57)	19.17 (25.95)
CD (P=0.05)	--	--	NS	2.85	3.54		2.61	2.48	
SE(m) (±)	--	--	--	0.94	1.17		0.86	0.82	

*Figures in the parenthesis are angular transformed value

Table 3: Bio- Efficacy of Flubendiamide 90% + Deltamethrin 60% SC on Fruit Borer, *Earias vitella* during *pre-kharif* 2018

Treatment	Chemicals	Dosage (gm or ml) /ha)	Pre spray count of damaged fruit %	Percentage of damaged fruit after 1st round spray			Percentage of damaged fruit after 2nd round spray		
				5 DAS	10 DAS	Mean percentage	5 DAS	10 DAS	Mean Percentage
T_1	Untreated control	--	31	35.67 (36.65)*	57.00 (49.00)	46.33 (42.83)	60.67 (51.14)	68.00 (55.56)	64.33 (53.33)
T_2	Flubendiamide 90 + Deltamethrin 60 w/v SC	250	38	20.00 (26.45)	17.00 (24.30)	18.50 (25.45)	19.33 (26.04)	16.67 (24.07)	18.00 (25.08)
T_3	Flubendiamide 90 + Deltamethrin 60 w/v SC	300	38	20.67 (26.98)	12.00 (20.22)	16.33 (23.65)	19.00 (25.76)	11.33 (19.66)	15.17 (22.75)
T_4	Flubendiamide 90 + Deltamethrin 60 w/v SC	400	40	14.00 (21.96)	9.00 (17.43)	11.50 (19.71)	12.00 (20.16)	8.67 (17.09)	10.33 (18.69)
T_5	Flubendiamide 480 SC w/v	75	39	25.00 (29.99)	17.67 24.77)	21.33 (27.42)	22.00 (27.95)	17.00 (24.30)	19.50 (26.15)
T_6	Deltamethrin 100 EC	240	41	28.00 (31.92)	23.33 (28.84)	25.67 (30.40)	23.00 (28.63)	22.00 (27.94)	22.50 (28.30)
T_7	Flubendiamide 480 SC w/v	100	29	16.33 (23.83)	7.67 (15.92)	12.00 (19.95)	15.00 (22.72)	7.33 (15.65)	11.17 (19.24)
T_8	Lambda-Cyhalothrin 4.9% CS	300	30	25.67 (30.42)	22.33 (28.18)	24.00 (29.31)	25.00 (29.96)	20.67 (26.98)	22.83 (28.51)
T_9	Imidachloprid 200 SL	100	36	23.33 (28.87)	19.00 (25.80)	21.67 (27.35)	20.00 (26.52)	17.67 (24.84)	18.83 (25.70)
CD (P=0.05)	--	--	NS	2.91	3.53		3.08	2.65	
SE(m) (±)	--	--	--	0.96	1.17		1.02	0.88	

*Figures in the parenthesis are angular transformed value

Table 4: Effect of Flubendiamide 90% + Deltamethrin 60% SC on predators in okra during *pre-kharif* 2017

Treatment	Chemicals	Dosage (g or ml/ha)	Pre-treated population /sq m	% reduction in population of predator after 1st round spray						% reduction in population of predator after 2nd round spray					
				1 DAS	3 DAS	5 DAS	7DAS	10DAS	Mean	1DAS	3DAS	5DAS	7DAS	10DAS	Mean
T_1	Untreated control	--	3.67	0.00 (4.05)*	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)
T_2	Flubendiamide 90 + Deltamethrin 60 w/v SC	250	3.87	20.73 (27.07)	31.82 (34.32)	19.80 (26.41)	10.90 (19.24)	8.64 (17.08)	18.38 (25.38)	21.93 (27.91)	32.74 (34.89)	20.33 (26.79)	11.06 (12.29)	9.83 (19.70)	19.18 (25.97)
T_3	Flubendiamide90 + Deltamethrin 60 w/v SC	300	4.07	22.27 (28.13)	35.18 (36.36)	21.24 (27.45)	14.07 (22.00)	10.58 (18.94)	20.67 (27.04)	23.53 (29.00)	37.76 (37.90)	22.56 (28.34)	17.58 (13.79)	12.45 (24.74)	22.78 (28.51)
T_4	Flubendiamide 90 + Deltamethrin 60 w/v SC	400	4.00	23.86 (29.20)	38.71 (38.46)	22.91 (28.58)	17.71 (24.87)	12.62 (20.80)	23.16 (28.77)	24.42 (29.60)	39.38 (38.85)	23.49 (28.96)	19.56 (16.31)	15.41 (26.21)	24.45 (29.64)
T_5	Flubendiamide 480 SC w/v	475	4.20	16.60 (24.03)	19.27 (26.02)	12.93 (21.04)	10.20 (18.60)	8.18 (16.58)	13.44 (21.50)	17.96 (25.05)	49.02 (44.42)	15.76 (23.33)	11.80 (8.70)	10.22 (20.07)	20.95 (27.24)
T_6	Deltamethrin 100 EC	240	4.13	37.16 (37.54)	47.53 (43.57)	27.69 (31.73)	25.16 (30.08)	18.16 (25.20)	31.14 (33.92)	39.74 (39.06)	49.67 (44.79)	29.20 (32.69)	27.62 (17.34)	20.56 (31.69)	33.36 (35.28)
T_7	Flubendiamide 480 SC w/v	100	3.80	18.38 (25.37)	20.16 (26.66)	16.73 (24.12)	13.69 (21.70)	10.65 (19.00)	15.92 (23.52)	19.89 (26.46)	21.73 (27.77)	18.67 (25.57)	14.49 (8.92)	12.73 (22.35)	17.50 (24.73)
T_8	Lambda-Cyhalothrin 4.9% CS	300	4.20	13.80 (21.78)	20.44 (26.87)	14.80 (22.59)	9.87 (18.24)	8.54 (16.95)	13.49 (21.55)	15.76 (23.37)	22.02 (27.96)	15.47 (23.14)	10.36 (12.12)	9.87 (18.73)	14.70 (22.54)
T9	Imidachloprid 200 SL	100	3.67	12.38 (20.57)	15.61 (23.26)	12.38 (20.58)	8.55 (16.97)	7.84 (16.24)	11.35 (19.69)	13.51 (21.55)	15.38 (23.07)	13.47 (21.48)	9.58 (10.24)	8.67 (18.00)	12.12 (20.38)
CD (0.05)			NS	2.08	1.47	1.76	2.24	1.88		1.59	1.43	2.20	2.18	2.23	
S. Em. ±				0.69	0.49	0.58	0.74	0.62		0.53	0.47	0.73	0.72	0.74	

*Figures in the parenthesis are angular transformed value

Table 5: Effect of Flubendiamide 90% + Deltamethrin 60% SC on other predators in okra during *pre-kharif* 2018

Treatment		Dosage (g or ml/ha)	Pre-treated population/sq m	% reduction in population of predator after 1st round spray						% reduction in population of predator after 2nd round spray					
				1 DAS	3 DAS	5 DAS	7DAS	10DAS	Mean	1DAS	3DAS	5DAS	7DAS	10DAS	Mean
T_1	Untreated control	--	3.93	0.00 (4.05)*	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)	0.00 (4.05)
T_2	Flubendiamide 90 + Deltamethrin 60 w/v SC	250	3.67	21.53 (27.65)	32.80 (34.94)	20.47 (26.89)	11.57 (19.87)	8.98 (17.43)	19.07 (25.89)	22.24 (28.13)	32.87 (34.98)	20.78 (27.11)	11.87 (20.12)	10.77 (19.11)	19.71 (26.35)
T_3	Flubendiamide90 + Deltamethrin 60 w/v SC	300	4.00	23.00 (28.65)	35.51 (36.58)	21.93 (27.93)	14.40 (22.29)	11.34 (19.66)	21.24 (27.44)	23.27 (28.84)	38.09 (38.11)	22.89 (28.58)	17.84 (24.94)	12.78 (20.94)	22.97 (28.64)
T_4	Flubendiamide 90 + Deltamethrin 60 w/v SC	400	4.13	24.53 (29.68)	39.38 (38.86)	23.58 (29.05)	18.38 (25.38)	12.22 (20.46)	23.62 (29.08)	24.33 (29.55)	39.71 (39.06)	23.82 (29.20)	20.16 (26.66)	15.61 (23.27)	24.73 (29.82)
T_5	Flubendiamide 480 SC w/v	475	4.33	16.27 (23.77)	20.27 (26.75)	13.27 (21.34)	10.87 (19.21)	8.91 (17.36)	13.92 (21.90)	18.29 (25.30)	49.36 (44.63)	16.42 (23.88)	11.87 (20.14)	10.89 (19.26)	21.73 (27.53)
T_6	Deltamethrin 100 EC	240	4.53	37.82 (37.95)	47.47 (43.55)	28.36 (32.17)	24.82 (29.87)	17.82 (24.96)	31.26 (33.99)	39.38 (38.87)	50.00 (45.00)	29.53 (32.91)	27.95 (31.92)	20.89 (27.19)	33.55 (35.40)
T_7	Flubendiamide 480 SC w/v	100	3.87	18.71 (25.62)	20.82 (27.14)	17.07 (24.39)	13.36 (21.43)	11.49 (19.80)	16.29 (23.80)	20.22 (26.70)	22.07 (28.02)	19.33 (26.08)	14.82 (22.62)	12.84 (20.99)	17.86 (25.00)
T_8	Lambda-Cyhalothrin 4.9% CS	300	4.07	14.13 (22.07)	21.11 (27.35)	15.13 (22.88)	10.27 (18.62)	9.14 (17.59)	13.96 (21.94)	16.09 (23.65)	22.35 (28.21)	15.67 (23.31)	10.89 (19.22)	10.20 (18.60)	15.04 (22.82)
T9	Imidachloprid 200 SL	100	3.87	12.71 (20.88)	15.94 (23.53)	13.05 (21.17)	8.22 (16.60)	8.84 (17.30)	11.75 (20.05)	14.04 (22.01)	16.22 (23.75)	14.13 (22.06)	9.91 (18.34)	9.00 (17.45)	12.66 (20.84)
CD (0.05)			NS	1.60	1.18	1.26	2.28	1.00		1.64	1.21	1.86	2.38	1.80	
S. Em. ±				0.54	0.39	0.42	0.76	0.33		0.55	0.41	0.62	0.80	0.60	

*Figures in the parenthesis are angular transformed value

Table 6: The yield obtained from different treatments of insecticides after application of two round of spraying during *pre-kharif* season of 2017 and 2018

Insecticides	Dosage/ha Formulation (g or ml /ha)	Yield (t/ha) 2017	Yield (t/ha) 2018
T_1= Untreated control	--	4.45	5.42
T_2= Flubendiamide 90 + Deltamethrin 60 w/v SC	250	8.95	9.00
T_3= Flubendiamide 90 + Deltamethrin 60 w/v SC	300	9.75	9.50
T_4= Flubendiamide 90 + Deltamethrin 60 w/v SC	400	11.53	11.39
T_5= Flubendiamide 480 SC w/v	75	8.53	8.50
T_6= Deltamethrin 100 EC	240	7.67	8.20
T_7= Flubendiamide 480 SC w/v	100	11.18	11.25
T_8= Lambda-Cyhalothrin 4.9% CS	300	6.13	7.25
T_9= Imidachloprid 200 SL	100	8.53	8.60
CD at 5%		0.44	0.48

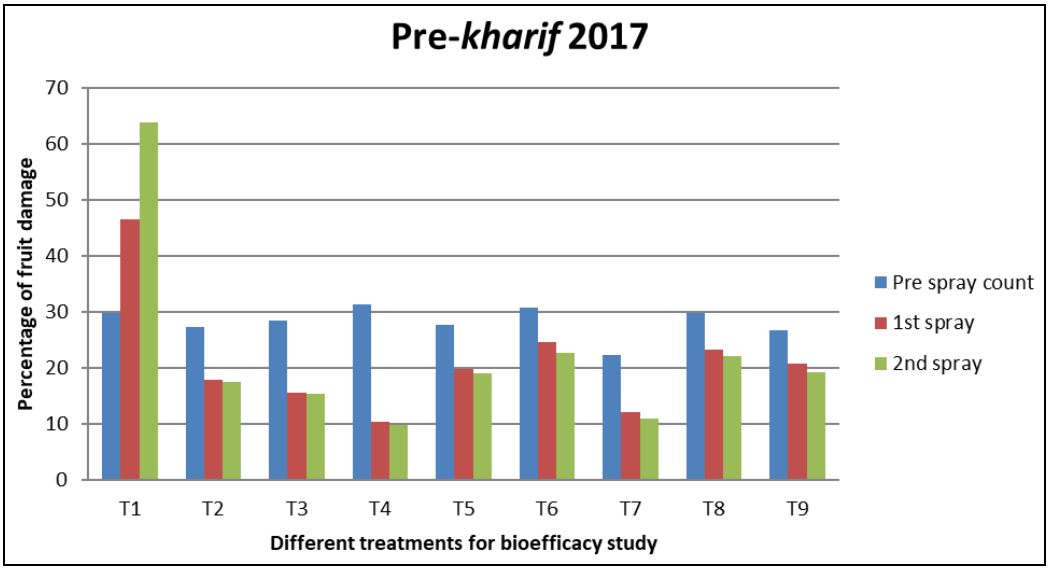

Fig. 1: Percentage of damage fruit in different treatments during pre – *kharif* 2017

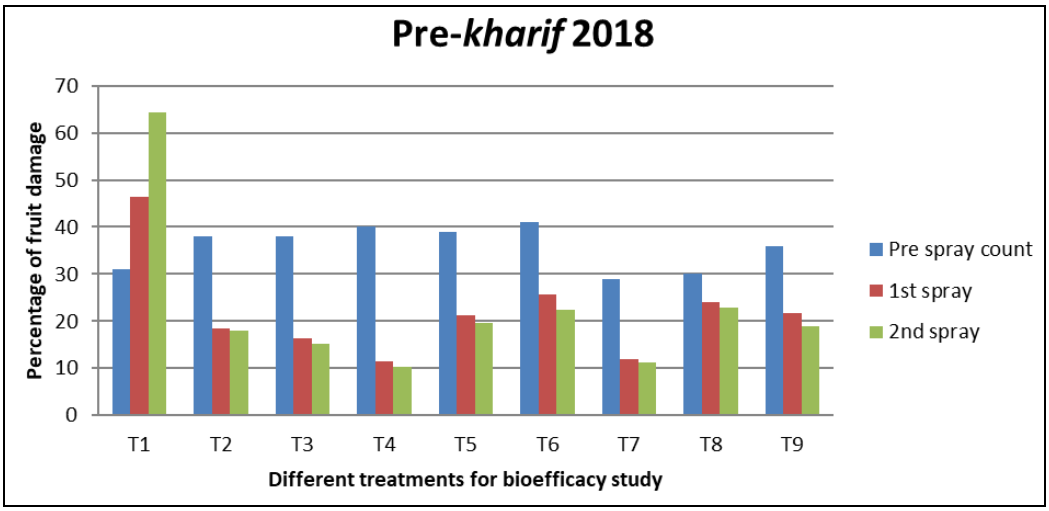

Fig 2: Percentage of damage fruit in different treatments during pre – *kharif* 2018

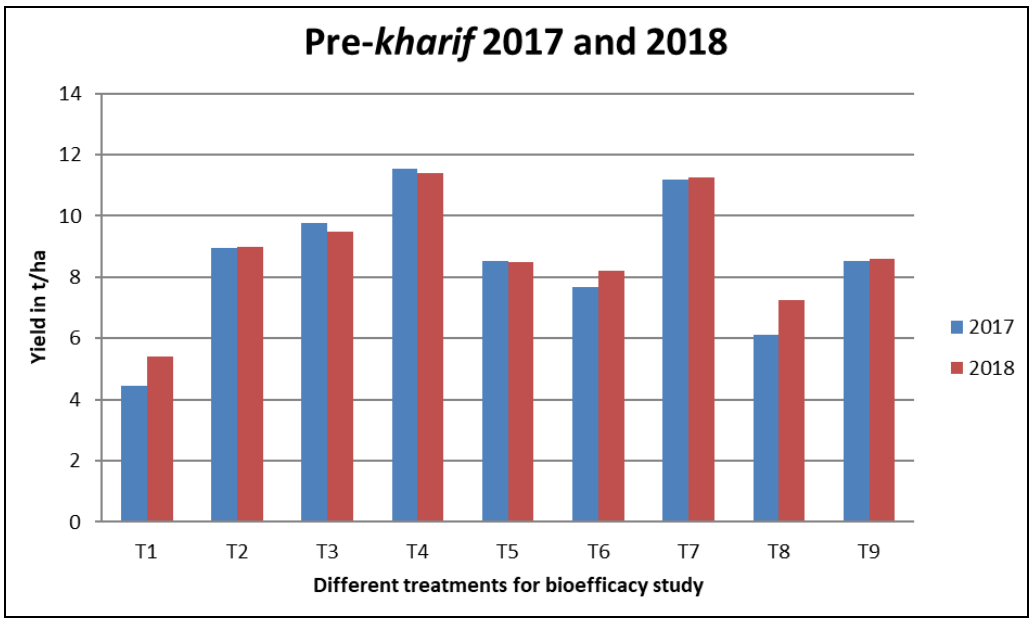

Fig 3: Yield of different treatments during *pre* – *kharif* of 2017 and 2018

4. Conclusion

The studies on bioefficacy of Flubendiamide 90% + Deltamethrin 60% SC against *Earias vitella*, of okra during *pre-kharif* 2017 and *pre-kharif* 2018 revealed that Flubendiamide 90% + Deltamethrin 60% SC @ 400 ml/ha was most effective for controlling this one of the major pest

of okra and recorded the highest yield during both year (11.53 t/ha and 11.25 t/ha respectively). The application of Flubendiamide 90% + Deltamethrin 60% SC has no adverse effects on natural enemies, thereby confirms the eco-safety.

5. Acknowledgments

The authors are grateful to 'BAYER CROP SCIENCE LTD'. For providing the financial support and Directorate of farms, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal for carrying out of this field trial at District Seed Farm, B.C.K.V., Kalyani.

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