INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES
Volume-7, Issue-1 Jan-Mar-2017 Coden: IJPAJX-CAS-USA, Copyrights@2015ISSN-2231-4490
Received: 1st Oct-2016 *Revised: 19th Nov-2016* *Accepted: 27th Nov-2016*
DOI: 10.21276/Ijpaes http://dx.doi.org/10.21276/ijpaes ***Research article***

AUTO CONFUSION TECHNOLOGY- AN INNOVATIVE AND NOVEL METHOD OF USE OF PHEROMONE FOR MANAGEMENT OF RICE YELLOW STEM BORER *SCIRPOPHAGA INCERTULAS* (WALKER) IN EASTERN INDIA.

C.R.Satpathi, A.M.Raut and K .Krishnaiah[1]

Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia - 741252, West Bengal, India.
[1]Former Project Director, Directorate of Rice Research, ICAR, Hyderabad, India

ABSTRACT: The rice yellow stem borer *Scirpophaga incertulas* Walk. (Lepidoptera, Pyralidae) is one of the important insect pests of rice in easternIndia as well as all rice growing areas of Asia, South east Asia, Pakistan and Bangladesh. The extentof borer damage induced yield losses which have been estimated to be13.07 to 70 % in Asia. An on-farm field trial was conducted to study the effect of pheromone mass trapping, mating disruption through auto confusion, farmer's practice (where two to three rounds chemical pesticides were used) and control (free from treatment) in eastern India during 2012 to 2013. The treatment involved in mating disruption through auto confusion technology with 20 mg tablet showed that the average index of egg mass (IE) and efficiency of mass trapping (EMT) reduced during second year as compare to the other treatments. Here there was no significant difference between mating disruption and mass trapping and farmers practice but all are significantly superior to control. The experiment also indicated that grain yield obtained from farmers practice were nearly at par with mating disruption through auto confusion but the paddy grain obtained were free from pesticide residue indicating produce in safe to the consumers. Study also indicate that auto confusion technology is compatible with integrated pest management (IPM) programme as it is species specific which assist biodiversity and support natural enemies.
Key words: Pheromone, auto confusion, yellow stem borer and biodiversity.

*Corresponding author: C.R.Satpathi, Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia -741252, West Bengal, India E-mail: crsatpathi2003@yahoo.co.in

INTRODUCTION

West Bengal is one of the leading rice growing state in eastern India, and cultivates rice over 5.69 m ha which constitutes 12.99% of total rice of India. Among five species of stem borers, yellow stem borer *Scirpophaga incertulas* (Walker) referred as YSB in the paper, divested the crop in eastern India. Larval feeding of YSB from inside stem (Pseudostem) severs central part of tiller at its base resulting in drying of central whorl rendering the tiller non-productive. Damage caused by the borer is typically termed as dead heart (DH) and white ear (WE) during vegetative and reproductive stage of crop respectively. The insect (YSB) was also a recorded as a major pest in all rice growing areas of Asia (Cohen *et al.*, 2000) [1], India (Murlidharan and Pasalu, 2005) [2] and Pakistan (Abro *et al.*, 2013)[3]. Yellow stem borer (YSB) had also been reported as amajor pest of rice from Bangladesh, Brunei, Cambodia, China, Hong Kong, Indonesia, Japan, Malaysia, North Borneo, Philippines, Taiwan, Thailand and Vietnam (Rao, 1965)[4]. The extent of borer damage induced yield losses have been estimated to range from 30 to 70% in Bangladesh (Catling *et al.*, 1987)[5], 25 to 30% in India (Puri, 2009)[6].At present one of our goal is to demonstrate a timely and meaningful invest in research on behavior modifying chemical for sustainable insect management. Pheromone or ectohormones are substances liberated by external gland which produce specific reaction in other individual of the same species. Olfactory pheromone includes the sex attractant substance produced by the lateral glands of the last abdominal segment of vergin female.

Different study showed that worldwide annual insecticide application has been increased from 7000 t in 1997 to more than 10000 t in the year 2000, ninty per cent of which used in rice production (Witzall *et al.*, 2010)[7]. Even some of the agrochemical industries now reached the view that further increase is not feasible and thus they support the alternate method of pest management in order to maintain sustainable level of pesticide use (Cork *et al*., 2008)[8]. Gaston et al., (1967) [9] first reported that pre-mating communication between the sexes can be disrupted by pre-meeting the atmosphere with an insect pheromone.The female sex pheromone of the rice yellow stem borer *Scirpophaga incertulas* was identified by Cork *et al.,* (1985) [10] using insects from Philippines. Du *et al.,* (1987)[11] confirmed (Z)-11-hexadecenal and (Z)-9-hexadecemal as the component of female sex pheromone of rice yellow stem borer.Extensive research had been conducted by NRI in collaboration with DRR, Hyderabad, and HDFC India, over a five year period to develop technology for controlling *Scirpophaga incertulas* by mating disruption (Cork and Basu, 1996[12],Cork *et al.*, 1996)[13].Several field trials with pheromone formulation had been conducted as mating disruption agent for managing rice stem borer in other rice growing countries of the world(Kanno *et al.,* 1978[14]; Yang *et al.*, 2001[15]; Alfaro *et al*., 2009) [16]. Present investigation is an innovative and novel method use of pheromone is established through auto confusion technology where in small quantity of pheromone impregnated in ento-wax (EXOSEX YSB_{Tab}) supplied by EXOSECT, United Kingdom, contaminated chain of rice stem borer male moth in easternIndia.

MATERIALS AND METHODS

ExosexYSB_{tab} along with hanger were collected from EXOSECT Limited, Leyland Business Park, Colden Common, Winchester Hampshire, SOZIITH, United Kingdom during the month of May of every year during 2012 to 2013. This tablet was made up of compressed wax powder containing female pheromone; Entostat is on the GRAS list in USA, approved as an inert in 91/414, BPD, VMD and MCA in Europe. This pheromone tablets were loaded into grove of the biodegrableplastic hanger which were tied to the bamboo stick of 1.5 m length. Such stick were fixed and placed in the transplanted field in a 11 × 11 m matrix at the rate of 80 per ha.

Detail of the Trials

A field experiment conducted in farmer’s field under Gopalpur co-operative society, Gopalpur, Burdwan, West Bengal, India. Swarna Mashuri (locally adopted) variety was used in the experiment having 150 days crop maturity. The experiment was laid out in completely randomized design with four treatments, each treatment was needed one hectare land and each treatment was separated from another with a gap 100 m. The 15 days old seedlings were transplanted during 7^{th} to 13^{th} August of every year and hills maintain 15 X 15 cm spacing. The recommended fertilizer dose (80 N: 60 P: 60 K) was provided throughout the experiment period.

Table 1- Detail of the treatments testing in rice field.

S.No.	Treatments	Nursery	Main field
T_1	Funnel trap with pheromone lure 250 mg per hectare (FTPL-5)	Fifty funnel traps $ha^{-1}$with lure or Pheromone@250 mg ha^{-1}	Fifty funnel trap/ha with lureinstalled within 10 days after transplanting of rice plant followed by twice lure replacement at 45 and 65 days respectively orPheromone @ 500 mg ha^{-1}
T_2	EXOSEX YSB_{tab} 20 mg through hanger (FYt-20) @ 100 mg/hectare	Fifty funnel traps $ha^{-1}$with lureor Pheromone@250 mg ha^{-1}	Single application within 15 days after transplanting @ 80 tablets ha^{-1}or Pheromone 1600 mg ha^{-1}
T_3	Farmers practice against stem borer	Recorded as per farmer’s action	Application of Carbofuran 500 gai ha^{-1}(granular pesticide) within 15 DAT followed byChlorantraniliprole 18.55%SC W/W @ @25 g a.i/hafollowed by the combination product of Chlorpyriphos&Cypermethin 55% @ 500 gai ha^{-1}at 35 DAT
T4	Without any management practice (Control)	-	-

Estimation of average index of egg masses

Nine rice fields from each treatment and control areas were selected randomly. Egg mass of *Scirpophaga incertulas* (Walk) were examined randomly selected 400 hills in each treatment. Sampling was done on 10 DAT, 20 DAT, 30 DAT and 40 DAT. The average index of egg mass (IE) of *S. incertulas* per 400 hills was calculated by the following formula.

$$IE\ \% = \frac{Ne}{Nf \times Nh \times Ms} \times 100$$

Where, IE = Average Index of Egg Masses

N_e = total number of egg masses in all sampled field.

N_f = Number of fields selected (12 in present study)

N_h = Number of hills examined (400 in present study) per treatment.

M_s = Average number of tiller/hill.

Catches of male moths for monitoring

The population size of *S. incertulas* was monitored in experimental plots using pheromone traps. Twelve, separate traps were installed both treated and control plot during 10 days after transplanting (DAT) every year. Male moths were captured and counted at seven days interval. The efficiency of mass trapping (EMT) with respect to control was calculated according to the following formula. Pheromone lure was replaced at every 21 days interval after installation.

$$EMT\ \% = \frac{Cc - Ct}{Cc} \times 100$$

Where, C_C = average of moth catches per trap in a week in control plot.

C_t = average of moth catches per trap in treated plot

Damage Assessment

Damage due to stem borer was assessed in term of DH and WE by counting total number of tillers and number of dead hearts (DH) in each selected hill at vegetative stage, total number of panicle bearing tiller and white ear heads (WE) at heading stage. Randomly selected 400 hills from each treatment and 100 hills from them considered as transect. Thus there were four transect with 100 sampling unit in each treatment. Each transect from the treatment was considered as a replication for analyzing the damage assessment. Damage assessment data were recorded at 10 days intervals commencing from 35 DAT.The larvae at the second generation damage both main stem as well as panicle bearing internodes; however, can lead to major crop loss. DH and WE were sampled at 10 days interval after application of treatment.

$$DH\ or\ WH\ \% = \frac{\text{Number of damage tillers}}{\text{Total number of tillers}} \times 100$$

Yield Loss

Yield loss was worked out from a square meter area from each treatment which was expressed to yield/hectare.

Statistical Analysis

Analysis of the variance of the data was done for each trial by considering each trial under completely randomized design. Critical and difference values were computed. Pest infestation data were subjected to angular transformation prior to analysis as stated earlier percent DH/WE of each transect of particular treatment formed one replication and each crop cut made from each triangular area of the treatment plot formed a replication. Moth capturing count data were subjected to square root transformation for normalized the data.

RESULTS AND DISCUSSION

Egg mass index

The number of egg masses observed was shown in Table 2. The average number of egg masses per 400 hills between the pheromone-treated fields and control fields were found statistically significant. The average egg mass index (IE %) during the ovi position period was found 0.154% in T_1 (Funnel trap with pheromone lure), 0.124% in T_2 (ExosexYSB$_{Tab}$), 0.300% in T_3 (farmers practice) and 0.393 % was found in T_4 (unprotected) during 2012. The average IE % in the treated field T_1, T_2 and T_3 were39.11, 31.53 and 76.17 % over the control field respectively. Lowest egg mass index was observed in mating disruption and that indicated the male moth do not find the female for matting. During 2013, the average egg mass index was observed 0.132, 0.113, 0.263 and 0.327% in T1, T2, T3 and T4 respectively. The average minimum IE was observed in ExosexYSB$_{Tab}$ (34.44%) followed by pheromone treated (40.23%) and farmer field (80.32%). In mass trapping and mating disruption treated field egg mass progressively decreased up to 40 DAT but in farmers and unprotected field slightly increase up to 20 DAT and decrease from 30 DAT.

Table 2- Average egg masses index (IE) value with respect to control in MTU rice variety.

Egg mass Index - 2012						
Treatments	10 DAT	20 DAT	30 DAT	40DAT	Average	IE % over control
T_1	0.222	0.186	0.152	0.057	0.154	39.11
T_2	0.193	0.153	0.117	0.032	0.124	31.53
T_3	0.311	0.436	0.324	0.129	0.300	76.17
T_4	0.390	0.527	0.445	0.212	0.393	
SEm ±	0.030	0.029	0.037	0.015		
CD @ 5 %	0.093	0.091	0.115	0.047		
Egg mass Index - 2013						
T_1	0.191	0.169	0.121	0.045	0.132	40.23
T_2	0.165	0.153	0.102	0.030	0.113	34.44
T_3	0.292	0.362	0.290	0.108	0.263	80.32
T_4	0.367	0.449	0.350	0.142	0.327	
SEm ±	0.026	0.022	0.020	0.012		
CD @ 5 %	0.080	0.068	0.063	0.038		

Catches of male moth

Catches male moths of *Scirpophaga incertulas* (Walk) by traps baited with synthetic pheromone from 12th August to 17th November with two distinct peaks during last week of August to first week of September and first week of October to second week of October of every year in eastern India (Fig 1 and 2). The efficiency of mass trapping catches (EMT) were 52.47 (T_1) and 81.51 (T_2) during 2012 while 46.67 (T_1) and 84.87% (T_2) during 2013 over the control. Data on catches of male moths were recorded for two consecutive years (2012-2013) from the same field with 3 replications with 9 ha. size, each (net) was located in one village with > 1 to 1.5 Km apart from one another. All field belonged to farmers of one co-operative (Gopalpur Co-operative, Dist.–Burdwan, West Bengal, India) who adopted almost similar cultivation practices.

During the first year (2011) a significant numbers of *Scirpophaga incertulas* (Walk) male moths were caught from sixpheromone treated, one chemical treated (FP) and control plots (Fig.1). The captures in the traps baited with synthetic pheromone lure accurately show the abundance of the YSB in that year of that particular locality. The population relates trap capture ultimately reflect on the damage caused by the next generation of larva of yellow stem borer. The most interesting things were noted that trap catches were significantly reduced during second year from the pheromone treated areas as compared to chemical treated plot (Farmers practices) (Fig. 2) suggested that pheromone treated were more effective during second year of treatment.

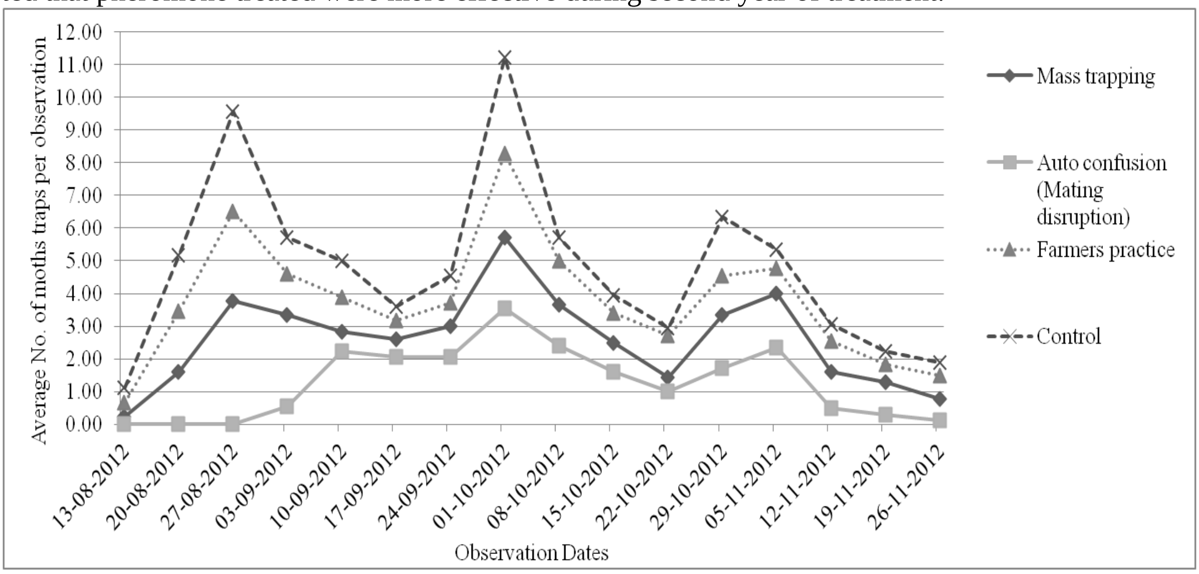

Fig. 1- Moth catches per trap from different treatment in MTU rice varietyduring 2012.

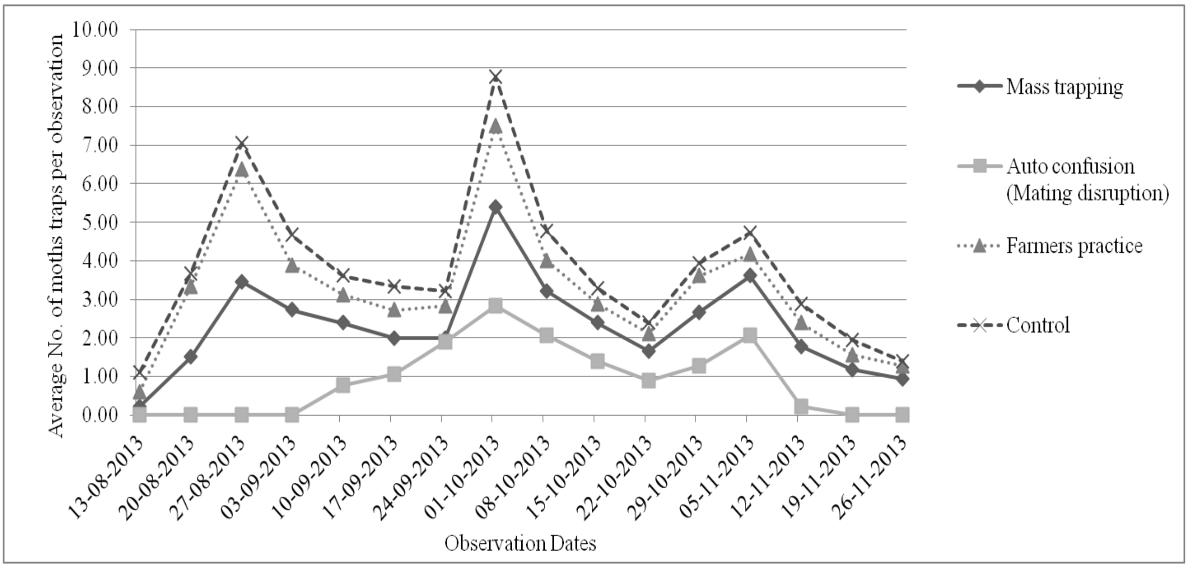

Fig. 2- Moth catches per trap from different treatment in MTU rice varietyduring 2013

Technically pheromones are used in Integrated Pest Management (IPM) programme in two principal ways viz. trapping and mating disruption. In mass trapping sex pheromone baited trap capture male capture continuously, thus preventing mating and multiplication of yellow stem borer in rice field. In the present investigation the most efficient method of trapping was accepted after series of testing in rice field where lure is replaced twice in a season during 45 DAT and 60 DAT respectively. The result also support the observation of Cork and Krishnaiah (2000)[17] and Verma *et al.*, (2004)[18] who found it was highly effective using indigenous lure at a density of 20 traps ha^{-1}wheredispensers were replaced after every three weeks. The present work is also the beginning for making the technique farmers friendly for management of rice yellow stem borer through auto confusion technology. Here the pheromone is used for disruption of mating which was achieved by placing single application of high concentration 1600 mg/hectare at 15 days after transplanting offered complete protection in the season. This auto confusion system used electrostatic powder mixed with synthetic female sex pheromone adhered to the male moths, causing sexual confusion to the covered moth. In this process, the moths'antenna becomes saturated with powder and pheromone and it can no longer locate female. In addition once the male moth leave with a powder spot, because it take some pheromone with it, it act as false female lure, to other males, enhancing the mating disruption effect. The transfer from one male to another in secondary transfer of the pheromone containing powder may leads to lower the chance of successful mating of male with the female. The application should be made as close to the beginning of first flight of yellow stem borer and it was essential to reduce the number of mating and viable eggs laid by the first generation adults and was key to the successful trial.The results is also in accordance to the observation of Cork *et al*., 2001[19] where the trap catch was found to be positively correlated with pheromone release rate, with the highest dose tested 200 µg catching significantly more male moths than the lower dose.

Table 3- Average moth catches from different treatments per generation and EMT value with respect to control.

Treatments	Generation 2012				Generation 2013			
	1st	2nd	Total	EMT %	1st	2nd	Total	EMT %
	27-08-2012	01-10-2012			27-08-2013	01-10-2013		
Mass trapping(T_1)	1.87 (1.40)*	3.50 (1.91)	5.37	52.47	1.72 (1.35)	2.90 (1.73)	4.62	46.67
Mating disruption through auto confusion (T_2)	0.00 (0.71)	2.09 (1.48)	2.09	81.51	0.00 (0.71)	1.31 (1.23)	1.31	84.87
Farmers practice (T_3)	3.54 (1.83)	4.73 (2.16)	8.27	26.81	3.44 (1.73)	4.01 (1.96)	7.46	13.97
Control (T_4)	5.28 (2.21)	6.02 (2.41)	11.30		3.94 (1.95)	4.72 (2.12)	8.67	
SEm ±	0.070	0.079			0.100	0.091		
CD @ 5 %	0.201	0.227			0.288	0.263		

*In figure parenthesis is square root transformation

In 2012, the average male moth catches in T_1(mass trapping) 1.87 to 3.50, T_2 (mating disruption) 0.00 to 2.09, T_3 (farmers practice) 3.54 to 4.73 and 5.28 to 6.02 in control plot. Among the treatments mating disruption was resulted significantly superior effect on trapping as well as EMT value over control.
The total moth catches in the treatment in mass trapping (T_1) which was not significantly ($P > 0.05$) different compared to mating disruption through auto confusion (T_2) but they were significantly ($P < 0.05$) less than chemical treatment (T_3). The Efficiency of Mass Trapping (EMT) value was also not significantly different to T_2 but they were significantly less than T_3. During second year 2013 a significant number of YSB male moths were captured but they were comparatively lower than the first years. Like the first year no significant ($P <0.05$) difference was found among the T_1 and T_2 but they were significantly lower than chemical treatment (T_2).Here the male moth gets covered with powder containing pheromone unable to attract the lure in funnel trap as well as female. Subsequently the freshly hatched male can fallow trails left by contaminated male. The end result is that trapping is significantly lower than the other treatments.

Crop Damage

Treatment efficiency is not only determined by the trap catches but also damage assessment. Howse (1998)[20] reported that the absence of trap catches during mating disruption treatment can be good indication that the technique is effective but crop damage provide the ultimate proof. Karg Sauer (1995)[21] also reported that crop damage assessment is the most evident way of showing the efficiency of mating disruption.It is evident from Table 4 that in the first year that the dead heart incidence ranged from 0.37 to 1.12 % in mass trapping (T_1) and 0.29 to 0.90% in mating disruption(T_2) , 0.47 to 2.05% in chemical control (T_3) and 0.73 to 3.14 % in control (T_4)at vegetative stage. Although the numerical value of DH in two treatments were closer but EXOSEX YSB_{tab} was found significantly superior to farmers practice as well as control. White ear incidence in T_1, T_2, T_3 and T_4 registered 2.69, 2.35, 3.55 and 4.33 %. There was no significant difference between T_1 and T_2 while both T_1 and T_2were significantly superior T_3. In respect of yield both mass trapping and auto confusion gave higher yield than the chemical treatment.Thus both mass trapping (T_1) and mating disruption through EXOSEX YSB_{tab}(T_2) were found superior both in respect of controlling YSB damage and giving high yield in 2012. The end result is that reduction of dead heart and white ear was obtained due to mating disruption through auto confusion.

Plate-1 Different stages of rice yellow stem borer and their normal mating position in rice Field

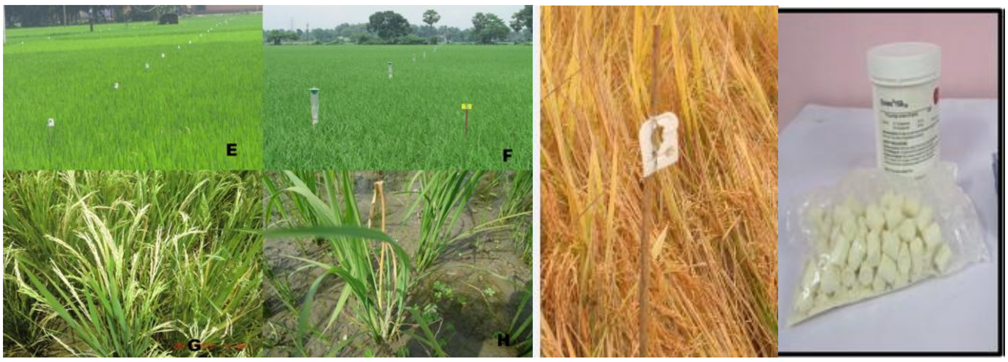

Plate2- Installation ExosexYSB_{tab} and funnel trap in rice field and tablet used in the experiment

Table 4-Average crop damage in mass trapping (T_1) mating disruption (T_2) and chemical treatment as per farmer's action (T_3) per generation ofeach year.

Treatments	Year 2012					Year 2013				
	1st generation		2nd generation		Yield (Q/ha)	1st generation		2nd generation		Yield (Q/ha)
	30 DAT (DH%)	45DAT (DH%)	60DAT (DH%)	90DAT (WE%)		30 DAT (DH%)	45DAT (DH%)	60DAT (DH%)	90DAT (WE%)	
Mass trapping (T_1)	0.37 (8.55)*[b]	1.12 (8.82)[b]	0.53 (8.72)[b]	2.69 (10.61)[bc]	52.73[ab]	0.27 (9.70)[b]	0.82 (9.18)[bc]	0.40 (9.07)[b]	2.37 (10.00)[b]	53.14[a]
Mating disruption through auto confusion (T_2)	0.29 (8.56)[b]	0.90 (8.42)[b]	0.41 (8.23)[b]	2.35 (9.95)[c]	53.98[a]	0.23 (9.61)[b]	0.70 (9.02)[c]	0.36 (9.28)[b]	2.06 (10.03)[b]	54.20[a]
Farmers practice (T_3)	0.47 (8.58)[b]	2.05 (9.53)[b]	1.07 (8.95)[b]	3.55 (11.37)[b]	48.56[b]	0.32 (9.63)[b]	1.36 (9.73)[b]	0.79 (9.41)[b]	3.17 (11.09)[b]	48.80[a]
Control (T_4)	0.73 (9.04)[a]	3.14 (10.94)[a]	1.81 (9.68)[a]	4.33 (12.20)[a]	40.80[c]	0.60 (10.08)[a]	2.49 (10.73)[a]	1.71 (10.43)[a]	4.70 (12.42)[a]	39.81[b]
SEm ±	0.087	0.345	0.226	0.267	1.628	0.072	0.197	0.178	0.357	2.243
CD @ 5 %	0.267	1.063	0.696	0.821	5.018	0.221	0.608	0.548	1.099	6.911

*In figure parenthesis is Angular transformation. [a]Figure marked by different letters are significantly different (α= 0.05) according to DMRT.

.Table-5: Diversity index of important predator species in different treatments

Name of insect predator	Name of insect family	Population per unit area	Treatment	Total abundance	Predator population range	Berger Parker dominance index	Dominant species
Odonata	Coenagrionidea (Damselfly)	No. of adult/m^2	T_1	43	2 - 10	0.242	*Ischnura aurora aurora* (Brauer)
			T_2	42	2 – 10	0.243	---do---
			T_3	31	2 – 4	0.179	*Pseudoagrionmicrocephalum* (Ram.)
			T_4	41	2 - 12	0.242	---do----
Dermeptera	Labiduridae and Formiculidae	No. of adult/m^2	T_1	43	4-25	0.568	*Forficulariadecipiens* (Gene)
			T_2	44	4-26	0.567	---do---
			T_3	21	2-6	0.237	*Doruaculeatum* (Scudder)
			T_4	43	4-24	0.568	*Forficulariadecipiens* (Gene)
Coleoptera	Carabidae	No. of adult/m^2	T_1	1215	15-382	0.327	*Ophionianigrofasciata* (Scht& Goebel)
			T_2	1216	15-380	0.328	---do---
			T_3	178	6-38	0.223	*Ophioneaishiishi* (Hab.)
			T_4	1214	16-382	0.327	---do---
Coleoptera	Staphylinidae	No. of adult/m^2	T_1	128	10-55	0.418	*Paederusfuscipes* (Curtis.)
			T_2	130	11-58	0.419	---do---
			T_3	80	6-35	0.348	*Paederusseparius* (L.)
			T_4	129	10-54	0.420	*Paederusfuscipes* (Curtis.)
	Coccinellidae	No. of adult/m^2	T_1	142	5-48	0.343	*Microspis discolor* (Fab.)
			T_2	143	6-47	0.341	---do---
			T_3	68	4-12	0.186	*Coccinellatransversalis* (Fab.)
			T_4	141	5-49	0.342	*Microspis discolor* (Fab.)

T_1=Mass trapping, T_2= Matting disruption through auto confusion, T_3= Farmers practice where three round chemical pesticides used and T_4= Control.

Effect on different treatments on predator biodiversity in rice ecosystem

The studies on the effect of different treatment showed that the minimum value (D= 0.179) for damselfly at the farmers field indicated most abundant species constitute only 17.9 % of the total population count. Its highest value (D= 0.242 to 0.243) at pheromone treated (T_1 and T_2) and control (T_4) indicate that most abundant species occurred 24.2 to 24.3 % of total population count. In case of Dermapteran insect, the Berger parker dominance had the highest value D= 0.567 to 0.568 were both in pheromone treated as well as control plot whereas the lowest value (D= 0.237) in farmers field. The value indicated that most abundant species accounted for 56.7 to 56.8 % and 23.7% in pheromone treated plot and farmers practices respectively.Coleopteran predator comprises the maximum predator group in rice ecosystem. From the studies on insect predator biodiversity showed that in all the cases minimum value in farmers practice as D= 0.223, D= 0.348 and D= 0.186 indicating that most abundant species consisted only 22.3 %, 34.6 % and 18.6% of total population count for Carabidae, Staphylinidae and Coccinellidae respectively whereas the maximum value in pheromone treated plot D= 0.327 to 0.328, D= 0.418 to 0.419 and D= 0.341 to 0.343 in other three treatments for the aforesaid species of Carabidae, Staphylinidae and Coccinellidae respectively.The pheromone was noted that in all the case the dominant species in rice ecosystem changes in farmers practice after application of chemical pesticide as given in table 5.

DISCUSSION

Since 1995 with the cultivation of some YSB susceptible variety in eastern India the damage caused by YSB *Scirpophaga incertulas* (Walk.) had increased gradually. Chemical crop protections with different pesticides were still extensively in practiced leading to arouse insect resistance. Like some other borers the firstinstar larva YSB bore into the stems immediately after hatching and thus offer a very short period for controlopportunity. Even there is a common trend of using Carbofuran 3G, Chlorantraniliprolegranuleor any granular mixture at 21 days after transplanting but their efficacy was not properly utilized due to shortage of water in the field. With the mating disruption technology, the timing of the application is still important but not so critical as the chemical treatment. The mating activity of female could be suppressed and number of egg masses could be reduced by both the mass trapping and mating disruption but later one is more effective with the former. Therefore EXOSEX YSB_{Tab} treatment is compatible with Integrated Pest Management programme as the pest life cycle disrupt prior to egg laying in field. The results also support the observation with Murthy and Krishnaiah(2008)[22].If the mating disruption through auto confusion was conducted at the same location for consecutive years, a progressive decline of field population *S incertulas* would be found. Auto confusion technique is highly selective, species specific, biological active, effective at very low concentration and has been successfully used in insect control. Unlike mating disruption it has no direct contact with the crop. This result is also supported by the observation of Coscolla, 1997[23]; Alfaro et al., 2009 [16]. Auto confusion is deemed to be different to mass trapping as it utilized the natural behavior of the male insect to effect control of the mating of the insect as opposed to preventing the natural behavior of the male insect. However plant damage caused by the third generation was not considered here as economically important; because the grain was already formed and grain yield would not be significantly affected if the damage was not too severe (Poitout and Bues, 1998)[24]. Thus the application of EXOSEX YSB_{tab} for managing stem borers also provided farmers with protection for their crops that was season long, users and environment friendly. Here the female pheromone is impregnated in a natural food grade wax powder or Entostat^{TM} powder. This Entostat is eco-friendly nontoxic to the natural enemies and also used in cosmetics food grazing, asthma inhalers and coating surgical instruments for keyhole surgery as per research report of EXOSEX Private Limited. The result indicated that auto confusion technology is compatible with Integrated Pest Management (IPM) programme as it is species specific which assist biodiversity and support natural enemies.The experiment also indicated that the grain yields obtained from the farmers field (T_3) were at per with EXOSEX tablet (T_2) but significantly higher than the control and pheromone lure (T_2) and further paddy grain obtained were from pesticide residue indicating that produce is safe to the consumers.From the result it is to be concluded that the indiscriminates use insecticide could be reduced the risk of environments and farmers. It is an innovative and novel method of management where chemical (pheromone) have no direct contact with crop, it reduced risk of residues in the produce.

ACKNOWLEDGEMENT

The authorsare grateful to the Director of Research, BCKV, State Agricultural University, West Bengal, India for providing the facilities to carry out the experiment. Also David Cary, Mark Battof EXOSECT, UK and Raman Murthy of PCI, Bangaluru ,India rendered important contributions in the materialization of the project. The authors are thankful to the Martin Brown of M/S Exosect Limited, Leyland Business Park, Colden Common, Winchester, Hamshire, SOZIITH, United Kingdom for giving a short training at United Kingdom before conducting the experiment.

REFERENCES

[1] Cohen, M. B., Romena, A. M.and Gould, F. 2000. Dispersal by larva of the stem borers *Scirpophaga incertulas* (Walker) (Lepidoptera; Pyralidae) and *Chilosuppresalis* (Lepidoptera; Pyralidae) in plots of transplanted rice; Population ecology. Environ. Entomol. 29: 958-971.

[2] Muralidharan, K. and Pasalu, I. C. 2005. Assessment of crop losses in rice ecosystems due to stem borer damage (Lepidoptera: Pyralidae). J. Crop Protection. 25: 409–417.

[3] Abro, G. H., Tajwer Sultana Syed, AbidHussain Shah, Jinjiecui.,MuzammilSattar and Mohammad Saeed Awan. 2013. Efficacy and Economics of different insecticides against stem borer *Scirpophaga incertulas* (Walk.) in rice crop. Pakistan J. Zool. 45 (4): 929-933.

[4] Rao, V. P. 1965. Natural enemies of rice stem borers and allied species on various part of the world and possibilities of their use in biological control of rice stem borer in Asia. Tech. Bull. Commonwealth Inst. Biol. Control. 6: 1-38.

[5] Catling, H. D., Islam, Z. and Pattrasudhi, R. 1987. Assessing yield losses in deep water rice due to yellow stem borer *Scirpophaga incertulas* (Walker) in Bangladesh and Thailand. Crop Protection. 6: 20-27.

[6] Puri, S. N. 2000. In: Farmer Led integrated pest Management India and the Pacific Asian Productive Organization, Tokyo. pp- 83-96.

[7] Witzall Peter, Philipp Krisch and Alan Cork 2010. Sex pheromone and their impact in insect pest management. J. Chem. Ecol.36: 80-100.

[8] Cork, A., Souza, K. De., Hall, D. R., Jones, O. T., Casagrande, E., Krishnaiah, K. and Syed, Z. 2008. Development of PVC-resin-controlled release formulation for pheromone and use in mating disruption of yellow rice stem borer *Scirpophaga incertulas*. Crop Protection. 27: 248-255.

[9] Gaston, L. K., Shorey, H. H. and Saario, C. A. 1967. Insect population control by use of sex pheromones to inhibit orientation between sexes. Nature.213, 1155.

[10] Cork, A., Beevor, P.S., Hall, D.R., Nesbitt, B.F., Arida, G.S. and Mochida, B 1985. Components of the female sex pheromone of the yellow stem borer *Scirpophaga incertulas* (Walkar). Entomologist Experimental Applicata.37 : 149-153.

[11] Du, J. W., Dia, X., Xu, S., Tang, X., Zhang, T., Zhu, Y. and Wang, M. 1987. Studies on sex pheromone of yellow stem borer *Scirpophaga incertulas* (Walker) (Lepidoptera: Pyralidae). Scientia Sinica *(Series B).*30: 967-973.

[12] Cork, A. and Basu, S.K. 1996. Control of the yellow stem borer, *Scirpophaga incertulas* Walker (Lepidoptera: Pyralidae) by mating disruption with a PVC resin formulation of the sex pheromone of *Chilosuppresalis*, in India. Bulletin of Entomological Research, 86; 1-9.

[13] Cork, A., De. Souza, K., Krishnaiah, K., Kumar, D.V.S.S.R. and Ashok Reddy, A. 1996. Control of yellow stem borer *Scirpophaga incertulas* (Lepidoptera: Pyralidae) by mating disruption on rice in India, effect of unnatural pheromone blends and application time on efficacy. Bulletin of Entomological Research. 86 : 515-524.

[14] Kanno, H., Tatsuki, S., Uchiumi, K., Kurihara, M., Fukami, J., Fujimoto, Y. and Tatsuno, T. 1978. Disruption of sex attraction in the rice stem borer moth, *Chilosuppresalis* Walker, with components of the sex pheromone and related chemicals. Appl. Entomol. Zool.13 (4): 321-323.

[15] Yang, C. M. and Cheng, C. H. 2001. Spectral characteristics of rice plants infested by brown plant hoppers. Proceeding of the National Science Council Republic of China Part B.Life Science. 25: 180-186.

[16] Alfaro, C., NavrroLiopis and Primo, J. 2009. Optimization of pheromone dispenser density for managing the rice striped stem borer Chilosuppresalis (Walker) by mating disruption. Crop Protection. 28: 567-572.

[17] Cork, A. and Krishnaih, K. 2000. Pheromone for control of yellow stem borer Scirpophaga incertulas (Walker) (Lepidoptera; Pyralidae) in India. Proceeding of XXI International Congress of Entomology, Iguassu, Brazil. pp. 132-141.

[18] Varma, N. R. G., Krishnaih, K., Pasalu, I. C. and Rao, P. R. M. 2004. Infuence of field size in management of yellow stem borer (YSB) Scirpophaga incertulas Walker through pheromone mediated mass trapping in rice. Indian J. of Plant Protection. 32(1); 39-41.

[19] Cork, A., Alam, S.W., Das, A., Das, C.S., Ghosh, G.C., Forman, D.I., Hall, D.R., Maslen, N.R., Vedhan, K., Phythiam, S.J., Rouf, F.M.A and Srinivasan, K. 2001. Female Leucinodesorbonalis blend optimization. J. Chem. Ecol. 27 (9): 1867-187.

[20] Howse, P. E. 1998. Pheromones and behavior. In: Howse, P.E., Stevens, I., Jones, O. T. (Eds). Insect pheromone and their use in Pest Management. Chapman and Hall London. 1-30.

[21] Karg, G.and Sauer, A. E. 1995. Spatial – distribution of pheromone in vineyards treated for mating disruption of the grape vine moth Lobesiabotrana measured with elctro-antennograms. J. Chem. Ecol. 21: 1299-1314.

[22] Murthy, K.S.R.K. and Krishnaiah, K. 2008. Auto confusion Pheromone – A new approach for the management of Rice Yellow Stem borer Scirpophaga incertulas Walk. Indian J. Plant Protection.36 (1): 158-162.
[23] Coscolla, R. 1997. La polilladelracimo de lavid (Lobesiabotrana Den and Schiff) GeneralitalValenciana, Valencia.
[24] Poitout, S. and Bues, R. 1978. Life cycle of the rice stem borer Chilosuppresalis (Walker) in rhone delta (Camargue) – Use of sex trap. Ann. Zool. Ecol. Anim. 10: 245-265.

INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES

ISSN 2231-4490

International Journal of Plant, Animal and Environmental Sciences