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Sujit Kumar Karmakar
Department of Agricultural Entomology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Snigdha Samanta
Department of Agricultural Entomology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Koushik Sen
Department of Agricultural Entomology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Arpana Manger
Department of Agricultural Entomology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Gayatri Kumari Padhi
Department of Agricultural Entomology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Umesh Das
Uttar Banga Krishi Viswavidyalaya, Cooch Behar, West Bengal, India

Arunava Samanta
Department of Agricultural Entomology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Correspondence
Snigdha Samanta
Department of Agricultural Entomology, Faculty of Agriculture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India

Bio-pesticidal management of brinjal shoot and fruit borer, *Leucinodes orbonalis* (Guen.)

Sujit Kumar Karmakar, Snigdha Samanta, Koushik Sen, Arpana Manger, Gayatri Kumari Padhi, Umesh Das And Arunava Samanta

Abstract
Field investigation was conducted to evaluate the efficacy of some biopesticides against shoot and fruit borer (*Leucinodes orbonalis* Guen.) on brinjal during *Rabi* season in 2015-2016. Among the treatments, Azadirachtin 1% EC @ 2ml/L was found superior than other treatments with 10.92% mean shoot infestation and 10.04% mean fruit infestation, respectively followed by Karanjin 2% EC @ 2ml/L (13.42% shoot and 12.83% fruit infestation). Azadirachtin 1% EC @ 2ml/L also registered as highest marketable fruit yield (38.75 q/ha). It can be concluded that Azadirachtin could be proved effective in the management of brinjal shoot and fruit borer under organic farming and IPM programmes.

Keywords: Biopesticides, efficacy, brinjal, *Leucinodes orbonalis*

1. Introduction
Vegetables are important constituents of Indian agriculture and nutritional security due to their short duration, high yield, nutritional richness, economic viability and ability to generate on-farm and off- farm employment [8]. Among the vegetable grown in India, Eggplant (*Solanum melongena* L.) is the most popular and economically important vegetable in Asia. Brinjal is one of the three most important vegetable species cultivated in South Asian region (India, Bangladesh, Nepal and Sri Lanka) accounting for almost 50% of the worlds area under its cultivation [1]. As per statistics [4], China is the top producer (58% of world output) while India ranks second (25%) in brinjal production. Insect pests are one of the important biotic factors which greatly affect the quality and productivity of brinjal crop through inflicting a direct damage [5]. In the tropics, brinjal production is severely affected by several insect and mite pests. The quit essential insect pests of brinjal include fruit and shoot borer (BSFB), whitefly, leafhopper, thrips, aphid, spotted beetles, leaf roller, stem borer, blister beetle, red spider mite, etc. [2]. Whitefly (*Bemicia tabaci*) and shoot and fruit borer (*Leucinodes orbonalis*) are the two destructive pests of brinjal causing substantial yield loss. Infestation due to this pest recorded 4.33 to 6.54 per cent shoot damage and 52.3 per cent fruit damage irrespective of the plantings month [7]. The loss caused by this pest was estimated to range from, 70-92 per cent in the fruit yield [6].
Therefore, without proper plant protection it is impossible to maintain the balance between enormous population and increasing demand of food. Though we are adopting various plant protection technologies but nothing is long lasting and ultimately farmer community rely on pesticides to protect their crops. In terms of monetary value, the Indian agriculture currently sets back at an annual loss of about Rs. 8, 63,884 million due to insect pests [3]. The use of synthetic chemical pesticides had been the widely used approach for reducing the estimated 45% gross crop loss due to pests and diseases, amounting to around Rs. 290 billion per annum. More and more quantities of chemicals are used for agricultural intensification to feed an ever growing population. In fact, the pest induced loss is on the rise despite increasing usage of pesticides. Fortunately, realization of the negative effects of these chemicals on nature and natural resources like pollution, pesticide residue, pesticide resistance etc., has forced many to shift focus on to more reliable, sustainable and environment friendly agents of pest control, the bio-pesticides. So, there is a very urgent need for alternative approaches for maintaining the insect pests. The biopesticides must be evaluated for effective control of the insect pests and along with that sustainable environmental management and maintenance of food quality.

2. Materials and methods

2.1 Experimental location

The experiment was carried out at the University Experimental Farm, 'C' Unit, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during *Rabi* season of 2015-16.

2.2 Experimental Layout

The field experiments were laid out in Randomized Block Design (RBD) comprising 9 treatments including controls with 3 replications for each. Total area of each plot was about 12 sq. m (4 m x 3 m) and total number of plots was 27. Thirty days old seedlings were transplanted in the experimental plots on 28 September, 2015. The seedlings were transplanted at a spacing of 50 x 60 cm. Spraying was done by using an air compressing knapsack sprayer for brinjal crop. First spray was given by the appearance of target pests i.e. 60 days after transplanting and subsequently second spray was applied after 15 days of first spray. For the experiment spray water was applied @ 500 litres/ha.

2.3 Observations

Before each spray an observation on pest populations were taken from 5 plants/plot for recording fruit and shoot borer infestation and then three observations were taken at the intervals of 3, 7 and 10 days after each spraying. The data recorded on different parameters were calculated using the following formula:

$$\% \text{ plant/shoot/fruit infestation} = \frac{\text{Number of infested plant/shoot/fruit}}{\text{Total number of plant/shoot/fruit}} \times 100$$

$$\% \text{ increase or decrease over control} = \frac{\text{Mean value of treated plot-Mean value of untreated plot}}{\text{Mean value of untreated plot}} \times 100$$

2.4 Statistical Analysis

Mean percent of shoot and fruit infestation and marketable yield of brinjal fruits were calculated for statistical analysis. The data were subjected to angular transformation and the critical difference (CD) at the 5% level of significance was worked out from the data of pest population build up before and after each treatment of two consecutive sprays.

3. Results and Discussion

3.1 Shoot infestation

The data presented in Table 1 revealed that there were no pronounced differences in mean percent shoot infestation among the treatments before the application of bio pesticides and the mean percent of shoot infestation a day before spraying ranged from 21.67 to 23.33%. The observations taken on 3rd, 7th and 10th days after spraying revealed that all the bio pesticides treatments were found to be superior over control in reducing shoot infestation. Azadirachtin recorded lowest shoot infestation i.e. 11.08% followed by karanjin, *Beauveria bassiana*, *Metarhizium anisopliae*, *Verticillium lecanii*, Annonin, *Bacillus thuringiensis* var. *kurstaki* and Yam bean seed extract with shoot infestation of 13.08, 16.33, 20.67, 23.58, 25.08, 25.67, 26.83 per cent, respectively. The untreated plot showed the highest level of shoot infestation with a mean of 35.33% and was found significantly different from other treatments. Azadirachtin @ 2ml/L and Karanjin @ 2ml/L showed the highest level of control over other treatments and were found statistically at par. *Bacillus thuringiensis* var. *kurstaki* @ 2g/L, *Verticillium lecanii* @ 5g and Annonin @ 2ml/L were statistically at par but are significantly different from other treatments especially Azadirachtin @ 2ml/L, Karanjin @ 2ml/L and *Metarhizium anisopliae* @ 5g/L. After second spraying almost all the bio pesticides treatments were found to be superior over control in reducing shoot infestation and also significantly different from each other.

The overall mean shoot infestation revealed that the lowest infestation was recorded in Azadirachtin @ 2ml/L (10.92%) with highest protection over control (68.85%) followed by karanjin (13.42%), *Beauveria bassiana* (16.29%), *Metarhizium anisopliae* (20.67%), *Verticillium lecanii* (23.79%), Annonin (24.88%), *Bacillus thuringiensis* var. *kurstaki* (25.71%) and Yam bean seed extract (26.54%). Whereas, in untreated plot shoot infestation was (35.04%). There was significant difference between all the treatments while Azadirachtin @ 2ml/L (10.92%) recorded the lowest shoot infestation was found statistically at par with.

Table 1: Effect of different Bio pesticides against *Leucinodes orbonalis* Guen. on per cent shoot infestation

Treatments	Dose (ml/L or g/L)	Mean percent shoot infestation of *L. orbonalis* on brinjal										Mean Infestation	% reduction over control
		First spray					Second spray						
		Pre-treatment count	3 DAS	7 DAS	10 DAS	Mean	Pre-treatment count	3 DAS	7 DAS	10 DAS	Mean		
Bacillus thuringiensis var. kurstaki	2g	21.67a (27.65)	29fg (32.59)	26d (30.47)	26e (30.66)	25.67ef (30.34)	24a (29.27)	26.33f (30.89)	26.33f (30.86)	26.33ef (30.85)	25.75fg (30.47)	25.71fg	26.63
Verticillium lecanii	5g	22a (27.91)	26e (30.65)	24.33cd (29.46)	22e (27.95)	23.58e (28.99)	23.33a (28.86)	23.67e (29.1)	24.67e (29.78)	24.33e (29.53)	24e (29.32)	23.79e	32.10
Metarhizium anisopliae	5g	22a (27.95)	21 (27.26d)	21.33c (27.4)	18.33c (25.33)	20.67d (26.99)	22.67a (28.44)	19d (25.84)	21d (27.28)	20d (26.55)	20.67d (27.03)	20.67d	41.02
Azadirachtin 1% EC	2ml	21.67a (27.7)	7a (15.32)	7.67a (15.94)	8a (16.38)	11.08a (18.84)	22.67a (28.4)	5.67a (13.73)	7.67a (15.99)	7a (15.25)	10.75a (18.34)	10.92a	68.85
Annonin 1% EC	2ml	22.33a (28.18)	28f (31.96)	25.67d (30.27)	24.33de (29.56)	25.08ef (29.99)	23.67a (29.06)	24.47e (29.79)	25e (29.99)	25.33ef (30.19)	24.67ef (29.76)	24.88ef	29.01
Beauveria bassiana	5g	23.33a (28.82)	14c (21.95)	15.33b (22.94)	12.67b (20.84)	16.33c (23.64)	23.67a (29.06)	13.33c (21.41)	14.33c (22.24)	13.67c (21.63)	16.25c (23.58)	16.29c	53.51
Karanjin 2% EC	2ml	22.67a (28.34)	10b (18.39)	10a (18.24)	9.67a (18.1)	13.08b (20.77)	25.33a (30.17)	9.33 (17.79b)	10.67b (19.07)	9.67b (18.06)	13.75b (21.27)	13.42b	61.71
Yam bean seed extract 5% EC	5ml	22.67a (28.42)	30.33g (33.43)	27.67d (31.57)	26.67e (31.09)	26.83f (31.13)	23.67a (29.08)	27 (31.32f)	27.33f (31.53)	27f (31.27)	26.25g (30.8)	26.54g	24.26
Untreated control	-	22.67a (28.39)	42h (40.41)	38.33e (38.21)	38.33f (38.27)	35.33g (36.32)	24.67a (29.75)	37.33 (37.68g)	39.67g (39.04)	37.33g (37.63)	34.75h (36.03)	35.04h	-
S.Em ±	-	-	0.35	0.86	0.66	0.66	-	0.33	0.47	0.47	0.32	-	NA
CD at 5%	-	-	1.04	2.58	1.98	1.86	-	0.99	1.41	1.42	0.89	-	NA

DAS = Days after spray, Figures in the parentheses are the angular transformed values, NA=Not Applicable, S. Em ± = Standard error of mean, CD (critical Difference) at 5 per cent level of significance figures marked with common letter are not significantly different from each other according to Duncans Multiple Range Test P ≤ 0.05%.

Bacillus thuringiensis var. *kurstaki* and Annonin. The untreated control showed up with highest mean shoot infestation i.e 35.04%. The data commensurate that highest reduction over control was achieved by Azadirachtin @ 2ml/L i.e 68.85% followed by karanjin (61.71%), *Beauveria bassiana* (53.51%), *Metarhizium anisopliae* (41.02%), *Verticillium lecanii* (32.10%), *Bacillus thuringiensis* (26.63%) and Yam bean seed extract (24.26%). It's revealed that all the treatments were found to be effective than the control plots.

3.2 Fruit infestation

The data of Table 2 revealed that there were no pronounced differences in mean percent fruit infestation among the treatments before the application of bio pesticides. The mean percent of fruit infestation a day before spraying ranged from 21.0 to 24.0%. The mean infestation of fruits recorded after 3days, 7days and 10days of the first spray recorded that Azadirachtin was recorded lowest fruit infestation (10.75%), followed by karanjin (12.58%), *Beauveria bassiana* (15.58%), *Metarhizium anisopliae* (19.92%), *Verticillium lecanii* (23.33%), Annonin (24.67%), *Bacillus thuringiensis* var. *kurstaki* (25.83%) and Yam bean seed extract (26.83%). While the mean fruit infestation in the untreated control was found to be 35.17%. Azadirachtin was found to be statistically different from other treatments but Karanjin was found statistically at par with it. *Bacillus thuringiensis* var. *kurstaki* and *Verticillium lecanii* were found to be statistically at par with each other and in the same way Anonin and Yam bean seed extract were found to be statistically at par. The observations taken after second spraying revealed that the mean fruit infested was accounted to be lowest in case of plots treated with Azadirachtin (11.83%), followed by karanjin (14.42%), *Beauveria bassiana* (16.50%), *Metarhizium anisopliae* (21.50%), *Verticillium lecanii* (23.92%), Annonin(25.17%), *Bacillus thuringiensis* var. *kurstaki* (26.08%) and Yam bean seed extract (26.83%). Azadirachtin was found to be significantly different from others and also was very effective over control. All the treatments were found to be statistically at par else Annonin and *Bacillus thuringiensis* var. *kurstaki* were statistically at par. The mean fruit infestation

Table 2: Effect of different Bio pesticides against *Leucinodes orbonalis* Guen. on per cent fruit infestation

Treatments	Dose (ml/L or g/L)	Mean percent fruit infestation of *L. orbonalis* on brinjal										Overall mean	% reduction over control
		First spray					Second spray						
		Pre-treatment count	3 DAS	7 DAS	10 DAS	Mean	Pre-treatment count	3 DAS	7 DAS	10 DAS	Mean		
Bacillus thuringiensis var. kurstaki	2g	21.67a (27.65)	29fg (32.59)	26d (30.47)	26e (30.66)	25.67 (30.34)ef	23.33a (28.78)	27.67f (31.72)	25f (29.94)	24ef (29.32)	25fg (29.94)	24.37fg	28.40
Verticillium lecanii	5g	22a (27.91)	26e (30.65)	24.33cd (29.46)	22e (27.95)	23.58e (28.99)	22.67a (28.40)	23.33e (28.83)	23e (28.65)	22.33e (28.18)	22.83e (28.51)	21.79e	35.98
Metarhizium anisopliae	5g	22a (27.95)	21 (27.26d)	21.33c (27.4)	18.33c (25.33)	20.67d (26.99)	23a (28.65)	22.33d (28.18)	21.67d (27.74)	19.67d (26.30)	21.66d (27.71)	20.79d	38.92
Azadirachtin 1% EC	2ml	21.67a (27.7)	7a (15.32)	7.67a (15.94)	8a (16.38)	11.08a (18.84)	22.67a (28.38)	7.67a (16.02)	6a (14.15)	6.67a (14.93)	10.75a (18.37)	10.04a	70.50
Annonin 1% EC	2ml	22.33a (28.18)	28f (31.96)	25.67d (30.27)	24.33de (29.56)	25.08ef (29.99)	23.67a (29.08)	26e (30.65)	24e (29.31)	23.33ef (28.88)	24.25ef (29.47)	24.04ef	29.37
Beauveria bassiana	5g	23.33a (28.82)	14c (21.95)	15.33b (22.94)	12.67b (20.84)	16.33c (23.64)	22.33a (29.09)	17c (24.34)	15.33c (23.05)	14.33c (22.21)	17.25c (24.42)	16.5c	51.52
Karanjin 2% EC	2ml	22.67a (28.34)	10b (18.39)	10a (18.24)	9.67a (18.1)	13.08b (20.77)	25a (29.95)	11.33 b (19.65)	9.67b (18.08)	9b (17.35)	13.75b (21.25)	12.83b	62.30
Yam bean seed extract 5% EC	5ml	22.67a (28.42)	30.33g (33.43)	27.67d (31.57)	26.67e (31.09)	26.83f (31.13)	24.33a (29.52)	27.67 f (31.71)	25f (29.99)	24.67f (29.76)	25.41g (30.24)	25.25g	25.82
Untreated control	-	22.67a (28.39)	42h (40.41)	38.33e (38.21)	38.33f (38.27)	35.33g (36.32)	23.67a (29.08)	39 g (38.64)	36.33g (37.02)	35.67g (36.54)	33.66h (35.32)	34.04h	-
S.Em ±	-	-	0.35	0.86	0.66	-	-	0.44	0.74	0.94	-	-	NA
CD at 5%	-	-	1.04	2.58	1.98	-	-	1.33	2.20	2.82	-	-	NA

DAS = Days after spray, Figures in the parentheses are the angular transformed values, NA=Not Applicable, S. Em ± = Standard error of mean, C D (critical Difference)at 5 per cent level of significance figures marked with common letter are not significantly different from each other according to Duncans Mutliple Range Test P ≤ 0.05%.

after two sprays revealed that the lowest infestation is recorded in Azadirachtin @ 2ml/L (10.04%) with highest protection over control (67.78%) as well as significantly different than other treatments, followed by karanjin, *Beauveria bassiana*, *Metarhizium anisopliae*, *Verticillium lecanii*, Annonin, *Bacillus thuringiensis* var. *kurstaki* and Yam bean seed extract with 13.50, 16.04, 20.71, 23.63, 24.92, 25.96 and 26.83% respectively. In an overall view Annonin and *Bacillus thuringiensis* var. *kurstaki* were found to be statistically at par. Whereas, in untreated plot mean fruit infestation was (35.04%). Murugesan and Murugesh [6] and Samota *et al.* [8] cited that Azadirachtin provided effective control over Brinjal fruit and shoot borer in both fruit and shoot infestation which corroborates the present findings.

3.3 Effect on marketable yield of Brinjal

From Table 3, it is evident that the effect of different treatments on marketable yield of Brinjal. The best results were attained in the plots treated with Azadirachtin 1% EC @ 2ml/L i.e. 38.75 q/ha followed by Karanjin 2% EC @ 2ml/L i.e. 36.24 q/ha. The untreated plot resulted with lowest yield i.e. 24.56 q/ha and also was found to be significantly at par with all other treatments. All the treatments were found to be significantly at par with each other

Table 3: Effect on marketable yield of Brinjal

Treatments	Dose ml/L or g/L	Marketable yield (q/ha)
Bacillus thuringiensis var. kurstaki	2g	26.34
Verticillium lecanii	5g	33.87
Metarhizium anisopliae	5g	35.98
Azadirachtin 1% EC	2ml	38.75
Annonin 1% EC	2ml	29.76
Beauveria bassiana	5g	35.21
Karanjin 2% EC	2ml	36.24
Yam bean seed extract 5% EC	5ml	25.88
Untreated control	-	24.56
S.Em ±	-	1.14
CD at 5%	-	1.01

4. Conclusion

It can be concluded from the present findings that as all the tested biopesticides were safe to the environment and also very effective in the management of certain insect pests which are noxious, they can be more efficiently incorporated into the management of insect pests in organic farming and Integrated Pest Management Programme (IPM).

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