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Field Evaluation of a New Ready Mix Formulation Ampligo 150 ZC (Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC) against Shoot and Fruit Borer (*Leucinodes orbonalis* Guen.) infestation in Brinjal

Koushik Sen, Arka Samanta, SK Fashi Alam, Partha Protim Dhar and Arunava Samanta

Abstract
Field experiments on new ready mix formulation Ampligo 150 ZC (Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC) against brinjal shoot and fruit borer (*Leucinodes orbonalis* Guen.) was conducted during *pre-kharif* seasons of 2014 and 2015. The study 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. The highest marketable fruit yield was obtained in the treatment with Ampligo 150 ZC @ 28 and 35 g a.i./ha (143.91-150.88 q/ha). The new mixture formulation, Ampligo 150 ZC @ 28-35 g a.i./ha proved to be significantly superior than other treatments against *L. orbonalis.* This novel mixture formulation can be effectively utilized in the IPM programme to minimize the infestation of *L. orbonalis* by reducing the application of highly toxic chemicals in the brinjal ecosystem.

Keywords: Bioefficacy, Mixture formulation, Insecticide, Brinjal, *Leucinodes orbonalis*.

1. Introduction
Brinjal or eggplant (*Solanum melongena* L.) is one of the most popular and principal solanaceous vegetable crops grown in India and other parts of the world. Brinjal is being cultivated throughout the year during *kharif*, *rabi* and summer season. It is a good source of minerals and contains vitamins A, B and C, rich in total water soluble sugars, free reducing sugars, amide proteins among other nutrients and also has ayurvedic medical properties, the fruit being good for diabetic patients [8, 11]. In India, brinjal occupies an area of 663 thousand ha with a production of 12515 thousand MT during 2015-16 [12]. As it is cultivated round the year the crop is proned to attack by a number of insect pests right from its seedling stage in the nursery to its harvesting in the main field [18]. Among them, brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen. (Lepidoptera: Pyralidae) is the most destructive noxious pest responsible for one of the limiting factor in quantitative as well as qualitative yield of brinjal fruits [4, 6, 10, 20]. In young plants, larvae bores into the young tender shoots resulting in drooping, withering and drying of the affected shoots. Later, caterpillars bore into the flower buds and fruits resulting shedding and the bored holes are invariably plugged with excreta [14]. The infested fruits become unfit for consumption due to loss of quality which ultimately reduces the market value. The yield losses due to this pest may vary from 70-92% in India [4, 7, 13, 17]. To combat this notorious pest farmers tend to apply highly toxic chemicals with higher doses twice a week and hence increases the cost of cultivation. This leads a serious health hazards as brinjal being a vegetable crop, its fruits are harvested frequently where fresh consumption is the sole priority given by the consumers and there is a highly chances of presence of toxic residues in the fruit. Besides these ill effects, frequent application of same insecticides causes resistance, secondary pest outbreaks and pest resurgence problems along with destruction of natural enemies and environmental pollution. A number of new generation insecticide molecules have been found to be more effective with lower doses as well as safer for non-target organism [2, 8, 14, 15, 19, 21, 22]. Keeping above aspects in mind, the present investigation reports the effectiveness of some novel insecticide combinations against brinjal shoot and fruit borer under field condition.

2. Materials and Methods

2.1 Experimental site

Two supervised and systematic field experiments were conducted at University Experimental Farm, 'C' Unit, Bidhan Chandra Krishi Viswavidyalaya, Kalyani, Nadia, West Bengal during pre-*kharif* seasons (February- June) of 2014 and 2015.

2.2 Experimental Layout

Field trials were laid out in Randomized Block Design (RBD) with eight treatment combinations including untreated control and three replications. A high yielding variety of brinjal (cv. Muktakeshi) was used for the present investigation. Seedlings were raised in nursery beds and one month old seedlings were transplanted in the plot size of 5m x 5m at a distance of 60 cm between plants and 60 cm between rows on raised beds in the main field. All recommended agronomic package of practices free from pesticide application were adopted for raising the crop. Soon after the initiation of shoot and fruit borer infestation spraying with different treatments viz., T_1 - Ampligo 150 ZC (Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC) @ 21 g a.i./ha, T_2 - Ampligo 150 ZC @ 28 g a.i./ha, T_3 - Ampligo 150 ZC @ 35 g a.i./ha, T_4 - Chlorantraniliprole 18.5% SC @ 30 g a.i./ha, T_5 – Lambda Cyhalothrin 4.9 CS @ 15 g a.i./ha, T_6 - Fenpropathrin 30% EC @ 75 g a.i./ha, T_7 - Deltamethrin 1% + Triazophos 35% EC @ 360 g a.i./ha and T_8 – Untreated control were applied thrice at 21 days interval. Spraying was done with a high volume pneumatic knapsack sprayer using spray fluid @ 500 litres/ha.

2.3 Observations taken

Pre and post treatment observations of shoot and fruit infestations were taken on ten randomly selected tagged plants from each plot in each replication at 1 day before and 7, 14 and 21 days after first, second and third sprayings. The healthy and damaged shoots from each replicated plot were counted and percent shoot infestation was calculated. Fruit pickings were done at weekly interval from each plot. Fruit infestation by shoot and fruit borer was recorded after each picking in each replicated plots by counting total number of harvested and damaged fruits. Marketable fruit yield was taken from each plot separately.

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 5% level of significance was worked out using statistical methods of MS-Excel.

3. Results and Discussion

3.1 Efficacy of insecticides on shoot infestation

From the data presented in Table 1, there was no significant difference in the mean percent shoot infestation among the treatments at one day before the application of insecticides. Perusal data on shoot infestation revealed that, all the treatments gave significant reduction of shoot damage compared to untreated control during both the years (2014 and 2015). Among treatments, the lowest percent of shoot infestation was observed in Ampligo 150 ZC (Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC) @ 35 g a.i./ha at 7 days after spray during the year 2014 (0.95%) and 2015 (0.58%) and all the treatments were able to lower the shoot infestation over untreated control (22.83% and 20.23%). Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 35 g a.i./ha was recorded the lowest mean shoot infestation during 2014 (1.45%) and 2015 (1.08%). The next best treatment in the reduction of shoot infestation was Ampligo 150 ZC (Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC) @ 28 g a.i./ha (1.83% and 1.35%) followed by Chlorantraniliprole 18.5% SC @ 30 g a.i./ha (4.10% and 3.43%) during the year 2014 and 2015. Fenpropathrin 30% EC @ 75 g a.i./ha (8.67% and 7.40%) was found least effective against shoot infestation compared to other treatments during both the years.

The overall mean percent shoot infestation data showed that (Table 1), Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 35 g a.i./ha (1.26%) was registered as the best treatment with maximum reduction over control (94.15%) followed by Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 28 g a.i./ha (1.59%) and Chlorantraniliprole 18.5% SC @ 30 g a.i./ha (3.76%) with 92.62% and 82.54% reduction over control, respectively. Among the treatments, the highest overall mean shoot infestation was recorded in Fenpropathrin 30% EC @ 75 g a.i./ha (8.04%) with lowest percent reduction over control (62.66%) and was found least effective.

Table 1: Effect of Ampligo 150 ZC (Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC) on shoot infestation by brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen.

Treatment	Dose (g a.i./ha)	Pre-treatment count (%)	Percent shoot infestation (days after each spray)								Overall mean (%)	Reduction over control (%)
			First Season, 2014 (Mean of three sprayings)				Second Season, 2015 (Mean of three sprayings)					
			7 DAS	14 DAS	21 DAS	Mean	7 DAS	14 DAS	21 DAS	Mean		
T_1	21 (13.95+6.90)	5.35 (13.37)	4.30 (11.84)	6.43 (14.67)	9.72 (18.16)	6.82 (14.94)	3.63 (10.95)	5.08 (13.02)	8.20 (16.63)	5.64 (13.55)	6.23 (14.26)	71.06
T_2	28 (18.60+9.20)	5.33 (13.34)	1.26 (6.34)	1.90 (7.92)	2.33 (8.74)	1.83 (7.72)	0.97 (5.40)	1.20 (6.26)	1.89 (7.84)	1.35 (6.61)	1.59 (7.19)	92.62
T_3	35 (23.25+11.50)	5.32 (13.32)	0.95 (5.42)	1.25 (6.36)	2.14 (8.38)	1.45 (6.81)	0.58 (4.19)	0.89 (5.33)	1.76 (7.50)	1.08 (5.80)	1.26 (6.33)	94.15
T_4	30	5.33 (13.34)	2.20 (8.51)	3.63 (10.94)	6.46 (14.72)	4.10 (11.41)	1.89 (7.89)	3.05 (10.03)	5.34 (13.36)	3.43 (10.44)	3.76 (10.94)	82.54
T_5	15	5.48 (13.53)	2.81 (9.65)	5.55 (13.61)	8.67 (17.09)	5.68 (13.47)	3.00 (9.96)	4.27 (11.91)	6.44 (14.70)	4.57 (12.20)	5.12 (12.86)	76.22
T_6	75	5.47 (13.51)	3.75 (11.16)	8.01 (16.43)	14.26 (22.18)	8.67 (16.60)	2.85 (9.72)	6.97 (15.29)	12.39 (20.59)	7.40 (15.21)	8.04 (15.92)	62.66
T_7	360 (10+350)	5.25 (13.24)	2.74 (9.52)	5.05 (12.95)	7.68 (16.08)	5.16 (12.87)	2.67 (9.39)	3.66 (11.02)	5.77 (13.90)	4.03 (11.44)	4.60 (12.18)	78.63
T_8	-	5.28 (13.28)	19.38 (25.51)	22.68 (28.02)	26.44 (30.61)	22.83 (28.50)	17.13 (23.71)	20.74 (26.60)	22.83 (28.22)	20.23 (26.69)	21.53 (27.61)	-

S. Em (±)	0.31	1.79	1.57	1.53	0.80	1.88	1.60	1.48	0.76	0.76	-
C.D. at 0.05%	NS	5.42*	4.77*	4.64*	2.43*	5.70*	4.86*	4.49*	2.32*	2.31*	

T1 - Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 21 g a.i./ha**; T2** - Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 28 g a.i./ha**; T3** - Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 35 g a.i./ha**; T4** - Chlorantraniliprole 18.5% SC @ 30 g a.i./ha; **T5** – Lambda Cyhalothrin 4.9 CS @ 15 g a.i./ha; **T6** - Fenpropathrin 30% EC @ 75 g a.i./ha; **T7** - Deltamethrin 1% + Triazophos 35% EC @ 360 g a.i./ha; **T8** - Untreated Control; **NS –** Not significant; Figures in parentheses are angular transformed values; *****Significant at 0.05 level; **DAS**-Days after spray

3.2 Efficacy of insecticides on fruit infestation

The mean fruit infestation in the pretreatment count which was done prior to insecticidal sprayings was found to be non-significant (Table 2). From the data presented in Table 2, it is evident that there exists significant differences between different treatments in all the three observation dates and all chemicals significantly reduce fruit infestation than untreated control during both the years. Among the treatments, Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 28 and 35 g a.i./ha was recorded significantly lowest mean fruit infestation during 2014 (2.11-2.66%) and 2015 (2.86-3.28%) which was statistically at par with Chlorantraniliprole 18.5% SC @ 30 g a.i./ha (3.04% and 3.59%). Next best treatments with lowest mean fruit infestation were found in Deltamethrin 1% + Triazophos 35% EC @ 360 g a.i./ha (3.40% and 3.89%), Lambda Cyhalothrin 4.9 CS @ 15 g a.i./ha (3.71% and 4.29%) and Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 21 g a.i./ha (3.93% and 4.57%) during both the years, respectively. Highest mean fruit infestation among the treatments was observed in Fenpropathrin 30% EC @ 75 g a.i./ha during 2014 (4.57%) and 2015 (4.87%) but found effective over untreated control (24.14% and 25.33%).

In terms of overall mean percent fruit infestation (Table 2), Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 28 and 35 g a.i./ha (2.49-2.97%) was recorded the best treatments with highest percent reduction over control (88.00-89.94%) followed by Chlorantraniliprole 18.5% SC @ 30 g a.i./ha (3.32%), Deltamethrin 1% + Triazophos 35% EC @ 360 g a.i./ha (3.65%), Lambda Cyhalothrin 4.9 CS @ 15 g a.i./ha (4.00%) and Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 21 g a.i./ha (4.25%) with86.58%, 85.25%, 83.83% and 82.82% reduction over untreated control, respectively. The least effective treatment in this case was recorded in Fenpropathrin 30% EC @ 75 g a.i./ha (4.52%) with 81.73% reduction over control.

Table 2: Effect of Ampligo 150 ZC (Chlorantraniliprole 9.3% + Lambdacyhalothrin 4.6% ZC) on fruit infestation by brinjal shoot and fruit borer, *Leucinodes orbonalis* Guen.

Treatment	Dose (g a.i./ha)	Pre-treatment count (%)	Percent fruit infestation (days after each spray)								Overall mean (%)	Reduction over control (%)
			First Season, 2014 (Mean of three sprayings)				Second Season, 2015 (Mean of three sprayings)					
			7 DAS	14 DAS	21 DAS	Mean	7 DAS	14 DAS	21 DAS	Mean		
T_1	21 (13.95+6.90)	4.97 (12.88)	3.36 (10.55)	4.10 (11.68)	4.32 (11.99)	3.93 (11.41)	4.08 (11.66)	4.83 (12.70)	4.80 (12.65)	4.57 (12.33)	4.25 (11.88)	82.82
T_2	28 (18.60+9.20)	4.74 (12.56)	1.81 (7.71)	2.87 (9.75)	3.31 (10.48)	2.66 (9.32)	2.61 (9.30)	3.55 (10.87)	3.67 (11.04)	3.28 (10.40)	2.97 (9.88)	88.00
T_3	35 (23.25+11.50)	5.21 (13.19)	1.37 (6.65)	2.02 (8.17)	2.94 (9.87)	2.11 (8.26)	2.12 (8.37)	3.04 (10.05)	3.42 (10.66)	2.86 (9.69)	2.49 (9.01)	89.94
T_4	30	5.16 (13.12)	2.32 (8.76)	3.17 (10.26)	3.64 (10.99)	3.04 (10.01)	3.03 (10.03)	3.87 (11.35)	3.87 (11.35)	3.59 (10.91)	3.32 (10.47)	86.58
T_5	15	5.01 (12.93)	3.15 (10.22)	3.89 (11.38)	4.10 (11.68)	3.71 (11.09)	3.84 (11.30)	4.49 (12.23)	4.54 (12.30)	4.29 (11.95)	4.00 (11.53)	83.83
T_6	75	5.51 (13.57)	3.51 (10.79)	4.40 (12.11)	4.57 (12.34)	4.16 (11.75)	4.52 (12.27)	5.04 (12.98)	5.06 (13.00)	4.87 (12.75)	4.52 (12.26)	81.73
T_7	360 (10+350)	5.29 (13.27)	2.84 (9.70)	3.48 (10.75)	3.88 (11.36)	3.40 (10.60)	3.39 (10.61)	4.13 (11.72)	4.16 (11.77)	3.89 (11.37)	3.65 (10.99)	85.25
T_8	-	5.12 (13.08)	18.85 (24.76)	25.14 (29.31)	28.44 (31.56)	24.14 (29.35)	23.14 (28.33)	25.62 (30.13)	27.24 (31.32)	25.33 (30.21)	24.74 (29.79)	-
S. Em (±)		0.31	2.20	2.10	2.10	0.51	1.49	1.29	0.98	0.21	0.34	-
C.D. at 0.05%		NS	6.66*	6.36*	6.36*	1.53*	4.53*	3.92*	2.96*	0.62*	1.03*	

T1 - Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 21 g a.i./ha**; T2** - Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 28 g a.i./ha**; T3** - Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 35 g a.i./ha**; T4** - Chlorantraniliprole 18.5% SC @ 30 g a.i./ha; **T5** – Lambda Cyhalothrin 4.9 CS @ 15 g a.i./ha; **T6** - Fenpropathrin 30% EC @ 75 g a.i./ha; **T7** - Deltamethrin 1% + Triazophos 35% EC @ 360 g a.i./ha; **T8** - Untreated Control; **NS –** Not significant; Figures in parentheses are angular transformed values; *****Significant at 0.05 level; **DAS**-Days after spray

Table 3: Effect of Ampligo 150 ZC (Chlorantraniliprole 9.3% + Lambdacyhalothrin 4.6% ZC) on marketable fruit yield of brinjal.

Treatment	Dose (g a.i./ha)	Yield (q/ha)		Mean Yield (q/ha)
		pre-*kharif*, 2014	pre-*kharif*, 2015	
T_1 - Chlorantraniliprole 9.3% + Lambdacyhalothrin 4.6% ZC	21 (13.95+6.90)	121.39	124.37	122.88
T_2 - Chlorantraniliprole 9.3% + Lambdacyhalothrin 4.6% ZC	28 (18.60+9.20)	143.81	144.00	143.91
T_3 - Chlorantraniliprole 9.3% + Lambdacyhalothrin 4.6% ZC	35 (23.25+11.50)	151.90	149.86	150.88
T_4 - Chlorantraniliprole 18.5% SC	30	138.24	136.47	137.36
T_5 - Lambdacyhalothrin 4.9 CS	15	127.27	131.77	129.52

T_6 - Fenpropathrin 30% EC	75	115.83	115.29	115.56
T_7 - Deltamethrin 1% + Triazophos 35% EC	360 (10+350)	135.34	136.26	135.80
T_8 - Untreated Control	-	65.18	64.43	64.81
S. Em (±)		2.36	2.07	1.58
C.D. at 0.05%		7.15*	6.28*	4.79*

*Significant at 0.05 level

3.3 Efficacy of insecticides on marketable fruit yield

The yield of marketable fruit of brinjal for the year 2014 and 2015 are presented in Table 3. All the insecticidal treatments exhibited significantly higher marketable fruit yield than untreated control. Among the treatments, Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 28 and 35 g a.i./ha provided the highest marketable fruit yield during 2014 (143.81 & 151.90 q/ha) and 2015 (144.00 & 149.86 q/ha) followed by Chlorantraniliprole 18.5% SC @ 30 g a.i./ha (138.24 & 136.47 q/ha), Deltamethrin 1% + Triazophos 35% EC @ 360 g a.i./ha (135.34 & 136.26 q/ha), Lambda Cyhalothrin 4.9 CS @ 15 g a.i./ha (127.27 &131.77 q/ha) and Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 21 g a.i./ha (121.39 & 124.37 q/ha) during both the years, respectively. Fenpropathrin 30% EC @ 75 g a.i./ha was recorded lowest marketable fruit yield among the treatments during 2014 (115.83 q/ha) and 2015 (115.29 q/ha) but found superior over untreated control (65.18 & 64.43 q/ha). The pooled data on marketable fruit yield revealed that, Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 28 and 35 g a.i./ha recorded the highest yield (143.91-150.88 q/ha) followed by Chlorantraniliprole 18.5% SC @ 30 g a.i./ha (137.36 q/ha) and Deltamethrin 1% + Triazophos 35% EC @ 360 g a.i./ha (135.80 q/ha) and lowest in untreated control (64.81 q/ha).

In the present investigation, Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC @ 28-35 g a.i./ha and Chlorantraniliprole 18.5% SC @ 30 g a.i./ha registered excellent performance in the reduction of shoot and fruit infestations and maximizing the fruit yield during both the years. The effectiveness of the new mixture formulation may be attributed due to its unique and novel mode of action. The literature regarding the efficacy of ready mix formulation Ampligo 150 ZC (Chlorantraniliprole 9.3% + Lambda Cyhalothrin 4.6% ZC) against *Leucinodes orbonalis* is very scanty. However, the effectiveness of Ampligo 150 ZC against bollworm complex in cotton is reported by Bajya *et al*. [3] which is similar to our findings. The efficacy of Chlorantraniliprole in reducing the shoot and fruit borer infestation with highest marketable fruit yield was reported by many researchers [5, 8, 9, 14, 16] which are in conformity of the present study. Pawar *et al*. [15] also reported that Chlorantraniliprole 18.5 SC @ 37g a.i./ha followed by Deltamethrin 1% + Triazophos 35% EC @ 360 g a.i./ha was significantly superior with least fruit damage and marketable fruit yield of brinjal, which corroborate the present findings. The efficacy of Lambda Cyhalothrin against brinjal shoot and fruit borer was reported by Anil and Sharma [1].

4. Conclusion

From the above discussion, it may be concluded that the new ready mix formulation Ampligo 150 ZC @ 28-35 g a.i./ha and Chlorantraniliprole 18.5 SC @ 30 g a.i./ha provided excellent control of brinjal shoot and fruit borer by maximizing the marketable fruit yield during the course of investigations. This novel mixture formulation can be effectively exploited in the IPM and insecticide resistance management programme for brinjal shoot and fruit borer.

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