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Evaluation of newer insecticides against brinjal shoot and fruit borer

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Abstract
The investigations on evaluation of newer insecticides against major insect pests of brinjal were conducted on research farm of Department of Agricultural Entomology VNMKV, Parbhani during *Kharif* 2021-22. The work was carried out in Randomized Block Design with thrice replications. Eight insecticides treatments. At 7th day after exposure of insecticidal spray indicated that the treatment Lambda cyhalothrin 9.5% ZC + Chlorantraniliprole 9.30% recorded lowest shoot infestation (1.20%). This was at par with Chlorantraniliprole 18.5 SC recorded (1.33%) and spinetoram 11.7% SC (1.51%). The lowest infestation by fruit borer was observed in Lambda cyhalothrin 9.5% ZC + Chlorantraniliprole 9.30% recorded (2.91, 2.67, 3.56% fruit infestation) and it was at par with chlorantraniliprole 18.5 SC (3.57, 3.31 and 2.59%). Highest fruit yield was observed in Lambda cyhalothrin 9.5% ZC + Chlorantraniliprole 9.30% (93.4 kg/ha), which is at par with chlorantraniliprole 18.5 SC (82.5 kg/ha) and Emamectin benzoate 5% SG (75.3 kg/ha) respectively.

Keywords: *Leucinodes orbonalis*, insecticides, bio efficacy, brinjal, yield

Introduction
Solanum melongena L is the native of India. Most commonly purple, the spongy absorbent fruit is used in several cuisines. The versatile use of brinjal in Indian cuisine for both everyday festive occasions has led to it being described as the “King of vegetables” China is the world's leading producer of brinjal, with India coming in second with 26 percent of global production. Brinjal production in the country totals around 11895.8 MT. Consumption of 135 g per capita per day versus the required 300 g per day (Dhanadapani, 2003) [2]. Because of its low production costs, and therefore it is often known as poor man's food. In India, brinjal production is 12873.80 metric tonnes in 749.50 ha area, yield is 17.18 MT/ha. And in Maharashtra under 20.85 ha, production of brinjal fruits are 361.79, yields is 17.36 MT/ha, during 2020-21. Brinjal was grown on 744 thousand hectares, with an annual production of 12682 million tonnes in 2019-20 [1]. But once fruit setting has been initiated, shoot infestations become negligible (Kumar and Dharmendra, 2013) [7] or completely disappear (Naqvi *et al.*, 2009) [10] .The infested fruits become unfit for consumption due to loss of quality which ultimately reduces the market value. The yields losses due to this pest may vary from 70-92% in India (Sen *et al.*, 2017) [8] .Bore holes clogged with excreta are attacked fruits. Fruits lose their form as well. It has also been found that contaminated fruits have a 68 percent reduction in vitamin C content (Hemi, 1995) [5].

West Bengal accounts for 61.5 percent of the total brinjal area. China is the most prolific producer, followed by India. There are various factors that contribute to a reduction in brinjal yield, one of which is insect pests. More than 70 insect pests attack brinjal; among these, the destructive pest of brinjal (*Leucinodes orbonalis* Guen.) (Singh, 1970) [9] damages the crop throughout the year. Shoot and fruit borer: *Leucinodes orbonalis* (Pyraustidae: Lepidoptera) larva bores into tender shoots and causes withering of terminal shoots/dead hearts. It also bores petioles of leaves, flower buds, and developing buds, causing withering of leaves, shedding of buds.

Methodology
The experiment were conducted during *kharif* 2021-22 to study the “Evaluation of newer insecticide against shoot and fruit borer of brinjal” at the research farm of Department of Agricultural Entomology, Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani, Maharashtra during *Kharif* 2021-22.

Number of infested shoots in each plot was recorded one day before spraying as well as 7 and 14 days after spraying. The percent shoot damage was worked out and converted to angular transformed values and the data later was subjected to statistical analysis. Observations were also recorded on number of infested fruits and number of marketable fruits on five randomly selected plants and all plants from each plot. Picking wise observations were also recorded on the weight of infested fruits and weight of marketable fruits on five randomly selected plants from each plot. The percent damage of fruit on weight and number basis was worked out and transform into angular value and the data will be subjected to statistical analysis. Fruits were harvested from each plot separately and yield per plant at each picking was recorded in kilograms. Net plot yield was converted to quintals per hectare. All the data was subjected to the statistical analysis. The cumulative percent shoot and fruit damage was worked out using following the formulae.

$$\text{Percent shoot infestation} = \frac{\text{No. of infested shoots}}{\text{Total no. of shoots}} \times 100$$

$$\text{Percent fruit infestation (Number basis)} = \frac{\text{No. of infested fruits}}{\text{Total no. of fruits}} \times 100$$

$$\text{Percent fruit infestation (Weight basis)} = \frac{\text{Weight of infested fruits}}{\text{Weight of total fruits}} \times 100$$

Results and Discussion

Spray 1st

The data present in Table 1 revealed that the population of *L. orbonalis* was found uniform throughout the experimental area with a mean number of 3.00 to 3.96 percent infestation as the data are statistically non-significant. Thereafter, the data on percent shoot infestation after application revealed significant results among the insecticidal treatments.

For recording shoot infestation, healthy and infested shoots were recorded from 5 randomly selected plants from each plot. Observations were recorded one day before spray and 7th, 14th days after each spray. The percent shoot infestation in untreated plots showed an increasing trend from 3.00 to 3.21% during a span of 14 days covering the first spray. All the insecticides were found to be significantly superior over untreated control in minimizing the incidence of brinjal shoot borer at all the days of observations after the first application of insecticides.

The data on mean percent infestation at 7th day after exposure of insecticidal spray indicated that the treatment Lamda cyhalothrin 9.5% ZC +Chlorantraniliprole 9.30% recorded lowest shoot infestation *i.e.* 1.20 percent. Which was at par with Chlorantraniliprole 18.5 SC recorded (1.33%) and spinetoram 11.7% SC (1.51%), followed by beta- cyfluthrin 8.49% + Imidacloprid 19.81% OD (1.56%), Emamectin benzoate 5% SG (1.68%), Pyriproxyfen 5% + Fenpropathrin 15% EC (1.83%), Thiamethoxam 12.6%+ Lamda cyhalothrin 9.5% ZC (1.94%). And it was significantly superior to reduce percent shoot infestation over untreated control plot (3.05% infestation).

Subsequently 14th day after spraying (Table 1) a similar type of trend was observed with a reduction in the shoot infestation in all the treatments. The application of treatment Lamda cyhalothrin 9.5% ZC + Chlorantraniliprole 9.30% recorded lowest shoot infestation *i.e.* 1.82 percent. And Chlorantraniliprole 18.5 SC recorded (1.89% shoot infestation) and spinetoram 11.7% SC (2.00 percent). These two treatments found to be at par with each other. Followed by beta- cyfluthrin 8.49% + Imidacloprid 19.81% OD (2.01%), Emamectin benzoate 5% SG (2.04%), Pyriproxyfen 5% + Fenpropathrin 15% EC (2.23%), Thiamethoxam 12.6%+ Lamda cyhalothrin 9.5% ZC (2.23%), and it was significantly superior to reduce percent shoot infestation over untreated control plot (3.21% infestation).

2nd spray

The data on an infestation of *L. orbonalis* on shoots after the second sprays was presented in Table No.1. After the second spray, all insecticidal treatments were significantly superior over untreated control in reduction in the shoot infestation of brinjal shoot borer. The reduction in shoot infestion was maximum after 7 days after spray, and gradual increase in the population after 14 days of spray.

The perusal data of the second spray mean percent infestation at 7th day after spray indicated that treatment Lambda cyhalothrin 9.5% ZC +Chlorantraniliprole 9.30% recorded lowest shoot infestation *i.e.* 1.09 percent. Which was at par with Chlorantraniliprole 18.5 SC recorded (1.41% shoot infestation) and spinetoram 11.7% SC (1.43%), followed by beta- cyfluthrin 8.49% + Imidacloprid 19.81% OD (1.52%), Emamectin benzoate 5% SG (1.54%), Pyriproxyfen 5% + Fenpropathrin 15% EC (1.56%), Thiamethoxam 12.6%+ Lambda cyhalothrin 9.5% ZC (1.60%), and it was significantly superior to reduce percent shoot infestation over untreated control plot (3.31% infestation).

Similarly, 14th day after spraying (Table 1) similar type of trend was observed with a reduction in the shoot infestation in all the treatments. The plot treated with Lambda cyhalothrin 9.5% ZC +Chlorantraniliprole 9.30% recorded lowest shoot infestation i.e.1.01 percent. Which was at par with Chlorantraniliprole 18.5 SC recorded (1.83% shoot infestation) and Spinetoram 11.7% SC (1.87%), followed by beta- cyfluthrin 8.49% + Imidacloprid 19.81% OD (1.87%), Emamectin benzoate 5% SG (2.01%), Pyriproxyfen 5% + Fenpropathrin 15% EC (2.06%), Thiamethoxam 12.6% + Lamda cyhalothrin 9.5% ZC (2.19%) and it was significantly superior to reduce percent shoot infestation over untreated control plot (3.49% infestation).

Table 2: Bio efficacy of newer insecticides against shoot borer infesting shoot.

Treatments	Average no. of shoot infestation / plant						
	1st spray			2nd spray		3 rd spray	
	Pre –count	7 DAS	14 DAS	7 DAS	14 DAS	7 DAS	14 DAS
T_1 Spinetoram	9.80 (3.09)	2.27 (1.51)	3.93 (2.00)	2.00 (1.43)	3.47 (1.87)	1.73 (1.33)	2.80 (1.69)
T_2 Thiamethoxam + Lambda cyhalothrin	12.80 (3.58)	3.73 (1.94)	5.07 (2.23)	2.53 (1.60)	4.73 (2.19)	2.33 (1.54)	3.40 (1.85)
T_3 Chlorantraniliprole + Lambda cyhalothrin	15.63 (3.96)	1.40 (1.20)	3.27 (1.82)	1.13 (1.09)	1.33 (1.01)	0.93 (0.99)	1.21 (1.47)
T_4 Emamectin benzoate	13.07 (3.62)	2.80 (1.68)	4.13 (2.04)	2.33 (1.54)	4.00 (2.01)	2.07 (1.45)	2.93 (1.73)
T_5 Chlorantraniliprole	12.07 (3.48)	1.73 (1.33)	3.53 (1.89)	1.93 (1.41)	3.33 (1.83)	1.53 (1.25)	2.00 (1.43)
T_6 Pyriproxyfen + Fenpropathrin	12.60 (3.54)	3.40 (1.83)	4.93 (2.23)	2.40 (1.56)	4.20 (2.06)	2.13 (1.47)	3.27 (1.74)
T_7 Beta- cyfluthrin + Imidacloprid	11.27 (3.32)	2.40 (1.56)	4.00 (2.01)	2.27 (1.52)	3.47 (1.87)	2.07 (1.44)	2.87 (1.71)
T_8 Untreated Control	9.00 (3.00)	9.27 (3.05)	10.27 (3.21)	11.00 (3.31)	12.13 (3.49)	11.40 (3.37)	13.13 (3.63)
S.E.$\pm$	0.22	0.10	0.13	0.11	0.17	0.11	0.16
C.D. at 5%	NS	0.31	0.41	0.33	0.61	0.33	0.49

3rd spray

The data of the third spray mean percent infestation at 7th day after spray indicated that treatment Lambda cyhalothrin 9.5% ZC+ Chlorantraniliprole 9.30% recorded lowest shoot infestation i.e. 0.99 percent. Which was at par with Chlorantraniliprole 18.5 SC recorded (1.25%) and Spinetoram 11.7% SC (1.33%), followed by beta- cyfluthrin 8.49% + Imidacloprid 19.81% OD (1.87%), Emamectin benzoate 5% SG (1.45%), Pyriproxyfen 5% + Fenpropathrin 15% EC (1.47%), Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC (1.54%) and it was significantly superior to reduce percent shoot infestation over untreated control plot (3. 37% infestation).

Similarly, 14th day after spraying (Table 1) Chlorantraniliprole 18.5 SC recorded (1.43% shoot infestation) with a reduction in the shoot infestation in all the treatments. After this the plot treated with Lambda cyhalothrin 9.5% ZC + Chlorantraniliprole 9.30% recorded shoot infestation i.e. 1.47 percent. Which was at par with and Spinetoram 11.7% SC (1.69%), followed by beta- cyfluthrin 8.49% + Imidacloprid 19.81% OD (1.71%), Emamectin benzoate 5% SG (1.73%), Pyriproxyfen 5% + Fenpropathrin 15% EC (1.74%), Thiamethoxam 12.6% + Lambda cyhalothrin 9.5% ZC (1.85%) and it was significantly superior to reduce percent shoot infestation over untreated control plot (3.63% infestation).

Percent fruit damage (Number basis)

The data of bio efficacy of newer insecticides against fruit borer on brinjal during 2021-22, average of 7 and 14 days based on number basis after first, second and third spray are presented in the Table 2.

Before application of spray, fruit borer incidence was ranged between 3.0 to 3.62 percent, showing slow increase in live count of fruit borer.

After 1st, 2nd and 3rd spray, all insecticidal treatments were significantly superior over untreated control in minimizing the pest incidence. The lowest infestation by fruit borer was observed in Lambda cyhalothrin 9.5% ZC +Chlorantraniliprole 9.30% recorded (2.91, 2.67, 3.56 percent fruit infestation respectively) and it was at par with Chlorantraniliprole 18.5 SC (3.57, 3.31 and 2.59%). And Spinetoram 11.7% SC (3.60, 3.39, 3.59%), followed by Beta-cyfluthrin 8.49% + Imidacloprid 19.81% OD (3.62, 3.40, 3.65%), Emamectin benzoate 5% SG (3.70, 3.45, 3.65%), Pyriproxyfen 5% + Fenpropathrin 15% EC (3.80, 3.47,3.82%), Thiamethoxam 12.6%+ Lambda cyhalothrin 9.5% ZC (3.95, 3.71, 3.96%) recorded fruit percent after 1st, 2nd and 3rd spray respectively.

The overall decreasing order of fruit infestation caused by fruit borer in different treatments was in Lambda cyhalothrin 9.5% ZC + Chlorantraniliprole 9.30% > Chlorantraniliprole 18.5 SC >spinetoram 11.7% SC > beta- cyfluthrin 8.49% + Imidacloprid 19.81% OD > Emamectin benzoate 5% SG > Pyriproxyfen 5% + Fenpropathrin 15% EC > Thiamethoxam 12.6%+ Lambda cyhalothrin 9.5% ZC. Evaluated against percent fruit damage were proved their significance over untreated control.

Percent fruit damage (weight basis).

The results of all three pickings of percent fruit damage indicated superiority of Lambda cyhalothrin 9.5% ZC + Chlorantraniliprole 9.30% recorded (2.76, 2.68, 2.72% fruit infestation) and it was at par with Chlorantraniliprole 18.5 SC (3.19, 3.18, 3.18%). Rest of the insecticidal treatments and spinetoram 11.7% SC (3.49, 3.28, 3.35%), followed by beta-cyfluthrin 8.49% + Imidacloprid 19.81% OD (3.70, 3.51,3.40%), Emamectin benzoate 5% SG (3.84, 3.68, 3.43%), Pyriproxyfen 5% + Fenpropathrin 15% EC (3.96, 3.69, 3.60%), Thiamethoxam 12.6%+ Lambda cyhalothrin 9.5% ZC (4.08, 3.51, 3.82%) recorded fruit percent after 1st, 2nd and 3rd spray, respectively, and it was found significantly superior to reduce fruit damage untreated control plot recorded (5.28, 5.16, 4.87% fruit damage).

The present result is concurrence with research of Sen *et al*. (2017) [8] investigate that the formulation of Ampligo 150 ZC (Chlorantraniliprole 9.3%+ Lambda Cyhalothrin 4.6% ZC) against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen).And revealed that Ampligo 150 ZC @ 35 g a.i./ha was recorded lowest percent of shoot (1.26%) and fruit (2.49%) infestation followed by Ampligo 150 ZC @28 g a.i./ha (1.59% shoot and 2.97% fruit infestation) and

Chlorantraniliprole 18.5% SC @ 30 g a.i./ha (3.76% shoot and 3.32% fruit infestation), respectively. Humane *et al*., (2019) [4] reported that the among all the treatments Chlorantraniliprole 18.5% SC recorded lowest shoot infestation followed by Cyantraniliprole 10.26% OD and Emamectin benzoate 5% SG and all treatments were found superior over the control. Ghuge *et al*. (2020) [3] resulted that chlorantraniliprole 18.5% SC (2.99 and 3.30%) recorded minimum mean percent fruit infestation on number basis as well as 74 weight basis. Kameshwaran *et al*. (2015) [6] the treatments the lowest mean percent shoot damage was recorded in the treatment with Chlorantraniliprole 20 SC @ 40 g a.i./ha followed by Emamectin benzoate 25 WG @ 11 g a.i./ha.

Table 2: Bio efficacy of newer insecticides against fruit borer infesting fruit.

Treatments	On No. Basis Average fruit infestation			On weight Basis Average fruit infestation		
	1st picking	1st picking	2nd picking	1st picking	2nd picking	3rd picking
T_1 Spinetoram	12.93 (3.60)	12.13 (3.49)	10.73 (3.28)	11.20 (3.35)	11.47 (3.39)	12.87 (3.59)
T_2 Thiamethoxam + Lambda cyhalothrin	15.60 (3.95)	17.27 (4.08)	12.47 (3.51)	14.73 (3.82)	13.73 (3.71)	15.67 (3.96)
T_3 Chlorantraniliprole + Lambda cyhalothrin	8.40 (2.91)	7.57 (2.76)	7.60 (2.68)	7.40 (2.72)	7.07 (2.67)	12.67 (3.56)
T_4 Emamectin benzoate	13.67 (3.70)	14.80 (3.84)	13.53 (3.68)	11.73 (3.43)	11.87 (3.45)	13.27 (3.65)
T_5 Chlorantraniliprole	12.73 (3.57)	10.13 (3.19)	10.07 (3.18)	10.13 (3.18)	10.93 (3.31)	12.87 (3.59)
T_6 Pyriproxyfen + Fenpropathrin	14.40 (3.80)	15.67 (3.96)	13.60 (3.69)	12.93 (3.60)	12.07 (3.47)	14.60 (3.82)
T_7 Beta- cyfluthrin + Imidacloprid	13.07 (3.62)	13.73 (3.70)	12.47 (3.51)	11.53 (3.40)	11.53 (3.40)	13.27 (3.65)
T_8 Untreated Control	23.60 (4.80)	27.87 (5.28)	26.60 (5.16)	24.00 (4.87)	22.53 (4.68)	21.53 (4.59)
S.E.±	0.23	0.24	0.23	0.22	0.23	0.20
C.D. at 5%	0.70	0.72	0.71	0.68	0.72	0.61

Before application of spray, fruit borer incidence was ranged between 3.0 to 3.62 percent, showing slow increase in live count of fruit borer.

After 1st, 2nd and 3rd spray, all insecticidal treatments were significantly superior over untreated control in minimizing the pest incidence. The lowest infestation by fruit borer was observed in Lamda cyhalothrin 9.5% ZC +Chlorantraniliprole 9.30% recorded (2.91, 2.67, 3.56 percent fruit infestation) and it was at par with Chlorantraniliprole 18.5 SC (3.57, 3.31 and 2.59%). Rest of the insecticidal treatments and Spinetoram 11.7% SC (3.60, 3.39, 3.59%), followed by Beta- cyfluthrin 8.49% + Imidacloprid 19.81% OD (3.62, 3.40, 3.65%), Emamectin benzoate 5% SG (3.70, 3.45, 3.65%), Pyriproxyfen 5% + Fenpropathrin 15% EC (3.80, 3.47,3.82%), Thiamethoxam 12.6%+ Lamda cyhalothrin 9.5% ZC (3.95, 3.71, 3.96%) recorded fruit percent after 1st, 2nd and 3rd spray, respectively.

Yield and economics

The data concerning to the yield of brinjal fruits presented in Table No.3 and revealed that there were significant differences in fruit yield (qt/ha) on insecticides applied treatment over control. Out of this treatment of Lamda cyhalothrin 9.5% ZC +Chlorantraniliprole 9.30% recorded highest fruit yield (q/ha) followed by Chlorantraniliprole 18.5 SC (q/ha), these treatments found at par with each other and remaining treatments also gave better yield i.e. Emamectin Benzoate 5% SG, followed by Spinetoram 11.7% SC, Pyriproxyfen 5% + Fenpropathrin 15% EC, beta- cyfluthrin 8.49% + Imidacloprid 19.81% OD, Thiamethoxam 12.6% + Lamda cyhalothrin 9.5% ZC (qt/ha) respectively. The data on the economics of different insecticidal treatments presented in Table 3 concluded that Emamectin Benzoate 5% SG has highest insecticidal cost benefit ratio (ICBR) i.e. 1:19.9, followed by Beta-cyfluthrin 8.49 + Imidacloprid 19.81% OD (1:10.04), Pyriproxyfen 5% + Fenpropathrin 15% EC (1:7.04), Chlorantraniliprole 18.5 SC(1:4.5), Thiamethoxam 12.6%+ Lambda cyhalothrin 9.5% ZC (1:3.6), spinetoram 11.7% SC (1:1.9), Chlorantraniliprole 9.30% + Lambda cyhalothrin 4.60% ZC (1:1.6).

Table 3: Yield and economics of various insecticides treatments in brinjal

Tr. No.	Treatments	Conc. (%)	Yield (qt/ha)	Increased yield over (qt/ha)	Total cost of plant protection (Rs/ha)	Gross realization over control (Rs/ha)	Net realization (Rs/ha)	ICBR
T_1	Spinetorum 11.7% SC	0.012	74.8	36.7	21500	110100	62800	1:3.12
T_2	Thiamethoxam 12.6%+ Lamda cyhalothrin 9.5% ZC	0.018	50.9	12.1	6450	36300	29850	1:3.6
T_3	Chlorantraniliprole 9.30% + Lamda cyhalothrin 4.60% ZC	0.011	93.4	55.3	9000	165900	156900	1:1.6
T_4	Chlorantraniliprole 18.5 SC	0.007	75.3	37.2	17083	111600	94517	1:4.5
T_5	Emamectin Benzoate 5% SG	0.002	82.5	44.4	6080	133200	127120	1:19.9
T_6	Pyriproxyfen 5% + Fenpropathrin 15% EC	0.10	59.8	21.7	7200	65100	57900	1:7.04
T_7	Beta-cyfluthrin 8.49 + Imidachloprid 19.81% OD	0.018	59.3	21.2	5280	63600	58320	1:10.04
T_8	Untreated control	-	38.1	-	-	-	-	-

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