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Management of Rice Yellow Stem Borer *Scirpophaga insertulas* (Walker) using Different Formulations of Insect Sex Pheromone in West Bengal

A.M. Raut[1,2]*, C.R. Satpathi[2] and K. Krishnaiah[3]

[1,2]Department of Plant Protection, School of Agriculture,
Lovely Professional University, Phagwara, Jalandhar, Punjab, India
[2]Department of Agricultural Entomology, Bidhan Chandra Krishi Viswavidyalaya,
Mohanpur, Nadia , West Bengal - 741235, India.
[3]Former Project Director, Directorate of Rice Research, Hyderabad, India.

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Yellow stem borer *Scirpophaga insertulas* (Walker) devastated the rice crop in both vegetative and reproductive growth stages during monsoon and summer seasons of West Bengal. A field trial was conducted for evaluating the efficacy of pheromone lure against rice yellow stem borer in farmers' fields under Gopalpur co-operative society, Burdwan during rainy 2011-2013. The field trials consisted of six treatments including control viz. T_1= 50 pheromone traps/ha installed at 10 DAT where lure was not replaced, T_2= 50 pheromone traps/ha installed at 10 DAT and lure replaced at 45 DAT, T_3= 50 pheromone traps/ha installed at 10 DAT and lure replaced at 45 and 60 DAT, T_4= 80 Exosex YSB_{tab} per hectare @ 20 mg installed at 15 DAT, T_5= as per farmers practice where cartap hydrochloride @ 750 g a.i/ha used at 45 and 60 DAT and T_6= untreated control. Here both the dispenser (lure) and Exosex YSB_{Tab} containing (Z)-11 hexadecinal and (Z)-9 hexadecinal at 3:1 ratio was used. This experiment, resulted that the two peaks were found (27th August and 1st October) during rainy season. The Exosex YSB_{Tab} @ 20 mg had significantly exhibited minimum oviposition by female as well as significantly managed the yellow stem borer as compared to other pheromone treatments.

Keywords: Yellow stem borer, pheromone, mass trapping and mass disruption.

West Bengal is one of the rice growing states, cultivating rice over 5.69 m ha which constitutes 12.99 percent of total rice area of India, producing 14.75 m tons forming 15.80% production of country with an average productivity of 2.59 tons/ha of milled rice (2006-07). Typical rice production seasons are Aus/Bhadri (autumn rice) – April/May to August/September, Aman (Kharif), June/July to November/December and Boro (like Rabi) November/December to April/May. Kharif rice is grown under diverse rice growing situations – irrigated, Rainfed (upland, Shallow-land, Semi-deep water, Deep water) (Anon., 2010-11). Catling and Islam (1995) studied the borer species composition in deep water rice in Bangladesh and found that *Scirpophaga incertulas* was the dominant borer species in deep water rice in the field stubbles during the growing season. Alam and Bhuiyan (1964) reported that in Bangladesh 3 to 20% of crop was lost due to rice stem borer annually and severe causing about 60% damage may occur (Catling and Islam, 1981). The intensive

* To whom all correspondence should be addressed.
E-mail: ankushento@gmail.com

studies on yield losses of deep water rice in Bangladesh showed that yellow stem borer *Scirpophaga incertulas* was responsible for 10-15% loss of rice crop with catastrophic outbreak causing upto 60% damage (Catling and Islam, 1981; Daryaei, 2005). On the other hand the application of insecticide increased the paddy yield of Basmati 385 by 42.6% to 54.5% over control (Khan *et al.,* 2010). Deep circular stem feeding was observed for 81.94% larvae incidence of partially emerged white head (59.19%) dominated the field in West Bengal (Satpathi *et al.,* 2012). The use of pesticides that often have stronger effect on natural enemies and often have a stronger effect on natural antagonists than on the target species because of widespread insecticide resistance (Pimentel *et al.,* 1992; Elzen and Hardee, 2003; Oerke, 2006). Even some agrochemical industries now have reached the view that a further increase is not feasible and thus they support the development of mating disruption and mass trapping of rice stem borer in order to maintain a sustainable level of pesticide use (Cork *et al.,* 2005). Keeping above background in mind, our aim was to evaluate the pheromone lure for sustainable management against rice yellow stem borer.

MATERIALS AND METHODS

A field experiments were conducted on farm trials at Gopalpur Co-operative field, Burdwan of West Bengal, India during 2012 and 2013 *kharif* (rainy) seasons. Each treatment with assigned three hectare was separated from other treatment demarcated with 100 m gap or more. Farmers' practice plots which belonged to different farmers were located adjacent to the treated plots. Treatments were replicated 2 km apart and farmers' practice plot and pheromone plots were located at 200 m apart from each other. Separate monitoring funnel traps were deployed throughout treated and control plots @ 3 traps ha^{-1}. The field trial was conducted for studying optimization of doses of pheromone which consists of five treatments viz. T_1 = 50 pheromone traps ha^{-1} at 10 days after transplanting (DAT) where lure was not replaced, T_2 = 50 pheromone traps ha^{-1} at 10 days after transplanting (DAT) but lure was replaced at 45 DAT, T_3 = 50 pheromone traps ha^{-1} at 10 days after transplanting (DAT) subsequently lure was replaced at 45 and 60 DAT, T_4 = EXOSEX YSB_{Tab} 20 mg at 15 DAT, T_5 = Cartap 4 G @ 750 g a.i ha^{-1} (twice at 25 and 45 DAT) along with Chlorpyriphos 50% EC + Cypermethrin 5% EC @ 250-350 g a.i ha^{-1} and Chlorantraniliplore 18.55% W/W @ 25 g a.i ha^{-1}, T_6 was untreated plot.

Dispenser for YSB containing (Z)-11 hexadecinal and (Z)-9 hexadecinal in 3:1 ratio was obtained from pest control India, Bangalore, India. Each dispenser was loaded with 5 mg pheromone chemical. The observations for borer damage were recorded from 50 randomly selected hills/sub plots at weekly interval. The damage caused at peak incidence only was taken into consideration. . In all fields were adopted almost similar cultivation practices were adopted. In Exosex YSB_{Tab} @ 20 mg pheromone tablets were loaded into the groove of the biodegradable plastic hangers which were tied to the bamboo sticks of 1.5 m length. Such sticks were fixed and placed in the transplanted field in 11 × 11 m matrix at the rate of 80 per ha. Tablets were installed at 15 DAT. The trap height was adjusted during the lure replacement in such a way that the trap canopy remains just above the crop height level.

Damage due to stem borer was assessed in term of dead heart (DH) and white ear (WE) by counting total number of tillers or total number of panicle bearing tillers and number of DH or WE in each selected hill at vegetative stage or heading stage. Randomly were selected 400 hills in each treatment and 100 hills considered as a replication. Damage assessment data were recorded at 30, 45 and 60 DAT at vegetative phase and 90 and 110 DAT at reproductive phase using formula 1. Grain yields were estimated on Gobindabhog (aromatic variety) through 5 × 5 meter area crop cuts from each treatment of each replication and converted in to yield per hectare. Calculating egg mass index were examined 400 hills in each treatments in diagonal way at 10, 20, 30 and 40 DAT using formula 2.

$$\text{DH or WE \%} = \frac{\text{Number of DH or WE}}{\text{Number of total tillers}} \times 100 \quad \text{...(1)}$$

$$\text{IE \%} = \frac{\text{Ne}}{\text{Nf} \times \text{Nh} \times \text{Ms}} \times 100 \quad \text{...(2)}$$

Where, IE = Average Index of Egg Masses

N_e = total number of egg masses in all sampled field
N_f = Number of fields selected (9 in present study)
N_h = Number of hills examined (400 in present study)
M_s = Average number of tiller/hill

Trap catch data were transformed to square root, while crop damage data was transformed to Angular to normalize the data. The transformed data were analyzed using one-way analysis of variance (ANOVA) were performed in SPSS (version 16).

RESULTS AND DISCUSSION

Estimation of egg mass index (IE%)

In order to find the oviposition preference of YSB on different treatment on long duration scented rice an experiment was conducted on rice variety Govindbhog in irrigated lowland areas of West Bengal and the results were presented in Tables 1 to 3. It is evident from the observations that the average egg mass index (IE %) in pheromone treated plots of irrigated rice field was significantly lower than plots with farmer's practices. The average egg mass index (IE %) during the oviposition period was found to be 0.153 % in T_4, 0.171 % in T_3, 0.173 % in T_2, 0.180 % in T_1 and 0.418 % in T_5 whereas reduction of IE over control were 29.83 %, 33.50 %, 33.74 %, 35.21 % and 81.66 % in respective treatments during 2012 (Table 1). During 2013, the average egg mass index figures were 0.133 %, 0.154 %, 0.164 %, 0.176 % and 0.428 % in T_4, T_3, T_2, T_1 and T_5 respectively whereas percent reduction of egg mass index were 25.54 %, 29.64 %, 31.57 %, 33.98 % and 82.41 % over control in the respective treatments (Table 2). Different oviposition preferences of YSB were recorded in both coarse and fine rice where the mean number of egg masses/m^2 were statistically higher on fine grain variety than scented fine rice variety in Pakistan (Rustamani, 2002).

The pooled egg mass index (IE %) value for the year 2012 and 2013 could be arranged in ascending order as T4 > T3 > T2 > T1 > T5 where the reduction of IE over control were 27.67 %, 31.55 %, 32.65 %, 34.59 % and 82.04 % respectively (Table 3**)**. The result is in accordance with Mishra and Sharma (2012) where the pheromone based Integrated Pest Management (IPM) module against YSB in scented rice (Basmati rice) showed that the incidence of YSB at vegetative stage ranged from 2.43 to 5.70 % in IPM plot as compared to 3.12 to 13.07 % dead heart in non – IPM (farmers' practice) plots during kharif 2008 respectively. However at maturity stage, the damage ranged between 1.15 to 5.10 % in IPM plots against 3.73 to 11.01 % white ear head in non – IPM plots in 2008. The pooled data showed that the maximum infestation were 5.19 and 12.35 % dead heart at vegetative stage whereas 4.91 and 10.58 % white ear head at maturity in IPM and non-IPM plots respectively. It is a common phenomenon that the adult moth mates between 7 to 10 AM and lay eggs in clusters after mating. According to Pathak (1967) the adult of YSB emerges during the evening or night. Jadhao and Khurad (2012) reported that one female moth lays eggs early at night in small masses of about 50 to 80 eggs near the leaf blade. The moth deposits only one egg mass per night and oviposition takes place for one to two days after emergence and die within two to three days after oviposition. From the present investigation it is observed that the fecundity is dependent not only on the temperature but also on relative humidity. Both male and female were found in tail to tail position for 30 minutes over the surface which ultimately lead to on oviposition by female **(Plate 13).** Doke (1936) studied the effect of temperature and humidity on ecology of stem borer. Here it is found that the sex pheromone is used for disruption of mating, which is achieved by placing high concentration of pheromone throughout the field. This high concentration of pheromone saturated the area resulting in males failing to find the female, thus preventing mating and laying of egg for multiplication of insect. This result is agreement with Islam (2012) who reported about the pheromone use for insect control in Bangladesh.

Monitoring of male YSB using insect sex pheromone

The relative attractiveness of the crop for shelter and oviposition was found to be foliage of the host plant, depending on density. To find out the influence of different treatments of pheromone for management of YSB in scented rice the experiments were conducted in irrigated lowland areas at Gopalpur, under the district of Burdwan

Table 1. Average egg mass index (IE%) value in different treatments of pheromone in long duration scented rice (Gobindobhog) at Gopalpur, Burdwan during 2012

Treatments	Egg mass index (IE %)				Average	IE % reduction over control
	10 DAT	20 DAT	30 DAT	40 DAT		
T_1	0.215	0.235	0.165	0.105	0.180	35.21
T_2	0.210	0.225	0.160	0.095	0.173	33.74
T_3	0.205	0.215	0.155	0.110	0.171	33.50
T_4	0.190	0.200	0.145	0.075	0.153	29.83
T_5	0.490	0.600	0.320	0.260	0.418	81.66
T_6	0.585	0.675	0.405	0.380	0.511	
SEm ±	0.053	0.069	0.066	0.057		
CD (P=0.05)	0.159	0.204	0.196	0.170		

Table 2. Average egg mass index (IE%) value in different treatments of pheromone in long duration scented rice (Gobindobhog) at Gopalpur, Burdwan during 2013

Treatments	Egg mass index (IE %)				Average	IE % reduction over control
	10 DAT	20 DAT	30 DAT	40 DAT		
T1	0.205	0.215	0.190	0.095	0.176	33.98
T2	0.195	0.205	0.170	0.085	0.164	31.57
T3	0.185	0.190	0.155	0.085	0.154	29.64
T4	0.175	0.165	0.140	0.050	0.133	25.54
T5	0.515	0.625	0.330	0.240	0.428	82.41
T6	0.580	0.695	0.465	0.335	0.519	
SEm ±	0.072	0.038	0.039	0.037		
CD (P=0.05)	0.214	0.114	0.115	0.110		

Table 3. Overall egg mass index (IE%) value in different treatments of pheromone in long duration scented rice (Gobindobhog) at Gopalpur, Burdwan during 2012 and 2013 (Irrigated lowland)

Treatments	Egg mass index (IE %)				Average	IE % reduction over control
	10 DAT	20 DAT	30 DAT	40 DAT		
T1	0.210	0.225	0.178	0.100	0.178	34.59
T2	0.203	0.215	0.165	0.090	0.168	32.65
T3	0.195	0.203	0.155	0.098	0.163	31.55
T4	0.183	0.183	0.143	0.063	0.143	27.67
T5	0.503	0.613	0.325	0.250	0.423	82.04
T6	0.583	0.685	0.435	0.358	0.515	
SEm ±	0.090	0.079	0.076	0.068		
CD (P=0.05)	0.257	0.225	0.219	0.195		

T1 = 50 Pheromone traps/hectare at 10 DAT where lure was not replaced, T2 = 50 Pheromone traps/hectare at 10 DAT but lure was replaced 45 DAT, T3 = 50 Pheromone traps/hectare at 10 DAT but lure was replaced 45 and 60 DAT, T4 = 80 Exosex YSBtab 20 mg at 15 DAT, T5 = Use two rounds of chemical pesticide at 25 and 45 DAT and T6 = Untreated control.

Table 4. Average crop damage due to yellow stem borer in different treatments of pheromone in rice cv. Gobindobhog at Gopalpur, Burdwan, West Bengal during *kharif* 2012

Treatments	Vegetative stage (DH%)			Average	% over control	Reproductive stage (WE%)		Average	% over control	Yield kg/ha
	30 DAT	45 DAT	60 DAT			90 DAT	110 DAT			
T_1	0.338 (8.774)*	0.559 (8.861)	1.661 (10.087)	0.853	51.39	2.217 (10.543)	4.464 (12.411)	3.341	41.39	3864.5[a]
T_2	0.335 (8.860)	0.428 (8.837)	1.373 (9.780)	0.712	42.93	2.120 (10.402)	4.144 (12.340)	3.132	38.80	3939.8[a]
T_3	0.314 (8.418)	0.435 (8.715)	1.295 (10.113)	0.681	41.07	2.052 (10.284)	4.018 (12.230)	3.035	37.60	3986.2[a]
T_4	0.294 (8.636)	0.321 (8.483)	0.736 (8.745)	0.451	27.16	1.730 (10.053)	3.816 (11.900)	2.773	34.36	3997.3[a]
T_5	0.431 (8.683)	1.300 (9.735)	1.581 (9.975)	1.104	66.53	3.090 (11.164)	7.608 (15.556)	5.349	66.27	3842.5[a]
T_6	0.795 (9.579)	1.622 (10.040)	2.560 (10.659)	1.659		3.956 (11.975)	12.187 (19.532)	8.071		3617.5[b]
SEm ±	0.166	0.286	0.348			0.346	0.558			65.54
C.D. (P=0.05)	0.494	0.849	1.034			1.029	1.657			194.73

T_1 = 50 Pheromone traps/hectare at 10 DAT where lure was not replaced, T_2 = 50 Pheromone traps/hectare at 10 DAT but lure was replaced 45 DAT, T_3 = 50 Pheromone traps/hectare at 10 DAT but lure was replaced 45 and 60 DAT, T_4 = 80 Exosex YSB_{tab} 20 mg at 15 DAT, T_5 = Use two rounds of chemical pesticide at 25 and 45 DAT and T_6 = Untreated control.
*Figures are parentheses in angular transformed values.

Table 5. Average crop damage due to yellow stem borer in different treatments of pheromone in rice cv. Gobindobhog at Gopalpur, Burdwan, West Bengal during kharif 2013

Treatments	Vegetative stage (DH%)			Average	% over control	Reproductive stage (WE%)		Average	% over control	Yield kg/ha
	30 DAT	45 DAT	60 DAT			90 DAT	110 DAT			
T1	0.224 (9.761)*	0.538 (9.542)	1.216 (9.738)	0.659	48.01	1.427 (10.052)	4.275 (12.221)	2.851	43.87	3907.3bc
T2	0.267 (9.699)	0.433 (9.491)	1.174 (9.849)	0.624	45.46	1.374 (9.890)	4.025 (12.018)	2.699	41.54	3981.2abc
T3	0.211 (9.815)	0.415 (9.436)	1.104 (9.957)	0.577	42.00	1.271 (9.851)	3.786 (11.789)	2.529	38.92	4135.3ab
T4	0.155 (10.689)	0.391 (9.191)	1.032 (9.847)	0.526	38.29	1.162 (9.782)	3.582 (11.465)	2.372	36.50	4273.7a
T5	0.320 (10.263)	0.839 (9.736)	1.501 (10.111)	0.886	64.54	2.116 (10.608)	7.192 (14.736)	4.654	71.61	3895.0bc
T6	0.665 (10.591)	1.025 (9.938)	2.430 (10.991)	1.373		3.099 (11.783)	9.899 (17.400)	6.499		3712.5c
SEm ±	0.168	0.121	0.194			0.350	0.647			106.66
C.D. (P=0.05)	0.498	0.360	0.575			1.040	1.923			316.91

T1 = 50 Pheromone traps/hectare at 10 DAT where lure was not replaced, T2 = 50 Pheromone traps/hectare at 10 DAT but lure was replaced 45 DAT, T3 = 50 Pheromone traps/hectare at 10 DAT but lure was replaced 45 and 60 DAT, T4 = 80 Exosex YSBtab 20 mg at 15 DAT, T5 = Use two rounds of chemical pesticide at 25 and 45 DAT and T6 = Untreated control.
*Figures are parentheses in angular transformed values.

Table 6. Overall crop damage due to yellow stem borer in different treatments of pheromone in rice cv. Gobindobhog at Gopalpur, Burdwan, West Bengal during kharif 2012 and 2013

Treatments	Vegetative stage (DH%) 30 DAT	45 DAT	60 DAT	Average	% over control	Reproductive stage (WE%) 90 DAT	110 DAT	Average	% over control	Yield kg/ha
T1	0.281 (9.268)*	0.548 (9.201)	1.438 (9.912)	0.756	49.860	1.822 (10.298)	4.370 (12.316)	3.096	42.493	3885.9b
T2	0.301 (9.279)	0.430 (9.164)	1.273 (9.814)	0.668	44.075	1.747 (10.146)	4.084 (12.179)	2.916	40.022	3960.5ab
T3	0.263 (9.117)	0.425 (9.075)	1.199 (10.035)	0.629	41.494	1.662 (10.067)	3.902 (12.010)	2.782	38.187	4060.8ab
T4	0.225 (9.663)	0.356 (8.837)	0.884 (9.296)	0.488	32.201	1.446 (9.917)	3.699 (11.682)	2.572	35.311	4115.5a
T5	0.375 (9.473)	1.069 (9.735)	1.541 (10.043)	0.995	65.632	2.603 (10.886)	7.400 (15.146)	5.001	68.652	3868.0bc
T6	0.730 (10.085)	1.323 (9.989)	2.495 (10.825)	1.516		3.527 (11.879)	11.043 (18.466)	7.285		3665.0c
SEm ±	0.236	0.310	0.398			0.492	0.854			70.24
C.D. (P=0.05)	0.677	0.890	1.142			1.412	2.451			208.68

T1 = 50 Pheromone traps/hectare at 10 DAT where lure was not replaced, T2 = 50 Pheromone traps/hectare at 10 DAT but lure was replaced 45 DAT, T3 = 50 Pheromone traps/hectare at 10 DAT but lure was replaced 45 and 60 DAT, T4 = 80 Exosex YSBtab 20 mg at 15 DAT, T5 = Use two rounds of chemical pesticide at 25 and 45 DAT and T6 = Untreated control.

*Figures are parentheses in angular transformed values.

during 2012 and 2013. The results are presented in Fig. 1 to 3.

It is evident from Fig. 1 that the male moths were trapped from 13th August to 26th November with two distinct peaks on 27th August and 1st October regardless of the treatment in scented rice cv. Gobindobhog grown in irrigated areas of Gopalpur under the district of Burdwan, West Bengal during 2012. Although the trapped population was high on 5th November but an uniform level of trapping was found subsequently from second peak to till the crop was harvested. The trapping was mostly identical in 2013 too when the maximum number of male moths were trapped in the last week of August and first week of October respectively without considering the treatment as given Fig. 2. The pooled data of 2012 and 2013 exhibited three peaks of which former two are distinct but the later one in very short during the first week of November as given in Fig. 3.

Management of YSB cause crop damage using insect sex pheromone

Yellow stem borer (*Scirpophaga incertulas* Walker) devastated the crop in all seasons. Larval feeding of YSB from inside stem (Pseudostem) severs central part of tiller at its base resulting in drying of the central whorl and rendering the tiller non productive. Damage thus caused by the borer in this way is typically termed as dead heart (DH) during vegetative stage. Similar nature of damage is seen at heading or reproductive stage, the panicle becomes chaffy (with empty grains) which is called as white ear head (WE).

Insecticides is primary method of control which generally applied at a minimum of two prophylactic rounds in a crop season to control YSB, which often results in the secondary pest resurgence, needing additional pesticide usage. Besides, pesticides are known to cause different types of health hazards to human beings and domestic animals through handling, contamination of food chain and environment as a whole. Further, success of insecticide application depends upon the detection of the pest incidence/ intensity. Among effective alternatives, insect sex pheromones have been proved to provide promising tool for management of YSB, both in monitoring and direct control of pest as well as minimizing pesticide load in rice ecosystem.

Table 4 suggests that the treatments

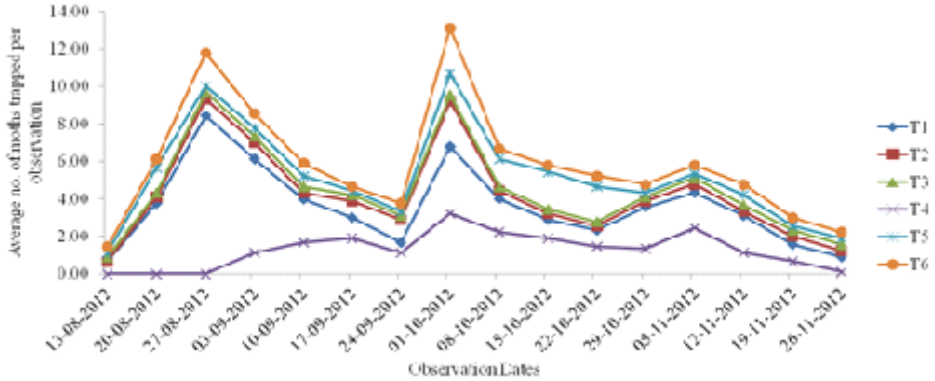

Fig. 1. Average YSB male moth catches per trap in different treatments of pheromone in rice cv. Gobindobhog at Gopalpur, Burdwan, West Bengal during 2012

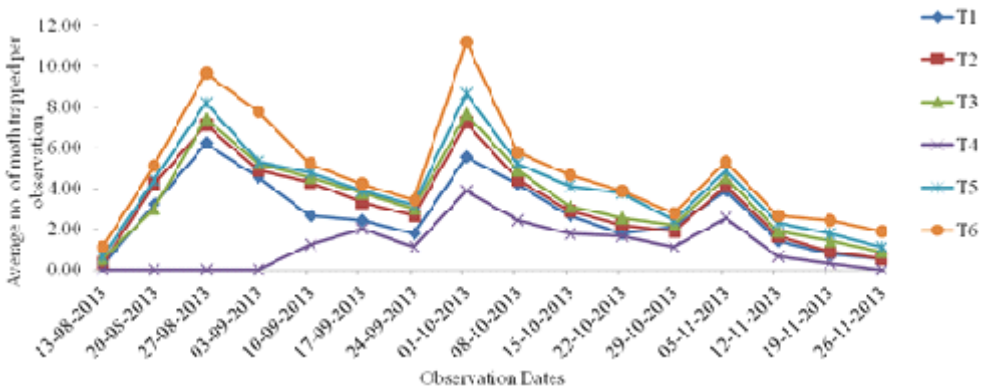

Fig. 2. Average YSB male moth catches per trap in different treatments of pheromone in rice cv. Gobindobhog at Gopalpur, Burdwan, West Bengal during 2013

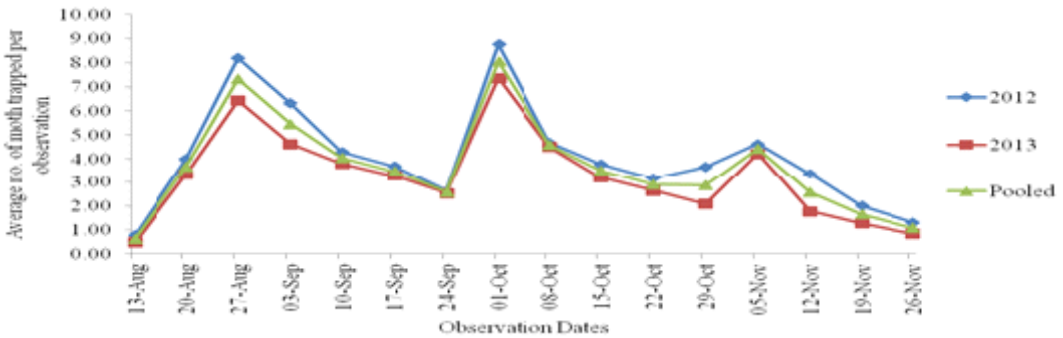

Fig. 3. Overall YSB male moth catches per trap in different treatments of pheromone in rice cv. Gobindobhog at Gopalpur, Burdwan, West Bengal during 2012 and 2013

could be arranged according to the subsequent DH% and WE% as ranging from 0.294 to 0.736% with average 0.451% and 1.730 to 3.816% with average 2.773 in T_4, followed by 0.314 to 1.295% with average 0.681% and 2.052 to 4.018% with average 3.132% in T_3, 0.335 to 1.373% with average 0.712% and 2.120 to 4.144% with average 3.132% in T_2, 0.338 to 1.66% with average 0.855% and 2.217 to 4.464% with average 3.341% in T_1. Here, the entire plot treated with pheromone exhibited numerically close to farmers practice or T_5 (DH ranges from 0.431 to 1.581% with average 1.104% and WE ranges from 3.090 to 7.608% with average 5.349%) but it was significantly better than control where the average dead heart and white ear head varied from 1.659% and 8.071% respectively during 2012. Similar results were also obtained in 2013 too where DH% varied from 0.155 to 1.032% with average 0.526% inT_4 which was very much close to T_3 (0.211 to 1.104% with average 0.577%), T_2 (0.267 to 1.174% with average 0.624%), T_1 (0.224 to 1.216% with average 0.659%). Average white ear head was observed from 90 DAT with 2.372%, 2.529%, 2.699% and 2.851% in T_4, T_3, T_2 and T_1 respectively. Numerically the value of T_5 is close to pheromone plots with average 0.886% DH and 4.654% WE but it was found that all treatments were significantly lower than control where average DH was 1.372% and 0.499% WE was recorded as given in Table 5**.**

The subsequent reductions of dead heart and white ear head were calculated with respect to control and found 27.16 and 34.36%, 41.07% and 37.60%, 42.93% and 38.80%, 51.39% and 41.39%, 66.53% and 66.27% during 2012 (Table 4**)** whereas it was 38.29% and 36.50%, 42.00% and 38.92%, 45.46% and 41.54%, 48.01% and 43.87%, 64.54% and 71.61% during 2013 (Table 5**)** in T_4, T_3, T_2, T_1 and T_5 respectively.

The variation of damage due to YSB was ultimately reflected in yield as T_4 exhibited its supremacy in both the years with 3997.3 kg/ha and 4273.7 kg/ha as mentioned in Tables 4 and 5. The yields of all the plots treated with pheromones were close to farmers' practice or T_5 but it was significantly better than control (T_6).

The pooled data of 2012 and 2013 were calculated and found that all the treatments could be arranged with respect to minimum damage and maximum yield as $T_4 > T_3 > T_2 > T_1 > T_5 > T_6$. Here the initial damage of dead heart reflected as subsequent white ear head and ultimately yield of rice crop cv. Gobindobhog as given in Table 6**.** Here, T_4 exhibited 0.225 to 0.884% DH with average 0.488% subsequently 1.446 to 3.699% WE with average 2.572% in the same field and it ultimately gave highest yield 4115.5 kg/ha of scented rice (Gobindobhog) in irrigated areas of Gopalpur under the district of Burdwan, West Bengal. Consequently T_6 exhibited maximum damage 0.730 to 2.495% DH with average 1.516% and 3.527 to

Plate 1. Mating of yellow stem borer in tail to tail position during mid night at Regional Research Substation, Chakdaha

Plate 2. Materials used against yellow stem borer

Plate 3. Installation of dispenser after transplanting above the crop height, 'A' 5 mg pheromone lure and 'B' 20 mg Exosex YSB_{Tab}

11.043% WE with average 7.285% which ultimately gave minimum yield (3665.0 kg/ha) in same field of Gopalpur. Numerically all the pheromone treatments were close to farmers' practice (T_5) but it was significantly higher than control (T_6).

The present finding are in agreement with result of the work on evaluation of Exosex YSB_{tab} for management of rice yellow stem borer through pheromone mediated auto confusion technology (Anon., 2010-2011) where a comparative study of Exosex YSB_{tab} @ 20 mg and farmers' practice (FP) or chemical control as per routine practice was made at the same field of Gopalpur on Gobindobhog during 2010 and found that in one trial the DH incidence ranged 0.56 to 0.88% and 0.85 to 1.73% in FP, the highest being FP at 45 and 60 DAT. Although numerical values of DH in two treatments were closer to Exosex YSB_{Tab} treatment was found to be significantly superior to FP. However incidence in all the treatments was below economic threshold level and thus both the treatments were effective in suppressing YSB damage during vegetative stage. White ear head incidence in Exosex YSBtab 3.2 mg (AC- 2) and FP was registered as 1.28 to 2.90% and 3.28 to 11.35% respectively. In respect of yield, AC-2 gave higher yield than farmers' practice. In another treatment dead heart incidence was recorded in Exosex YSB_{Tab} and FP treatments which ranged from 0.34 to 0.80% and 1.90 to 2.25% respectively. Here both the treatments controlled the pest damage effectively and maintained it below economic threshold level. Although DH incidence in both the treatments was numerically very similar, Exosex YSB_{tab} treatment was found to be superior to farmers practice. A similar trend was observed in respect of WE incidence at heading stage. Mean WE incidence ranged from 1.80 to 7.63%, the highest infestation was registered in FP. YSB pheromone tablet successfully controlled YSB damage while FP failed by registering 11.67% WE during second observation. At both observations YSB pheromone tablets were significantly superior to farmers practice. WE incidence in AC-2 (1.60% and 1.82%) was significantly less than FP. Overall YSB damage at both vegetative and heading stages was kept in check by YSB pheromone tablets and were found to be superior to FP in all observations. Among YSB pheromone tablet a single application of 20 mg at 15 DAT was managing the pest effectively. Yield registered by AC-2 (4013 kg/ha) of Gobindobhog was significantly higher than that of farmers practice (3678 kg/ha). In third trial AC-2 and FP treatments effectively suppressed the pest incidence during vegetative stage of crop with DH% ranging from 0.12 to 2.62%. However, DH level in FP was significantly higher than that found in YSB pheromone. DH% level in AC-2 ranged from 0.30 to 2.05% as against the highest record of 10.81% in FP at 110 DAT. Thus YSB pheromone tabs effectively protected the crop from YSB at heading stage while the FP of chemical control was not successful (Anon., 2010-2011). The mean YSB infestation level at vegetative stage of the crop in AC-2 was reflected in 0.16 to 0.52% DH as against 1.57 to 2.20% in FP. However, the level of DH was significantly lower in Exosex YSB_{tab} than the farmers practice. Mean pre-harvest YSB damage accounted for 11.28% WE incidence which was considered as fairly high level of damage and indicated failure of FP involving use of three rounds of insecticide to control the pest. Grain yields were estimated with the help of crop cutting experiments. Exosex YSB_{tab} recorded significantly higher yields over farmers method which varied from 3.0 to 4.5 q/ha (Anon., 2010 -2011).

CONCLUSION

From the result of this experiment, it is to be concluded that auto-confusion technology (T_4 = 80 Exosex YSB_{tab} @ 20 mg) could more effectively control the YSB population than the other application of pheromone in rice ecosystem as it utilizes the natural behavior of the male insect to control the matting of the insect as opposed to preventing the natural behavior of male insect.

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