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Evaluation of some novel insecticides on brinjal fruit and shoot borer (BFSB) in West Bengal, India

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Abstract
Brinjal fruit and shoot borer (BFSB) is the major threat for brinjal cultivation throughout the globe. It can causes 100% yield loss if proper management strategies are not taken. The larva is the damaging stage can cause shoot and fruit damage. Here the experiment was conducted to evaluate the efficacy of some new insecticides against this notorious insect pest and it has found that Emamectin benzoate 1% + Cartap hydrochloride 25% SG @ 1500g/ha and 1750g/ha gave the best results than other treatments.

Keywords: BFSB, yield loss, emamectin benzoate, cartap hydrochloride

Introduction
Brinjal (*Solanum melongena* L.) commonly known as eggplant is one of the most important and popular Solanaceous vegetables in South and South-East Asia (Thapa, 2010) [1]. It prefers hot and humid climatic conditions or its growth and development (Hanson *et al*., 2006) [2]. This crop was domesticated from the Indo-Pak Subcontinent region of the globe (Dunlop, 2006) and it occupies a huge area in world estimated about more than 1,600,000 ha and production is 50 million tonns (FAO, 2012) [3]. It has reported that Brinjal is very much prone to attack many insect pests like brinjal shoot and fruit borer (*Leucinodes orbonalis*), coccinelide beetle (*Epilachna vigintioctopunctata*), jassid *(Amrasca bigutulla bigutulla*), aphid (*Aphis gossyppii*) and white fly (*Bemisia tabaci*). Among them Brinjal fruit and shoot borer is very dangerous and noxious insect pest causing havoc yield loss (Latif *et al*., 2009) [4, 5]. In 1854, brinjal shoot and fruit borer was first designated as *Leucinodes orbonalis* by Guenee (Capps, 1948) [6]. Larva is the only damaging stage of this pest which feeds inside the fruit and form large exit holes in the fruits for pupation after complete development, later decreasing the market value of the fruits and rendering them unfit for human consumption (Alam *et al.*, 2003) [7]. The primary damage initiates at seedling stage of the crop and continues till the fruit harvesting. The eggs are laid just undersurface of the leaves and after hatching the first instar larva bores into petioles and midribs of large leaves and young shoots, at the initial stages of plant growth, leads to closing the entry holes with their frass and continue their feeding inside the shoot (Butani and Jotwani, 1984) [9]. and then take entry within the fruits which causes finally drooping and withering of the shoot (Alam and Sana, 1962) [10]. which in turn make the fruit unfit for consumption and reduces its quality and market value. Among the elements in charge of low yield of brinjal, brinjal shoot and fruit borer (BSFB), *Leucinodes orbonalis* is the most genuine one, which may cause 100% damage if no control measures are connected (Rahman, 2007). [11]. This pest may decrease the product yield up to 60-70% (Singh and Nath, 2010) [12]. Lot of research work was carried out against this insect pest and it was established that on average a larva can infest 4 to 7 fruits during itslife span (Jayaraj and Manisegaran, 2010) [13]. Infestation by this pest results in serious problem in lowering the content of vitamin C in the fruit up to 80 percent (Sharma, 2002) [16, 17]. Keeping this view in mind, henceforth the present experiment was conducted to study the efficacy of some new generation insecticides against this noxious insect pest and to find the best insecticide which keep this pest population very low.

Materials and Methods
The present experiment was conducted in District Seed Farm, Bidhan Chandra Krishi Viswavidyalaya during 2018-2019 by taking the variety Pusa Purple Long. Eight insecticidal treatments with three replications were taken into consideration and statistical analysis was done by randomized block design (RBD). Brinjal plant was shown by giving the proper spacing at 75cm x 60 cm and fertilizer was recommended as 60:30:30 (N:P:K) with Farm yard

manure @ 2 mt/ ha. Spraying schedule was fixed for two times in each year (2018-19) and three sprays were done at 10days interval when pest population reached Economic Threshold Level (ETL) level with battery operated knapsack sprayer fitted with hollow cone nozzle with a water volume @ 500 l/ha. In this present experiment the percent of shoot or fruit infestation was calculated.

Result and Discussion

The efficacy of different insecticides treatment schedules of against brinjal shoot and fruit borer has been presented in Table 1A & 1B for 1st season (*Kharif*, 2017) and Table 2A & 2B for 2nd season (*Kharif*, 2018) respectively. All the treated plots with chemicals were significantly superior in their performance over that of untreated control.

Emamectin benzoate 1% + Cartap hydrochloride 25% SG @ 1500g/ha and 1750g/ha gave best control of shoot and fruit borer with maximum percent reduction of brinjal shoot and fruit damage over control during both the seasons. Emamectin benzoate 1% + Cartap hydrochloride 25% SG @1750g/ha treatment which was found at par with Emamectin benzoate 1% + Cartap hydrochloride 25% SG @ 1500g/ha dose in efficacy (Table 1A & 1B and 2A & 2B).

Extensive research work has been carried out throughout the world in the management of this noxious insect pest. Our experimental results are very much similar and close with the findings of Pareet (2006). He suggested that Emamectin benzoate (Timer 1.9EC) to be effective up to last harvest in reducing brinjal fruit borer damage.

Another experiment was conducted and the obtained result was kept the parity with our findings. Anil and Sharma (2010) [16, 17]. Sharma and Sharma (2010) [16, 17]. Wankhede and Kale (2010) [18]. Chatterjee and Mondal (2012) [19]. and Shah *et al*. (2012) [20]. Reported that emamectin benzoate (Timer 1.9EC) was the most effective insecticide Inreducing BSFB infestation and increasing marketable fruit yield. We have got same result in aspect of marketable yield of this crop with the treatment of Emamectin benzoate1% + Cartap hydrochloride 25% SG @ 1750 g/ha With the Maximum marketable yield i.e. 166.08 q/ha and 165.15 q/ha during 1st season and 2nd season respectively was recorded in Emamectin benzoate 1% + Cartap hydrochloride 25% SG @ 1750 g/ha dose which was found at par with Emamectin benzoate 1% + Cartap hydrochloride 25% SG @ 1500 g/ha dose recorded 162.63 q/ha and 161.68q/ha marketable fruit yield during 1st season and 2nd season respectively (Table 3). Highest cost-benefit ratio was recorded by Emamectin benzoate 1% + Cartap hydrochloride 25% SG@ 1500 g/ha during both the seasons.

According to Stanley *et al*. (2007) [21]. Emamectin benzoate (5 SG) @ 10 g ai/ ha was found to be the superior than any other treatments.

Table 1A: Effect of Insecticides on shoot infestation by brinjal shoot and fruit borer, (Leucinodes orbonalis Guenee) during Kharif, 2018 (Season-I, 1st spray)

Treatments	Formulation Dose (g or ml) / Ha	Pre-count	Percent shoot infestation (day after each spray)									Reduction over control (%)
			After First Spray			After Second spray			After Third spray			
			3 DAS	5 DAS	10 DAS	3 DAS	5 DAS	10 DAS	3 DAS	5 DAS	10 DAS	
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1250	6.00 (14.15)	4.48 (12.22)	5.00 (12.92)	5.35 (13.37)	3.85 (11.32)	4.14 (11.74)	5.62 (13.71)	4.52 (12.27)	5.09 (13.04)	5.73 (13.85)	52.64
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1500	5.56 (13.63)	2.44 (8.98)	2.84 (9.70)	3.27 (10.41)	2.06 (8.25)	2.37 (8.85)	2.96 (9.91)	1.81 (7.71)	1.43 (6.84)	1.00 (5.70)	91.73
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1750	5.92 (14.06)	2.25 (8.62)	2.66 (9.39)	2.99 (9.95)	2.02 (8.17)	2.18 (8.49)	2.79 (9.61)	1.65 (7.37)	1.28 (6.47)	0.90 (5.42)	92.56
Cartaphydrochloride75%SG	500	6.12 (14.31)	3.96 (11.48)	4.48 (12.21)	4.83 (12.69)	3.33 (10.51)	3.62 (10.97)	5.10 (13.05)	4.00 (11.54)	4.57 (12.34)	5.21 (13.19)	56.94
Emamectin benzoate 5% SG	200	5.63 (13.71)	3.46 (10.72)	3.90 (11.39)	4.48 (12.22)	2.74 (9.53)	3.28 (10.43)	3.89 (11.37)	2.85 (9.72)	3.05m (10.05)	3.12 (10.17)	74.21
Lambda-cyhalothrin 5% EC	300	5.69 (13.78)	3.57 (10.89)	4.27 (11.92)	4.63 (12.43)	2.89 (9.79)	3.31 (10.48)	4.22 (11.85)	3.12 (10.17)	3.60 (10.93)	3.85 (11.31)	68.18
Chlorantraniliprole 18.5% SC	200	5.48 (13.53)	2.68 (9.42)	3.21 (10.32)	3.67 (11.04)	2.40 (8.91)	3.08 (10.11)	3.45 (10.70)	2.40 (8.91)	2.49 (9.07)	2.57 (9.22)	78.76
Untreated control	-	6.10 (14.29)	6.86 (15.19)	7.38 (15.76)	7.62 (16.02)	7.89 (16.31)	8.13 (16.57)	8.28 (16.72)	9.77 (18.21)	10.19 (18.62)	12.10 (20.36)	-
SEM (±)	-	NS	0.11	0.13	0.12	0.14	0.16	0.15	0.25	0.33	0.31	-
CD at 5%	-	NS	0.34	0.43	0.37	0.44	0.49	0.45	0.78	1.01	0.96	-

DAS - Days after spraying. *Figures in the parentheses are Angular transformed values

Table 1B: Effect of Insecticides on fruit infestation by brinjal shoot and fruit borer, (*Leucinodes orbonalis* Guenee) during *Kharif*, 2018 (Season-I, 2nd spray)

Treatments	Formulation Dose (g or ml) / Ha	Pre-count	Percent fruit infestation (day after each spray)									Reduction over control (%)
			After First Spray			After Second spray			After Third spray			
			3 DAS	5 DAS	10 DAS	3 DAS	5 DAS	10 DAS	3 DAS	5 DAS	10 DAS	
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1250	8.07 (16.50)	5.49 (13.55)	4.97 (12.88)	5.76 (13.89)	4.97 (12.88)	3.88 (11.36)	4.27 (11.92)	3.69 (11.07)	2.89 (9.77)	3.57 (10.88)	69.03
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1500	7.78 (16.20)	5.05 (12.99)	3.34 (10.53)	4.49 (12.23)	2.74 (9.52)	2.25 (8.62)	2.44 (8.97)	1.73 (7.54)	1.21 (6.30)	0.96 (5.59)	91.67
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1750	7.59 (15.99)	4.86 (12.74)	3.29 (10.44)	4.19 (11.81)	2.57 (9.22)	2.14 (8.40)	2.25 (8.62)	1.56 (7.14)	1.03 (5.80)	0.83 (5.22)	92.80
Cartaphydrochloride75%SG	500	8.20 (16.64)	6.62 (14.91)	6.14 (14.35)	6.55 (14.83)	6.12 (14.32)	6.10 (14.30)	5.74 (13.86)	5.13 (13.08)	5.29 (13.29)	5.94 (14.09)	48.48
Emamectin benzoate 5% SG	200	8.13 (16.57)	6.09 (14.29)	5.61 (13.70)	6.02 (14.21)	5.59 (13.67)	5.57 (13.65)	5.21 (13.19)	4.60 (12.38)	4.76 (12.60)	5.39 (13.42)	53.25

Lambda-cyhalothrin 5% EC	300	7.79 (16.21)	5.36 (13.39)	4.91 (12.80)	5.47 (13.53)	4.76 (12.60)	3.77 (11.19)	3.12 (10.17)	3.50 (10.78)	2.75 (9.53)	2.45 (8.99)	78.75
Chlorantraniliprole 18.5% SC	200	7.57 (15.97)	5.21 (13.19)	4.71 (12.54)	4.79 (12.64)	4.18 (11.79)	3.61 (10.95)	3.78 (11.20)	3.10 (10.14)	2.39 (8.87)	2.12 (8.36)	81.61
Untreated control	-	8.10 (16.53)	8.35 (16.80)	8.68 (17.14)	9.04 (17.50)	9.28 (17.74)	9.58 (18.03)	9.84 (18.28)	10.26 (18.68)	10.80 (19.19)	11.53 (19.85)	-
SEM (±)	-	**NS**	**0.10**	**0.16**	**0.14**	**0.23**	**0.25**	**0.28**	**0.32**	**0.35**	**0.38**	-
CD at 5%	-	**NS**	**0.32**	**0.48**	**0.45**	**0.71**	**0.78**	**0.85**	**0.97**	**1.06**	**1.17**	-

DAS - Days after spraying. *Figures in the parentheses are Angular transformed values

Table 2A: Impact of different insecticides on shoot infestation by brinjal shoot and fruit borer, (*Leucinodes orbonalis* Guenee) during *Kharif*, 2019 (Season-II, 1st spray)

Treatments	Formulation Dose (g or ml) / Ha	Pre-count	Percent shoot infestation (day after each spray)									Reduction over control (%)
			After First Spray			After Second spray			After Third spray			
			3 DAS	5 DAS	10 DAS	3 DAS	5 DAS	10 DAS	3 DAS	5 DAS	10 DAS	
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1250	6.29 (14.52)	4.86 (12.74)	5.38 (13.41)	5.73 (13.85)	4.23 (11.87)	4.52 (12.27)	6.00 (14.18)	4.90 (12.79)	5.47 (13.52)	6.12 (14.32)	52.00
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1500	5.75 (13.87)	2.63 (9.33)	3.03 (10.02)	3.46 (10.72)	2.25 (8.62)	2.56 (9.20)	3.15 (10.22)	2.00 (8.12)	1.62 (7.29)	1.12 (6.03)	91.21
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1750	6.12 (14.32)	2.44 (8.98)	2.85 (9.72)	3.18 (10.27)	2.21 (8.55)	2.37 (8.85)	2.98 (9.94)	1.84 (7.79)	1.47 (6.94)	0.98 (5.64)	92.31
Cartaphydrochloride 75%SG	500	6.29 (14.52)	4.28 (11.94)	4.80 (12.65)	5.15 (13.12)	3.65 (11.01)	3.94 (11.45)	5.42 (13.46)	4.32 (11.99)	4.89 (12.77)	5.53 (13.60)	56.62
Emamectin benzoate 5% SG	200	5.95 (14.12)	3.78 (11.21)	4.22 (11.85)	4.80 (12.66)	3.06 (10.07)	3.60 (10.94)	4.21 (11.84)	3.17 (10.25)	3.37 (10.57)	3.44 (10.69)	73.02
Lambda-cyhalothrin 5% EC	300	6.01 (14.19)	3.89 (11.37)	4.59 (12.37)	4.95 (12.85)	3.21 (10.32)	3.63 (10.98)	4.54 (12.30)	3.44 (10.69)	3.92 (11.41)	4.17 (11.78)	67.29
Chlorantraniliprole 18.5% SC	200	5.71 (13.82)	3.00 (9.97)	3.53 (10.83)	3.99 (11.52)	2.72 (9.49)	3.40 (10.62)	3.77 (11.19)	2.72 (9.49)	2.81 (9.65)	2.89 (9.79)	77.33
Untreated control	-	6.35 (14.59)	7.16 (15.52)	7.68 (16.09)	7.92 (16.35)	8.19 (16.63)	8.43 (16.88)	8.58 (17.03)	10.07 (18.50)	10.49 (18.90)	12.75 (20.92)	-
SEM (±)	-	NS	0.12	0.14	0.13	0.15	0.17	0.16	0.26	0.34	0.32	-
CD at 5%	-	NS	0.39	0.45	0.40	0.48	0.53	0.51	0.79	1.04	0.98	-

DAS - Days after spraying. *Figures in the parentheses are Angular transformed values

Table 2B: Effect of different insecticides on fruit infestation by brinjal shoot and fruit borer, (*Leucinodes orbonalis* Guenee) during *Kharif*, 2019 (Season-II, 2nd spray)

Treatments	Formulation Dose (g or ml) / Ha	Pre-count	Percent fruit infestation (day after each spray)									Reduction over control (%)
			After First Spray			After Second spray			After Third spray			
			3 DAS	5 DAS	10 DAS	3 DAS	5 DAS	10 DAS	3 DAS	5 DAS	10 DAS	
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1250	8.35 (16.79)	5.81 (13.95)	5.29 (13.29)	6.08 (14.28)	5.29 (13.29)	4.20 (11.82)	4.59 (12.36)	4.01 (11.55)	3.21 (10.32)	3.89 (11.37)	67.58
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1500	7.97 (16.40)	5.24 (13.23)	3.53 (10.83)	4.68 (12.49)	2.93 (9.85)	2.44 (8.98)	2.63 (9.32)	1.92 (7.95)	1.30 (6.52)	1.05 (5.85)	91.25
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	1750	7.78 (16.20)	5.05 (12.99)	3.48 (10.75)	4.38 (12.08)	2.76 (9.56)	2.33 (8.77)	2.44 (8.98)	1.75 (7.58)	1.12 (6.03)	0.92 (5.48)	92.33
Cartaphydrochloride75%SG	500	8.40 (16.85)	6.93 (15.26)	6.45 (14.71)	6.86 (15.18)	6.43 (14.69)	6.41 (14.66)	6.05 (14.23)	5.44 (13.48)	5.60 (13.69)	6.24 (14.46)	48.00
Emamectin benzoate 5% SG	200	8.45 (16.90)	6.41 (14.67)	5.93 (14.09)	6.34 (14.58)	5.91 (14.07)	5.89 (14.04)	5.53 (13.60)	4.92 (12.81)	5.08 (13.02)	5.71 (13.82)	52.41
Lambda-cyhalothrin 5% EC	300	8.11 (16.55)	5.68 (13.78)	5.23 (13.22)	5.79 (13.92)	5.08 (13.02)	4.09 (11.66)	3.44 (10.69)	3.82 (11.27)	3.07 (10.08)	2.77 (9.57)	76.91
Chlorantraniliprole 18.5% SC	200	7.89 (16.31)	5.53 (13.60)	5.03 (12.96)	5.11 (13.07)	4.50 (12.25)	3.93 (11.43)	4.10 (11.68)	3.42 (10.65)	2.71 (9.47)	2.44 (8.96)	79.66
Untreated control	-	8.38 (16.83)	8.56 (17.02)	8.91 (17.37)	9.27 (17.73)	9.51 (17.96)	9.81 (18.25)	10.07 (18.50)	10.49 (18.90)	11.03 (19.40)	12.00 (20.27)	-
SEM (±)	-	NS	0.11	0.17	0.15	0.24	0.26	0.29	0.31	0.34	0.36	-
CD at 5%	-	NS	0.35	0.52	0.45	0.73	0.81	0.88	0.94	1.03	1.10	-

DAS - Days after spraying. *Figures in the parentheses are Angular transformed values

Table 3: Effect of different insecticides on fruit yield of brinjal during *Kharif*, 2018(Season-I) and *Kharif*, 2019 (Season-II)

Treatments	g a.i. Dose/ha	Formulation dose (g or ml) / ha	Kharif, 2018 Yield (Q/Ha)			Kharif, 2019 Yield (Q/Ha)		
			Yield of marketable fruits	Yield of damaged fruits	Total fruit yield	Yield of marketable fruits	Yield of damaged fruits	Total fruit yield
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	312.5 + 12.5	1250	133.12	13.64	146.76	132.10	14.04	146.14
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	375.0 + 15.0	1500	163.63	7.20	170.83	162.68	7.15	169.83
Emamectin benzoate 1% + Cartap hydrochloride 25% SG	437.5 + 17.5	1750	166.08	5.58	171.66	165.15	5.50	170.65
Cartaphydrochloride75%SG	375	500	123.52	18.12	141.64	122.68	17.70	140.38
Emamectin benzoate 5% SG	10	200	128.45	15.54	143.99	127.34	15.56	142.90
Lambda-cyhalothrin 5% EC	15	300	138.15	13.02	151.17	137.05	13.08	150.13
Chlorantraniliprole 18.5% SC	40	200	139.50	12.75	152.25	138.50	12.72	151.22
Untreated control	-	-	96.44	36.42	132.86	95.24	36.25	131.49
SEM (±)	-	-	1.54	-	0.68	1.75	-	1.20
CD at 5%	-	-	4.65	-	2.04	5.27	-	3.62

Conclusion

It is evident from the present investigation that Emamectin benzoate 1% + Cartap hydrochloride 25% SG @ 1500g/ha - 1750g/ha was found best and effective as well as at par with each other against brinjal fruit and shoot borer (*Leucinodes orbonalis* Guenee). Whereas, Emamectin benzoate 1% + Cartap hydrochloride 25% SG @ 1500 g/ha found much suitable with favorable cost-benefit ratio. Therefore, Emamectin benzoate 1% + Cartap hydrochloride 25% SG @ 1500g/ha could be recommended for safe and economic use in brinjal for effective control of shoot and fruit borer.

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