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Bioefficacy of some new insecticidal formulation against rice yellow stem borer (*Scirpophaga incertulas* Walker) and study its impact on predatory fauna

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Abstract
A field experiment was conducted at Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal to evaluate the efficacy of some novel insecticidal formulation for the control of yellow stem borer in rice. Shatabdi -IET 4786, a popular cultivar considered as a test variety for the experiment. All the treatments were found significantly effective in reducing the infestation of stem borer and increasing the yield compared with control. Application of Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) @ 120 ml/ha resulted by 47.57% yield increase over control and only presence of 0.76% and 1.44% dead heart and white ear head respectively in field with a cost benefit ratio by (1: 4.56), proved to be the most effective treatment for reducing the stem borer infestation similarly proved to be highly safe towards the native predatory fauna.

Keywords: rice, bioefficacy, natural enemy, safety

Introduction
Rice (Oryza sativa L.) is the world's second most important cereal crop, feeding about 50% of the world population and provides 19% of the global calories intake (Anonymous, 2014) [2]. Insect-pests are the major constraints in enhancing rice productivity, besides diseases and weeds (Behura *et al*., 2011) [4]. Rice is essentially a crop of warm, humid environment which is conducive to survival and proliferation of lepidopteron insect pests like stem borers and rice leaf folder although more than 100 species of insects are known as pests of this crop. Among stem borers, the yellow stem borer (YSB), *Scirpophaga incertulas* (Walker) is the dominant species in India and rice plants are most prone to its infestation at their tillering and flowering stages. YSB inflicted 18 to 40 % damage to the rice crop (Anonymous, 2006) [3] while (Rath, 2001) [8] and Sachan *et al*., (2006) [9] reported the attack of yellow stem borer, *Scirpophaga incertulas* (Walker) is quite serious as it can cause 25-30 per cent damage to the crop. Stem borer larvae after emerging from egg mass enter the tiller to feed inside it and damages the central whorl that turn brownish and dries resulting in "dead hearts". The affected tillers do not grow further and dries up. At reproductive stage, the damage is characterized by whitish, erect and chaffy panicles called, "white ears". Muralidharan and Pasalu (2006) [7] and(Dhaliwal *et al*., (2010) [6] reported that due to 1 % dead heart or white ear, or due to both phases stem borer damage would be 2.5, 4.0, and 6.4 % yield loss, respectively. Farmers still consider application of insecticides as the key component of Integrated Pest Management but indiscriminate use of these insecticides resulted in reduction of natural enemies, environmental pollution and residues in seeds etc. New molecules are now emerging as a viable component of IPM strategies in all crops in view of their good efficacy to pest control and safety to non-target organisms. Therefore the present investigation was undertaken to evaluate the efficacy of some novel insecticides against yellow stem borer of rice under lower gangetic zone of west Bengal.

Materials and Methods
A field experiment was conducted at Central Research Farm, Gayeshpur, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal to evaluate the efficacy of some novel insecticidal formulation for the control of yellow stem borer on rice variety Shatabdi -IET 4786, a popular variety in the West Bengal, during both rabi and kharif seasons of 2016-17 and 2017. Experiment was laid on a Randomized Block design with eight treatments including untreated control and each treatment replicated thrice. Twenty five days old seedlings were transplanted at a spacing 15 x 15 cm and the crop was raised by adopting a standard package of practices except the plant protection measures. Treatment combination includes
T1- Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) @ 80 ml/ha,
T2 - Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) @ 120 ml/ha,
T3 - Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) @ 160 ml/ha,
T4 - Lambda Cyhalothrin 5% EC @125 ml/ha,
T5 - Chlorpyriphos 50% EC 1500 ml/ha,
T6 – Cartap hydrochloride 50% SP @ 1000 ml/ha,
T7 - Fipronil 5% SC @ 1500 ml/ha
T8 - Untreated control

Were tested at field condition. A total of three applications was given during the crop period at fifteen days interval. Yellow stem borer damage as well as Dead Heart percentage and White Ear Head percentage were recorded at their respective vegetative and reproductive stage were recorded from 10 hill per plot after one, three, seven and ten days after chemical application. The percentage dead heart and white ear head were calculated as given:

% Dead hearts = (Total number of dead hearts/ Total number of tillers) X 100
% White ears = (Total number of white ears/ Total number of tillers) X 100

The natural enemy population *viz.* wolf spider, long jaw spider, and rove beetle were recorded per twenty hill while the *Trichogramma* population were recorded based on percent egg parasitization. The per cent infestation of damage transformed into angular value while natural enemy population were transformed into square root value for analysis. The yield data was recorded from each plot separately. Grain yield from each plot was converted in to quintals per hectare. Cost benefit ratio was also assessed by dividing the net returns by the total additional cost due to treatments.

Results and Discussions

The stem borer infestation was recorded on the basis of percentage dead heart and white ear head percentage. To study the efficacy of insecticidal formulation against YSB, three consecutive insecticidal application was done with first application done at 25 days after transplanting (DAT) of crop while subsequent spar was done at fifteen days interval where all the treatment proved

Table 1: Comparative efficacy of some new insecticides against yellow stem borer in rice during Rabi and Kharif seasons of 2017-18 and 2018.

Treatments		Formulation (ml/ha)	Per cent Dead Hearts				Per cent White Ears			Yield (q/ha)			
			PTC (Egg mass/5 hills)	*Rabi* 2017-2018	*Kharif* 2018	Pooled	*Rabi* 2017-2018	*Kharif* 2018	Pooled	*Rabi* 2017-2018	*Kharif* 2018	Pooled	% yield increase over control
T1	Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex)	80	3.25	3.33 (10.52)	3.61 (10.95)	3.47 (10.73)	4.82 (12.68)	5.00 (12.92)	4.91 (12.81)	33.53	31.38	32.45	**11.59**
T2	Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex)	120	3.0	0.70 (4.78)	0.83 (5.24)	0.76 (5.01)	1.39 (6.77)	1.50 (7.03)	1.44 (6.90)	44.16	41.68	42.92	**47.57**
T3	Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex)	160	3.5	0.56 (4.28)	0.70 (4.78)	0.63 (4.53)	1.50 (7.04)	2.21 (8.54)	1.85 (7.79)	43.98	41.15	42.56	**46.35**
T4	Lambda Cyhalothrin 5% EC	125	3.25	2.78 (9.59)	2.36 (8.84)	2.57 (9.21)	2.22 (8.57)	2.50 (9.10)	2.36 (8.83)	39.83	35.53	37.68	**29.55**
T5	Chlorpyriphos 50% EC	1500	3.25	2.92 (9.83)	3.47 (10.74)	3.19 (10.28)	4.68 (12.49)	4.00 (11.54)	4.34 (12.01)	33.28	32.39	32.83	**12.89**
T6	Cartap hydrochloride 50% SP	1000	3.25	1.53 (7.10)	1.67 (7.42)	1.60 (7.26)	1.71 (7.51)	2.30 (8.72)	2.00 (8.11)	42.06	39.88	40.97	**40.86**
T7	Fipronil 5% SC	1500	4.12	2.50 (9.10)	2.50 (9.10)	2.51 (9.10)	2.16 (8.45)	3.12 (10.17)	2.64 (9.31)	37.63	35.25	36.44	**25.29**
T8	Untreated control		4.0	5.00 (12.92)	5.55 (13.63)	5.275 (13.27)	9.11 (17.57)	8.23 (16.67)	8.67 (17.12)	29.50	28.67	29.08	
	CD (p=0.05)		NS	0.56	0.68	0.61	0.29	0.25	0.28	0.96	1.18		

Figures in parenthesis are angular transformed value of original one

Table 2: Relative effect of different treatment against prevailing natural enemies of rice ecosystem (Pooled value of both *Rabi*, 2017-2018 and Kharif, 2018 season)

Treatments		Formulation (ml/ha)	Natural Enemy Fauna			
			Wolf spider	Long jaw spider	Rove beetle	Per cent egg parasitization by *Trichogramma*
T1	Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex)	80	1.54 (1.24)	0.78 (0.88)	1.13 (1.06)	76.13
T2	Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex)	120	1.35 (1.16)	0.68 (0.82)	0.98 (0.99)	72.10
T3	Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex)	160	1.33 (1.15)	0.65 (0.81)	0.95 (0.98)	67.97
T4	Lambda Cyhalothrin 5% EC	125	1.13 (1.07)	0.40 (0.63)	0.82 (0.90)	60.04
T5	Chlorpyriphos 50% EC	1500	0.79 (0.89)	0.27 (0.52)	0.59 (0.77)	53.01
T6	Cartap hydrochloride 50% SP	1000	1.09 (1.04)	0.56 (0.75)	0.86 (0.93)	67.55
T7	Fipronil 5% SC	1500	0.92 (0.96)	0.38 (0.62)	0.70 (0.84)	60.59
T8	Untreated control	-	1.84 (1.36)	0.93 (0.96)	1.18 (1.09)	77.75
	CD (p=0.05)		0.33	0.37	0.42	

Mean of 20 hills; Values in parentheses are square root transformed value of original one.

To be effective upon the untreated one. The results of percent reduction and subsequent yield advantage is presented in Table 1, which depicts that there is no significant difference in between egg mass/hill before the pesticidal application while pooled data of percent dead heart after three spraying during rabi season shows that lowest head heart percentage (0.56%) observed when the plot it treated with Ladex (Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v) @160ml/ha which is at par when the

plot is treated with the same chemical @120 ml/ha (0.70% dead heart) followed by application of Cartap hydrochloride 50% SP @ 1000 ml/ha where the recorded total damage is 1.53%. The highest damage next to untreated was recorded when plant treated with Ladex (Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v)-T1 @
80 ml/ha followed by T5 (Chlorpyriphos 50% EC @ 1500 ml/ha) where the recorded dead heart percentage by 3.33% and 2.78% respectively. A similar trend was observed during kharif season and subsequent in pooled data also where recorded minimum dead heart observed in T3 by 0.70% and 0.63% followed by T2, 0.83% and 0.76% during Kharif season and pooled value respectively while T1 proved to be the least effective in respect to dead heart management with recorded dead heart percentage by 3.33% and 3.47% during kharif season and pooled value of two season respectively followed by T5 (Chlorpyriphos 50% EC @ 1500 ml/ha) with 3.47% and 3.19% recorded dead heart in field condition. Although, Cartap hydrochloride (1.60 % DH), Fipronil (2.51 % DH) and Lambda Cyhalothrin (2.57 % DH) proved significantly superior over untreated control (5.27 % DH). The sole application of lambda cyhalothrin 5 EC @ 500 ml/ha was responsible for 2.07 % dead hearts and chlorpyriphos 20 EC @ 1 lit/ha had maximum infestation (5.36 % dead hearts) where as in the control plot the infestation was 6.06 per cent in basmati rice during kharif season (Sachan *et al*., 2018)[10]. Abro *et al*., (2013) [1] reported that cartap hydrochloride was found most effective insecticide with the minimum percent infestation (4.37%) in rice infested with yellow stem borer while infestation recorded 8.68% when field treated with fipronil. All other treatments were significantly superior over untreated control in reducing white ears damage but a slight change was observed in efficacy towards management of white ear in rice where the lowest percentage of white ear observed by 1.39%, 1.50%,1.44% during rabi, kharif season and their pooled value respectively in case of second treatment (T2) followed by in T3 (1.50%,2.21% and1.85% in rabi, kharif and pooled value) and T6 (1.71%,2.30% and 2.00% in rabi, kharif and pooled value respectively) while the application of Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) @ 80 ml/ha (T1) proved to be least effective one with presence of 4.91% white ear in field after treatment. However, Cartap hydrochloride (2.0% WE), Lambda Cyhalothrin (2.36% WE), Fipronil (2.64% WE) and Chlorpyriphos (4.34% WE) were significantly superior over untreated control (8.67 % WE). Chormule *et al*., (2014) [5]. Reported that presence of 3.13% dead heart and 4.33% white ear in field condition when treated with Fipronil 5 SC and application of Cartap hydrochloride 50 SP can't reduce dead heart and white ear by 3.92% and 5.07% respectively in rice field.
Studies revealed (Table: 2) that all the chemical proved to be lethal at their certain range when compared with untreated one but among them lowest abundance of predatory fauna observed when plant treated with Chlorpyriphos 50% EC with recorded wolf spider, long jaw spider and rove beetle by 0.79, 0.27 and 0.59 /20 hill respectively where recorded egg parasitization by *Trichogramma* by 53.01%. The highest abundance of natural enemy recorded in T1which is significantly at per with T2 where recorded wolf spider, long jaw spider and rove beetle by1.35, 0.68, 0.98 /20 hill respectively and 72.10 % observed
egg parasitization. Chormule *et al*., (2014)[5] observed that 2.66, 2.83 and 3.15 number / 5hill of natural enemies in rice filed when treated with Lambda cyhalothrin 5 EC, Cartap hydrochloride 50 SP and Fipronil compared to a total of 5.92 number / 5hill against untreated on. The grain yield data was also revealed that, all the insecticidal treatments was

Table 3: Economics of treatments in pooled yield of rice during Rabi and Kharif season of 2017-18 and 2018.

Treatments		Formulation (ml/ha)	Mean yield of rice (q/ ha)	Extra yield over control (q/ ha)	Cost of treatments (Cost of insecticide/ ha + cost of labour for spraying/ ha) (Rs./ ha)	Value of additional yield (Rs./ ha)	Net profit (Rs/ha)	Incremental Cost: Benefit Ratio (ICBR)
T1	Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex)	80	32.45	3.37	3870.00	5729	1859	1 : 0.48
T2	Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex)	120	42.92	13.84	4230.00	23528	19298	1 : 4.56
T3	Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex)	160	42.56	13.48	4590.00	22916	18326	1 : 3.99
T4	Lambda Cyhalothrin 5% EC	125	37.68	8.60	3412.00	14620	11208	1 : 3.28
T5	Chlorpyriphos 50% EC	1500	32.83	3.75	5875.00	6375	500	1 : 0.06
T6	Cartap hydrochloride 50% SP	1000	40.97	11.89	6750.00	20213	13463	1 : 1.99
T7	Fipronil 5% SC	1500	36.44	7.36	9900.00	12512	2612	1 : 0.26
T8	Untreated control		29.08					

Price of rice: Rs. 1700/ quintal; Labour cost: Rs 275/ man-day; chemical price are accordance with date of purchase.

Significantly superior over untreated control (Table 1). The yield data indicates that, Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) @ 120 ml/ha recorded significantly higher yield (42.92q/ha) in paddy with a yield advantage of 47.57% followed by application of Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) @ 160 ml/ha with an yild advantage of 13.48q/ha and 11.89 q/ha in the plot treated with Cartap hydrochloride 50% SP (Table 3). Similarly Lambda Cyhalothrin 5% EC (37.68q ha^{-1}) was proved to be fourth best treatment followed by Fipronil 5% SC (37.68 qha^{-1}) and Chlorpyriphos 50% EC (12.89 qha^{-1}) while application of Ladex @ 80 ml/ha recorded to be least efficient among those chemical with only 11.59% yield advantage over untreated one.
Cost benefit ratio was calculated based on the pooled yield data obtained during the seasons of rabi, 2017-18 and kharif 2018 (Table 3) and the highest cost benefit ratio was obtained in Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) (1 : 4.56) followed by Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) (1 : 3.99), Lambda Cyhalothrin 5% EC (1 : 3.28), Cartap hydrochloride 50% SP (1:1.99), Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) (1:0.48), Fipronil 5% SC (1:0.26) while

Chlorpyriphos 50% EC (1 : 0.06) recorded by least economical one.

Conclusion

Results showed that new insecticide molecule shows higher efficacy in controlling yellow stem borer damage by reducing dead heart and white ear percentage in rice. However a new insecticidal mixture combination of Lambda Cyhalothrin 25% w/v + Chlorpyriphos 10% w/v zw (Ladex) with application rate @ 120 ml/ha found to be most economical in respect for controlling pest infestation besides safer towards the beneficial fauna with highest economic return under field condition.

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