Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2017; 5(4): 41-45
© 2017 JEZS
Received: 05-05-2017
Accepted: 04-06-2017

Ajit Tripura
College of Post Graduate Studies, CAU, Umiam, Meghalaya, India

ML Chatterjee
College of Post Graduate Studies, CAU, Umiam, Meghalaya, India

Rachna Pande
Division of Crop Protection, ICAR- Central Institute for Cotton Research, Nagpur, Maharashtra, India.

Sandip Patra
Division of Crop Protection, ICAR RC for NEH Region, Umiam, Meghalaya, India

Correspondence
Ajit Tripura
College of Post Graduate Studies, CAU, Umiam, Meghalaya, India

Biorational management of brinjal shoot and fruit borer (*leucinodes orbonalis* guenee) in mid hills of meghalaya

Ajit Tripura, ML Chatterjee, Rachna Pande and Sandip Patra

Abstract
The present field experiments were conducted to evaluate some biorational pesticides against brinjal shoot and fruit borer (BSFB) under field condition during kharif season of 2015 and 2016 at ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya, India. The treatments *viz.* chlorantraniliprole 18.5 SC (0.4ml/l), spinosad 45 SC (0.5ml/l), chlorfenapyr 10 SC (2ml/l), indoxacarb 14.5 SC (1ml/l), *Bacillus thuringiensis* (*Bt*) (2g/l), azadirachtin 0.03EC (5ml/l), *Metarhizium anisoplae* (2.5g/l), *Beauveria bassiana* (2.5g/l), chlorpyriphos 20EC (2.5 ml/l) were applied thrice at fifteen days interval starting from initiation of BSFB infestation. Mean shoot infestation was minimum in chlorantraniliprole plots (6.32%) followed by spinosad, chlorfenapyr, indoxacarb. Among bio-pesticides, *Beauveria* and *Bt* were found effective treatments in reducing shoot infestation. Chlorantraniliprole recorded lowest fruit infestation (8.25%) and highest marketable fruit yield (250.30q/ha) followed by spinosad and chlorfenapyr.

Keywords: bio rational, *leucinodes orbonalis*, chlorantraniliprole, spinosad, *bacillus thuringiensis, beauveria bassiana*

1. Introduction

Among solaneceous vegetables, brinjal (*Solanum melongena* L.) is one of the important crops grown throughout India. Eggplant is adapted to a wide range of climatic conditions, such as high rainfall and high temperatures from North to South and West to East. It is also one among the few vegetables capable of high yields in hot-wet environments [1]. Brinjal fruits are reasonable sources of vitamins and minerals. India is the second largest producer of brinjal in the world next to China. In India, brinjal covered 7.11 lakh hectare area and produced 135.58 lakh tonnes with an average productivity of 19.1 MT/ha during 2013-14 [2] where as in Meghalaya it occupied 0.96 thousand hectare and produced 13.05 thousand tonne with a productivity of only 13.59 MT/ha [3] which is much lower than national average. Insect pests infestation is one the major constraints for commercial production in all brinjal growing areas. Generally, brinjal crop attacks by many insects such as shoot and fruit borer, leafhopper, whitefly, thrips, aphid, spotted beetles, leaf roller, stem borer and blister beetle. About 27 insect pests were recorded in this area that infests the brinjal crop [4]. Among insect pests, brinjal shoot and fruit borer (BSFB) is one of the most destructive pests on eggplant in South and Southeast Asia. It is found throughout the tropics in Asia and Africa, where it can reduce yield by as much as 70% [5]. The yield reduction is reported to be around 20-30 percent [6] as high as 70 percent [7]. The BSFB caused 26.3-62.5% fruits damage in Khasi hills of Meghalaya [8]. To control this notorious pest, farmers have been using conventional insecticides injudiciously. Indiscriminate use of these insecticides for management of shoot and fruit borer of brinjal has led to development of resistance, resurgence and environmental contamination. Keeping these views in mind, the present experiments were undertaken to evaluate some biorational pesticides against BSFB.

2. Materials and Methods

Efficacy of some biorational pesticides were evaluated against brinjal shoot and fruit borer (BSFB) under field condition during kharif season of 2015 and 2016 at ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya, India. The experiments were laid out in randomized block design (RBD) with ten treatments and three replications. Chhaya variety of brinjal was sown in nursery and subsequently seedlings were transplanted in 12 m^2

m^2 area with a spacing of 60 cm (R-R) × 50 cm (P-P). The treatments *viz.* chlorantraniliprole 18.5 SC (0.4ml/l), spinosad 45 SC (0.5ml/l), chlorfenapyr 10 SC (2ml/l), indoxacarb 14.5 SC (1ml/l), *Bacillus thuringiensis* (*Bt*) (2g/l), azadirachtin 0.03EC (5ml/l), *Metarhizium anisoplae* (2.5g/l), *Beauveria bassiana* (2.5g/l), chlorpyriphos 20EC (2.5 ml/l) were applied thrice at fifteen days interval starting from initiation of BSFB infestation. Spraying was done by pneumatic knapsack sprayer using spray fluid @ 400 l/ha. Observation was taken from five randomly selected tagged plants from each plot on 1 day before and on 7, 14 days after each spray. Shoot infestation was recorded by counting infested shoot and total shoot during each observation. Infested and healthy fruits were recorded after each picking on number and weight basis from each replicated plot. Then data were subjected to suitable transformation and the critical difference (CD) was worked out at 5% level of significance.

3. Results and Discussion

3.1 Effect of some biorational pesticides on shoot infestation of brinjal during 2015 and 2016

During 2015, pretreatment shoot infestation ranged from 11.15 to 12.90% (Table 1) and it was non-significant among treatments. Results revealed that all treatments were effective against BSFB in reducing shoot infestation and superior over untreated control plots. Though, chlorantraniliprole recorded lowest mean shoot infestation (5.20%) followed by spinosad (7.36%), chlorfenapyr (9.04%) and indoxacarb (9.84%). Among bio-pesticides, *Beauveria bassiana* and *Metarhizium anisoplae* were found to be relatively effective treatments against BSFB with 12.38 and 12.69% mean shoot infestation, respectively whereas in control plots mean shoot infestation was 24.20%. Highest per cent reduction over untreated control was maximum in chlorantraniliprole treated plots (78.51%) followed by spinosad (69.58%), chlorfenapyr (62.64%), indoxacarb (59.33%) and chlorpyriphos (53.42%).

Effect of different pesticidal treatments on shoot during 2016 is presented in Table 2. Pre-treatments observation showed non-significant results among treatments and it varied from 14.10 to 16.65%. Among the insecticide treated plots, chlorantraniliprole showed lowest mean shoot infestation (7.45%) followed by spinosad (9.55%), indoxacarb (9.67%). Next best treatments were chlorfenapyr and chlorpyriphos with 10.35 and 12.67% mean shoot infestation, respectively. Among the bio-pesticides, *Bacillus thuringiensis* (13.31%) recorded lowest mean shoot infestation. Neem oil (15.05%), *M. anisoplae* (15.1%) and *B. bassiana* (15.37%) were at par with each other and significantly superior over untreated control plots (25.68%).

3.2 Effect of some biorational pesticides on fruit infestation and yield of brinjal during 2015 and 2016

Effect of different treatments on fruit infestation and yield of brinjal during 2015 is presented in Table 3. Among the insecticide treatments, chlorantraniliprole treated plots recorded lowest mean fruit infestation (8.37%) followed by chlorfenapyr (11.10%) and indoxacarb (11.47%). Among the bio-pesticides, neem recorded minimum fruit infestation (16.36%). *Metharhizium anisoplae, B. thuringiensis* and *B. bassiana* were not so effective treatments but all were superior over untreated control plots (35.23%). Maximum per cent reduction over untreated control was found in the chlorantraniliprole (76.24%) treated plots followed by chlorfenapyr (68.49%), indoxacarb (67.42%), spinosad (59.57%) and chlorpyriphos (59.04%). Among the bio-pesticides, highest per cent reduction was observed in neem oil (53.56%) followed by *M. anisoplae* (50.38%) and *B. thuringiensis* (50.18%).

During 2015, the highest marketable yield was observed in the chlorantraniliprole (258.25 q/ha) followed by spinosad (211.20 q/ha), chlorpenapyr (198.50 q/ha), chlorpyriphos (195.50 q/ha). Among the bio-pesticides, *B. thuringiensis* (170.0 q/ha) recorded maximum yield followed by *M. anisoplae* (162.00 q/ha) and *Beauveria bassiana* (157.75 q/ha) whereas in untreated control plot marketable yield was 105.60 q/ha (Table 3). During 2016, almost similar trend of efficacy against fruit infestation and yield of brinjal were observed for all treatments (Table 4).

In the present investigation, chlorantraniliprole was most effective insecticide against brinjal shoot and fruit borer. Chlorantraniprole (rynaxypyr) was the first commercialized ryanodine receptor insecticide from the anthranilic diamide class and it has insecticidal activity on a large number of lepidopteran pests and on some orders including coleopteran, diptera, isopteran and hemiptera [9]. The results are in agreement with the findings of many workers [10, 11] who reported that chlorantraniliprole was found to be the most effective treatment to control the brinjal shoot and fruit borer. Synthetic chemical targeting ryanodine receptor (Chlorantraniprole) treatments was found to be the most effective against brinjal shoot and fruit borer in eggplant crop [12]. Similar results of chlorantraniliprole were reported by many researchers earlier [13, 14]. Spinosad is highly effective on many pest species including lepidopteran, dipteran, thysanopteran pests and some coleopteran, homopteran, hymenopteran, and orthopteran species [15]. Results of efficacy of spinosad are in conformity with the findings of earlier workers [16, 17] who reported that among the treatments, spinosad was found to be most effective in reducing shoot and fruit infestation. High efficacy of spinosad against brinjal shoot and fruit borer was reported by many workers [18,19]. Chlorfenapyr was also good insecticide against this pest in reducing shoot and fruit infestation. The present findings of chlorfenapyr are in the line of many researchers [20,21,22]. Effectiveness of indoxacarb against brinjal shoot and fruit borer was reported by earlier worker [23] who reported that indoxacarb was found to be the most effective treatment against brinjal shoot and fruit borer and gave maximum fruit yield.

In the present investigation bio-pesticides were also effective treatments as compared to untreated control. It was reported that amongst *Bt* formulations, halt treated plots recorded maximum fruit yield of brinjal while delfin treatment recorded minimum fruit yield [23]. Among the bio-pesticides, foliar application of Bt @ 2 g/litre of water recorded lowest shoot and fruit infestation as well as highest marketable yield followed by NSKE (5%) [24]. Five percent NSKE was found to be the most effective treatments in reducing the whitefly and shoot and fruit borer infestation on brinjal on different spray schedule and also recorded maximum yield of brinjal [25]. Literatures regarding efficacy of microbial pesticides *viz. Metarhizium anisopliae and Beauveria bassiana* against brinjal shoot and fruit borer of brinjal are very limited, therefore, present findings may be compared with related works. It was reported that high mortality of *Ceratitis capitata* found in *M. anisopliae* treatment [26]. Entomopathogenic fungi *B. bassiana* and *Metarhizium anisopliae* could be effectively used as pest management option in production of organic tomato [27]. *M. anisopliae* was found most effective entomopathogenic fungi with minimum surviving larval population of pod borer [27]. Entomopathogenic fungi *Beauveria bassiana* is a promising and extensively researched biological control agent that can suppress a variety of economically important insect pests [28].

From the present experiment it may be concluded that chlorantraniliprole is the best insecticides among treatments for effective management of brinjal shoot and fruit borer followed by spinosad. Among bio-pesticides, *Bt* and neem oil may be incorporated for integrated management practices of brinjal shoot and fruit borer.

Table 1: Effect of some biorational pesticides on shoot infestation of brinjal during 2015

Treatment	Dose ml or gm/L	Percent shoot infestation (Days after each spray)							Mean shoot infestation (%)	% protection over untreated control
		Pre-treatment damage (%)	Spray I		Spray II		Spray III			
			7 DS1	14 DS1	7 DS2	14 DS2	7 DS3	14 DS3		
Chlorantraniliprole	0.3 ml/L	12.20 (20.44)	7.75 (17.21)	8.25 (17.71)	5.60 (14.89)	4.10 (13.05)	3.25 (11.90)	2.30 (10.47)	5.20	78.51
Spinosad	0.5 ml/L	11.20 (19.55)	9.28 (18.70)	8.20 (17.66)	7.00 (16.43)	6.78 (16.20)	6.65 (16.06)	6.25 (15.62)	7.36	69.58
Chlorfenapyr	2 ml/L	12.90 (21.05)	8.35 (17.80)	7.70 (17.15)	8.76 (18.20)	9.50 (18.91)	10.23 (19.58)	9.75 (19.14)	9.04	62.64
Indoxacarb	1 ml/L	11.80 (20.09)	8.72 (18.17)	9.23 (18.65)	9.23 (18.65)	10.38 (19.72)	11.25 (20.49)	10.25 (19.60)	9.84	59.33
Bacillus thuringiensis	2 gm/L	11.75 (20.05)	11.24 (20.48)	10.50 (19.82)	14.44 (23.14)	16.50 (24.73)	18.50 (26.21)	16.75 (24.92)	14.65	39.46
Neem oil	5 ml/L	12.85 (21.01)	10.25 (19.60)	10.25 (19.60)	16.60 (24.80)	16.50 (24.73)	17.25 (25.29)	19.80 (27.13)	15.10	37.60
Metarhizium anisoplae	2.5 gm/L	12.45 (20.66)	11.00 (20.27)	10.65 (19.96)	11.50 (20.70)	13.00 (21.97)	14.70 (23.34)	15.30 (23.81)	12.69	47.56
Beauveria bassiana	2.5 gm/L	11.80 (20.09)	8.00 (17.46)	9.75 (19.14)	11.30 (20.53)	12.50 (21.56)	15.45 (23.93)	17.25 (25.29)	12.38	48.84
Clorpyriphos	2.5 ml/L	12.50 (20.70)	9.50 (18.91)	10.25 (19.60)	11.75 (20.92)	11.00 (20.27)	12.10 (21.22)	13.00 (21.97)	11.27	53.42
Control	-	11.85 (20.14)	11.80 (20.96)	14.30 (23.03)	20.60 (27.69)	29.45 (33.49)	32.65 (35.46)	36.40 (37.70)	24.20	-
SE. m ±	-	N.S	0.78	0.58	0.56	0.53	0.50	0.47	-	-
CD at 5%	-	-	2.31	1.71	1.61	1.58	1.48	1.39	-	-

Figures in parentheses are angular transformed value * Means refers to post count observations, NS- Non significant; DS_1- Days after first spray, DS_2- Days after second spray, DS_3- Days after third spray * significant at 5% level

Table 2: Effect of some biorational pesticides on shoot infestation of brinjal during 2016

Treatments	Percent shoot infestation (days after each spray)							Mean shoot Infestation (%)	% Protection over control
	Pre-treatment damage	Spray – I		Spray – II		Spray – III			
		7 DS1	14 DS1	7 DS2	14 DS2	7 DS3	14 DS3		
Chlorantraniliprole	15.65 (23.30)	12.60 (21.64)	10.50 (19.82)	7.75 (17.21)	5.75 (15.06)	4.30 (13.31)	3.80 (12.66)	7.45	70.98
Spinosad	14.10 (22.06)	12.45 (21.51)	11.15 (20.40)	10.40 (19.73)	8.45 (17.90)	7.30 (16.74)	7.60 (17.05)	9.55	62.81
Chlorfenapyr	16.25 (23.77)	12.75 (21.77)	13.20 (22.14)	9.35 (18.77)	8.60 (18.05)	10.75 (20.05)	7.50 (16.95)	10.35	59.69
Indoxacarb	16.00 (23.58)	13.20 (22.14)	11.20 (20.44)	8.40 (17.85)	7.30 (16.74)	9.70 (19.90)	8.25 (17.71)	9.67	62.34
Bacillus thuringiensis	15.55 (23.22)	13.35 (22.26)	13.60 (22.46)	14.40 (23.11)	13.40 (22.30)	11.70 (20.88)	13.45 (22.34)	13.31	48.16
Neem oil	15.25 (22.99)	13.20 (22.14)	14.30 (23.03)	15.20 (23.73)	15.65 (24.08)	16.25 (24.54)	15.75 (24.16)	15.05	41.39
Metarhizium anisoplae	15.00 (22.79)	15.10 (23.66)	16.15 (24.46)	16.30 (24.58)	14.25 (22.99)	14.25 (22.99)	14.75 (13.55)	15.1	41.19
Beauveria bassiana	16.65 (24.01)	16.40 (24.65)	15.25 (23.77)	14.00 (22.79)	16.75 (24.92)	16.30 (24.58)	13.55 (22.42)	15.37	40.14
Clorpyriphos	15.75 (23.38)	15.55 (24.01)	12.00 (21.13)	15.60 (24.04)	11.25 (20.49)	10.40 (19.73)	11.25 (20.49)	12.67	50.66
Control	14.10 (22.06)	16.15 (24.46)	21.50 (28.32)	21.80 (28.52)	28.60 (32.96)	32.25 (35.21)	33.60 (36.03)	25.68	-
SE. m ±	N.S	0.45	0.40	0.43	0.2	0.24	0.51	-	-
CD at 5%	-	1.35	1.20	1.27	0.60	0.73	1.52	-	-

Figures in parentheses are angular transformed value * Means refers to post count observations, NS- Non significant; DS_1- Days after first spray, DS_2- Days after second spray, DS_3- Days after third spray * significant at 5% level

Table 3: Effect of some biorational pesticides on fruit infestation and yield of brinjal during 2015

Treatment	Mean percent fruit infestation after different pickings					Cumulative mean % fruit-infestation	% protection over control	Yield of marketable fruits (q/ha)	Yield of damaged fruits (q/ha)	Percent damaged fruits (weight basis)	Total Gross) fruit yield (q/ha)
	First	Second	Third	Fourth	Fifth						
Chlorantraniliprole	15.10 (23.66)	8.25 (17.71)	9.40 (18.81)	6.35 (15.73)	2.75 (11.17)	8.37	76.24	258.25	20.45	7.33	278.70
Spinosad	17.25 (25.29)	17.00 (25.10)	15.20 (23.73)	11.20 (20.44)	10.55 (19.87)	14.24	59.57	211.20	36.10	14.59	247.30
Chlorfenapyr	14.10 (22.87)	12.75 (21.77)	12.05 (21.18)	8.60 (18.05)	8.00 (17.46)	11.10	68.49	198.50	35.25	15.08	233.75
Indoxacarb	15.20 (23.73)	13.75 (22.59)	12.40 (21.47)	7.75 (17.21)	8.25 (17.71)	11.47	67.42	187.75	28.70	13.25	216.45
Bacillus thuringiensis	19.10 (26.64)	17.65 (25.59)	17.00 (25.10)	19.40 (26.85)	14.60 (23.26)	17.55	50.18	170.00	36.20	13.80	206.20
Neem oil	18.40 (26.13)	14.35 (23.07)	13.65 (22.50)	16.40 (24.65)	19.00 (26.57)	16.36	53.56	168.50	30.15	15.17	198.65
Metarhizium anisoplae	19.15 (26.67)	17.45 (25.44)	16.25 (24.54)	16.00 (24.35)	18.55 (26.24)	17.48	50.38	162.00	32.50	16.70	194.50
Beauveria bassiana	18.75 (26.39)	20.25 (27.45)	19.00 (26.57)	15.65 (24.08)	16.25 (24.54)	17.98	48.96	157.75	33.25	17.40	191.00
Clorpyriphos	17.25 (25.29)	14.50 (23.18)	16.25 (24.54)	11.65 (20.83)	12.50 (21.56)	14.43	59.04	195.50	26.9	12.09	222.40
Control	28.70 (33.02)	31.65 (34.85)	42.85 (41.47)	38.60 (39.00)	34.35 (36.48)	35.23	-	105.60	59.85	36.17	165.45
SE. m ±	0.32	0.44	0.37	0.44	0.48		-	5.67			7.28
CD at 5%	0.94	1.31	1.07	1.30	1.43		-	16.83			21.62

Figures in parentheses are angular transformed values; * Means refers to post count observations, * significant at 5% level

Table 4: Effect of some biorational pesticides on fruit infestation and yield of brinjal during 2016

Treatment	Mean percent fruit infestation after different pickings					Cumulative mean % fruit infestation	% protection over control	Yield of marketable fruits (q/ha)	Yield of damaged fruits (q/ha)	Percent damaged fruits (weight basis)	Total (Gross) fruit yield (q/ha)
	First	Second	Third	Fourth	Fifth						
Chlorantraniliprole	12.35 (21.43)	10.50 (19.82)	7.75 (17.21)	7.00 (16.43)	3.20 (11.83)	8.13 (17.59)	74.37	242.5	24.0	9.0	266.5
Spinosad	16.00 (24.35)	19.25 (26.74)	12.50 (21.56)	12.00 (21.13)	11.65 (20.83)	14.28 (23.01)	54.99	213.25	25.75	10.77	239.0
Chlorfenapyr	17.45 (24.55)	14.00 (22.79)	14.45 (23.15)	9.00 (18.43)	10.35 (19.69)	13.05 (22.01)	58.87	207.40	30.1	12.67	237.5
Indoxacarb	13.45 (22.34)	10.65 (19.96)	10.40 (19.73)	8.35 (17.80)	7.00 (16.43)	9.97 (19.34)	68.57	211.50	29.5	12.24	241.0
Bacillus thuringiensis	21.25 (28.14)	18.45 (26.17)	16.20 (24.50)	14.55 (23.22)	13.65 (22.60)	16.82 (24.97)	46.99	166.25	33.25	16.66	199.5
Neem oil	22.25 (28.83)	16.35 (24.62)	14.00 (22.79)	17.25 (25.29)	18.65 (26.31)	17.7 (25.62)	44.21	159.0	29.6	15.69	188.6
Metarhizium anisoplae	21.55 (28.35)	19.65 (27.03)	19.00 (26.57)	15.35 (23.85)	17.75 (25.66)	18.66 (26.32)	13.07	154.5	30.2	16.35	184.7
Beauveria bassiana	22.50 (29)	21.55 (28.35)	18.65 (26.31)	16.80 (24.95)	15.35 (23.85)	18.97 (26.54)	40.21	149.7	30.3	16.83	180.0
Clorpyriphos	19.35 (26.81)	19.00 (26.57)	15.25 (23.77)	13.00 (21.97)	11.20 (20.44)	15.56 (24.01)	50.96	187.8	25.6	11.99	213.4
Control	26.45 (31.60)	29.65 (33.62)	34.60 (36.63)	35.55 (37.20)	32.40 (35.30)	31.73 (34.90)	-	119.0	37.0	23.71	156.0
SE. m ±	0.2	0.23	0.14	0.29	0.97	0.32	-	5.73	-	-	6.44
CD at 5%	0.59	0.68	0.41	0.88	2.89	0.95	-	17.01	-	-	19.12

Note: Figures in parentheses are angular transformed values; * Means refers to post count observations, * significant at 5% level

4. Acknowledgement

The authors are highly grateful to the Director, ICAR Research Complex for North Eastern Hill Region, Umiam, Meghalaya for providing the facilities required to conduct this experiment.

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