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EVALUATION OF EXO SECT – A PELLET FORMULATION CONTAINING SEX PHEROMONE FOR MANAGEMENT OF RICE YELLOW STEM BORER THROUGH AUTO CONFUSION TECHNOLOGY

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ABSTRACT

Rice yellow stem borer, *Scirpophaga incertulas* is one of the most economically important biotic constraints to rice production throughout the Asian region. The female moth produces sex pheromone that could be used for the management of YSB through mating disruption, mass trapping or auto confusion. Field trials were conducted at three locations of Warangal district-Andhra Pradesh, to evaluate the effectiveness of Auto confusion technology for management of yellow stem borer Vis a Vis farmers practice or mass trapping. Auto confusion technique registered lower white ear incidence than mass trapping and farmers practice proving the effectiveness of Auto confusion technology in the management of yellow stem borer populations. Auto confusion technique was found to be eco-friendly by harbouring a larger number of predator populations. The effectiveness of the technique was either comparable or at times better than chemical control.

Keywords: Rice, Yellow stem borer, Scirpophaga incertulas, auto confusion, Sex Pheromone.

INTRODUCTION

Rice is the staple food crop of over half of the world's population and is grown in about 145 million hectares. It is one of the major cereal crops of India and is grown in 42.56 million hectares with an annual production of 95.33 million tones (2010-11, Source: Directorate of Economics and Statistics). The stem borers are generally considered to be the most serious pests of rice. They damage rice crop from seedling stage to maturity [1] In many of the rice growing regions of Asia, and India in particular, the most economically important insect pest is the rice yellow stem borer, *Scirpophaga incertulas* Walker (Lepidoptera: Pyralidae) [2,3]. The major pre-harvest loss in India is due to stem borers and on average stem borer damage in tropical Asia results to an estimated yield loss of 5-10%, while in India 3-95% losses are reported [4].

The stem borers (specifically yellow stem borer, *Scirpophaga incertulas* Walker) due to internal feeding behavior, symptoms of its occurrence are not visible till the damage is done. A minimum of two prophylactic rounds of Insecticides (which form primary method of control) are applied, which often result in the secondary pest resurgence, needing additional pesticide use causing health hazards to human beings and domestic animals through contamination of food and the environment as a whole. Further, success of insecticide application depends on the detection of the pest incidence/intensity. Non availability of stem borer resistant cultivars, constraints on the successful use of biocontrol agents and partial or ineffective chemical control warranted the need to look for alternative pest management strategies to combat this pest. Among effective alternatives, insect sex pheromones provide promising tool for management *S. incertulas* Walker and minimize the pesticide load to the rice eco-system.

Pheromones on the other hand, are species-specific, have no adverse effects on the biota or the environment, and hence would be fully compatible with an integrated pest management (IPM) approach to control rice pests. By permeating the air with a synthetic blend of female pheromone components male moths are prevented from following odour trials of pheromone released by conspecific females. This results in a reduce level of mating, or mating disruption, that can subsequently lead to a significant reduction in the larval population of the next generation and hence a reduction in the damage sustained by a crop. Keeping this point in view, the study was conducted to evaluate exo sect an effective auto-confusion technology – a pellet formulation containing yellow stem borer pheromone for management of yellow stem borer on rice. Auto-confusion employs electrostatically charged, wax powder impregnated with pheromone that is attractive to male moths. On close approach male moths, and their antennae in particular, are coated with the powder that prevents them orienting towards the other pheromone sources and causes them to act as decoys for untreated males [4].

MATERIAL AND METHODS

Layout of field

The experiment was conducted in 2007-08 during Rabi season in three locations i.e., Sangam, Yelgurrangampet and Narlavai of Sangam mandal of Warangal district, A.P. Area of trial plots under each treatment were of 3 ha in size. There were three treatments, (i) Exo sect (pheromone pellet formulation containing 3.2 mg pheromone mixture (ii) Mass trapping containing 5mg pheromone lures and (iii) farmers' practice wherein insecticides were used, each replicated 6 times or arranged at 6 sites, at two sites in each village (Table 1). Each set of treatments / replication were positioned at least 1 km apart and paired farmers' practice plots and the treatment plots in each replications were fixed at >200 m apart from one another.

The auto-confusion pheromone formulation had a putty-like consistency, and individual pellets (1 x 1x 1 cm) were pasted onto split bamboo canes (1.5 m long) on the inter-nodal junction block by applying thumb pressure to mould them onto the bamboo canes 91.5 m long) on the inter-nodal junction block by applying thumb pressure to mould them onto the bamboo. Application of auto confusion involved fixing 80 bamboo sticks in one hectare area by arranging them length and breadth wise at 10 m equidistance. The first application was done at 10-15 days after transplanting and the second application of Exo Sect was made 45 days after first application, pellets height was fixed according to crop canopy.

In case of Mass trapping, the funnel traps loaded with rubber septum (lure) impregnated with 5 mg pheromone mixture containing Z-11 hexadecenal and Z-9 hexadecenal in 3:1 ratio were installed at a spacing of 20x25m. The pheromone lures were replaced twice at 20-day interval.

In farmer practice plots, farmers were allowed to act independently while taking up protection measures. During this Rabi season, farmer practice plots received 3 rounds of insecticides usage i.e., phorate granules @5 kg per acre 15 days after transplanting, imidacloprid @80ml per acre and cartap hydrochloride@ 400g per acre during active tillering to panicle initiation stage of the crop.

Farmers were persuaded to refrain from insecticide application against stem borer in the auto confusion and mass trapping treatment plots. To monitor the yellow stem borer moth population, funnel traps used in mass trapping were placed in the Exo Sect and farmers practice plots at the rate of one per Ha. One out of 20 traps in a hectare plot was marked for monitoring moth activity in Mass trapping treatment.

Variety planted at all locations was MTU-1010 (Cotton Dhora Sannalu) with 120 days maturity duration and moderate resistance to BPH. Farmers followed recommended crop management practices and need based fungicidal application against blast disease. There was no menace of insect pests other than yellow stem borer during the season.

Recording of field observations

Stem borer damage in the farmers practice and pheromone-treated plots was assessed at ten days interval. From each plot counts of dead hearts, white ears and predators were taken and analyzed the data by using analysis of variance (ANOVA).

Counts of male moth catch from each trap fixed/ear marked (one per hectare) were recorded at 3-days interval to monitor phenology and dynamics of stem borer moth populations.

At the time of harvesting of the crop wet grain yield (kg/ha) and straw yield (kg/ha) were estimated from 5 x 5 m ($25m^2$) area from 3 places /plot (@one crop cut per hectare) following the standard crop cutting protocols. Dry weight estimates were then calculated by reducing the grain moisture content uniformly to 14% and average yields for each trial plot has been compared by ANOVA.

Six one kilogram grains one each per replication was collected and analyzed for pesticide residues at Exo Sect Company.

In order to assess the release rates of pheromone from the pellet formulation, 39 pellets were pasted on to the cleft of bamboo sticks and exposed fully in the trial plots. A similar batch of pellets loaded in a newly provided plastic hanging device was subjected to field exposure. Six pheromone pellets (3 pellets separately from each batch) were collected at 0, 1, 3, 5, 7, 10, 15, 20, 30, 40, 50, 60 days after placement, stored at -10^{o} Celsius and analyzed at Exosect Company. Samples of the pellets loaded on to the bamboo sticks at the first and second application were collected 30 days after field exposure and supplied to the Exosect Company for estimation of residual pheromone.

Table 1. Details of layout and treatments

Treatment	Pheromone				No. of Replications or Sites	Area per site (Ha)	Total area under each treatment (Ha)	No. of insecticide applications	No. of Pheromone Monitoring traps / Ha
	No. of Point Sources / traps Per Ha	Dose / Point Source (mg)	No. of applications / Season	Dose / Ha Over all applications (mg)					
Auto confusion (Exo sect 800	80	3.2	2	512	6	3	18	Nil	1
Mass Trapping	20	5.0	3	300	6	3	18	Nil	-*
Farmers Practice	-	-	-	-	6	3	18	3	1
Statistical design including number of replications					Single Factor ANOVA with 3/6 replications				

* 1 out of 20 traps in the treatment plot was marked for monitoring of moth populations.

Table 2. Mean Percentage dead hearts/white ears (transformed percentages)

	& DAT				&35 DAT				&45 DAT				&55 DAT				*65 DAT				*75DAT			
Village	Exo sect	FP	Mass trapping	Mean	Exo sect	FP	Mass trapping	Mean	Exo sect	FP	Mass trapping	Mean	Exo sect	FP	Mass trapping	Mean	Exo sect	FP	Mass trapping	Mean	Exo sect	FP	Mass trapping	Mean
Narlavai-I	6.87	16.42	11.16	11.48	1.49	3.13	2.07	2.23	1.84	0.74	1.01	1.19	0.63	0.42		0.61	6.02	9.68	5.60	7.10	3.98	4.69	4.23	4.30
Narlavai-II	3.33	14.19	10.53	9.35	4.10	7.46	2.49	4.68	0.64	1.38	1.29	1.11	0.50	0.64	0.65	0.59	5.35	9.46	6.58	7.13	3.92	3.95	3.16	3.68
Rangampet-I	13.40	3.24	1.39	6.01	7.77	3.13	1.06	3.99	1.28	0.55	0.98	0.93	0.60	0.66	0.59	0.62	4.89	8.45	4.64	5.99	6.50	6.71	5.94	6.38
Rangampet-II	6.76	1.89	0.57	3.07	6.92	2.71	0.86	3.50	0.41	1.33	0.91	0.88	0.34	0.57	0.52	0.48	4.26	7.80	6.11	6.06	6.47	6.60	7.18	6.75
Sangem-I	3.95	15.65	17.26	12.29	4.47	5.07	1.65	3.73	0.78	0.75	0.63	0.72	0.64	0.54	0.46	0.55	3.17	6.94	4.52	4.88	6.26	11.12	13.05	10.14
Sangem-II	0.52	2.05	10.41	4.32	2.17	2.62	6.96	3.92	0.74	1.06	1.58	1.13	0.37	0.71	0.57	0.55	3.02	2.87	3.12	3.00	7.98	7.12	7.23	7.44
Mean	5.80	8.91	8.55	7.75	4.49	4.02	2.51	3.67	0.95	0.97	1.07	0.99	0.51	0.59	0.59	0.57	4.45	7.53	5.09	5.69	5.85	6.70	6.80	6.45
Cd(.05)		**0.06**			Cd(.05)		**0.4**		Cd(.05)		**0.19**		Cd(.05)		**0.14**		Cd(.05)		**0.51**		Cd(.05)		**0.49**	
Fvalue for treat=60.70**					**Fvalue for treat=49.91****				**Fvalue for treat=0.78 NS**				**Fvalue for treat=0.74 NS**				**Fvalue for treat=77.28****				**Fvalue for treat=8.37****			
Vill.	**155.05**				**Vill.**	**15.46**			**Vill.**	**3.16**			**Vill.**	**0.51 NS**			**Vill.**	**35.45**			**Vill.**	**83.8**		

&= Dead hearts; *=White ear heads

Table 3. Predator population (Spiders and Coccinellids) in different treatments in the Auto confusion trial during Rabi 2007-08-Warangal

	No predators /10 hills																							
	25 DAT				35 DAT				45 DAT				55 DAT				65 DAT				75 DAT			
Village	Exo sect	FP	Mass trapping	Mean	Exo sect	FP	Mass trapping	Mean	Exo sect	FP	Mass trapping	Mean	Exo sect	FP	Mass trapping	Mean	Exo sect	FP	Mass trapping	Mean	Exo sect	FP	Mass trapping	Mean
Narlavai-I	0.000	0.000	0.000	0.000	0.275	0.000	0.325	0.020	0.325	0.075	0.300	0.023	0.625	0.025	0.025	0.023	0.650	0.100	0.600	0.045	0.700	0.375	0.525	0.053
Narlavai-II	0.300	0.150	0.250	0.023	0.350	0.200	0.250	0.027	0.375	0.100	0.275	0.025	0.375	0.000	0.350	0.024	0.525	0.225	0.600	0.045	0.525	0.450	0.700	0.056
Rangampet-I	0.150	0.000	0.200	0.012	0.300	0.150	0.250	0.023	0.450	0.100	0.375	0.031	0.375	0.400	0.400	0.039	0.700	0.250	0.525	0.049	0.650	0.350	0.800	0.060

Rangampet-II	0.200	0.150	0.175	0.018	0.375	0.200	0.275	0.028	0.250	0.125	0.225	0.020	0.000	0.400	0.375	0.026	0.625	0.375	0.550	0.052	0.800	0.500	0.750	0.068
Sangem-I	0.300	0.175	0.275	0.025	0.250	0.250	0.300	0.027	0.300	0.150	0.275	0.024	0.350	0.300	0.000	0.022	0.600	0.350	0.625	0.053	0.600	0.475	0.550	0.054
Sangem-II	0.300	0.075	0.250	0.021	0.200	0.125	0.175	0.017	0.225	0.075	0.350	0.022	0.525	0.325	0.425	0.043	0.450	0.225	0.400	0.036	0.475	0.600	0.650	0.058
Mean	**0.208**	**0.092**	**0.192**	0.016	**0.292**	**0.154**	**0.263**	0.024	**0.321**	**0.104**	**0.300**	0.024	**0.375**	**0.242**	**0.263**	0.029	**0.592**	**0.254**	**0.550**	0.047	**0.625**	**0.458**	**0.663**	0.058
Cd(.05)		**0.07**				**0.08**				**0.08**				**0.09**				**0.11**				**0.14**		
Fvalue for treat=5.92**					**Fvalue for treat=5.45****				**Fvalue for treat=14.52****				**Fvalue for treat=4.33****				**Fvalue for treat=18.29****				**Fvalue for treat=4.39****			
Vill.	**6.45**				**Vill.**	**1.06**			**Vill.**	**0.706**				**3.49**			**Vill.**	**1.01**			**Vill.**	**0.56**		

Table 4. YSB Male moth trap catch during *Rabi* 2007-08, Warangal
No. of moths in 18 traps over 3 days

DATE	Exosect	MT	Fp
19-Feb	14.00	12.00	16.00
23-Feb	14.00	16.00	15.00
26-Feb	8.00	19.00	17.00
29-Feb	14.00	26.00	33.00
3-Mar	24.00	34.00	44.00
6-Mar	32.00	29.00	33.00
9-Mar	21.00	33.00	34.00
12-Mar	42.00	54.00	37.00
15-Mar	53.00	53.00	60.00
18-Mar	25.00	23.00	23.00
27-Mar	22.00	34.00	40.00
30-Mar	22.00	29.00	42.00
2-Apr	20.00	24.00	22.00
5-Apr	11.00	11.00	10.00
8-Apr	6.00	8.00	7.00
11-Apr	10.00	9.00	7.00
14-Apr	11.00	14.00	13.00
17-Apr	7.00	11.00	8.00
Mean	**19.78**	**24.39**	**25.61**

The differences among the treatments were non-significant

Table 5. YSB damage (% white ear heads) assessed from crop cutting experiments

	Treatments			
Village / Site	**Exosect**	**MT**	**FP**	Average
Narlavai I	5.33	6.18	3.60	**5.04**
Narlavai II	3.17	3.35	1.30	**2.61**
Yelgurrangampet- I	5.64	3.33	3.67	**4.21**
Yelgurrangampet- II	6.85	3.62	2.72	**4.39**
Sangem I	1.61	5.90	7.89	**5.13**
Sangem II	1.64	1.75	5.52	**2.97**
Average	**4.04**	**4.02**	**4.12**	**4.06**

Differences among means were non-significant

Table 6. Yield assessment in Auto-Confusion Trial, *Rabi* 2007-08, Warangal (Crop Cutting experiments)

Village / Site	**Grain yield Kg Ha^{-1}**			
	Exosect	**Farmers Practice**	**Mass Trapping**	**Mean**
Narlavai I	4717	5875	5483	**5358**
Narlavai II	7619	5820	7247	**6895**

Sangem I	6201	5455	5424	**5693**
Sangem II	5497	4725	4953	**5059**
Yelgurangampet I	5016	5365	4529	**4970**
Yelgurrangampet II	4196	4247	5997	**4813**
Mean	5541	5248	5606	**5465**
CD(.05) Villages				**95**5
Treatment	**NS**			
CV%	18.4			
F = Villages	5.23**			
Treatment	0.65 NS			

Figure 1. Yellow stem borer Damage (DH/WE) during Rabi, 2007-08, Warangal.

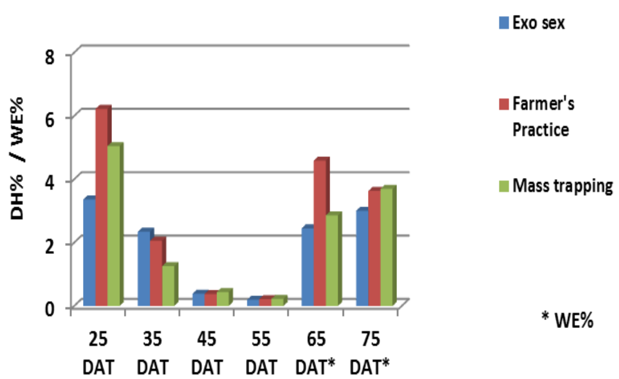


Figure 2. Yellow Stem borer male moth catches in pheromone traps during RABI 2007-2008, Warangal District, A.P.

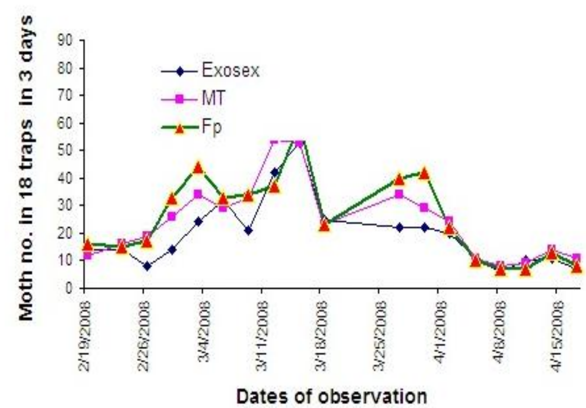
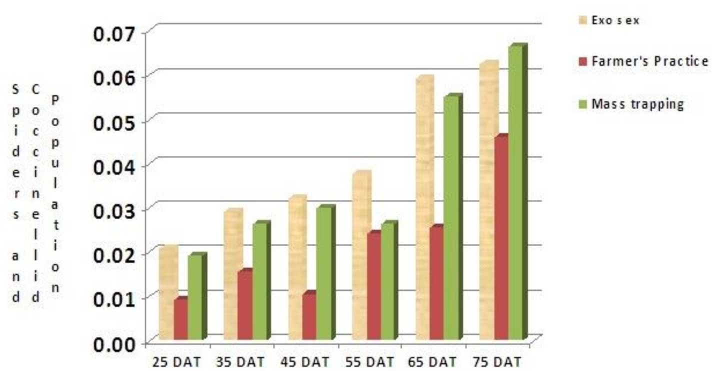


Figure 3. Predator Population



RESULTS AND DISCUSSION

Pheromone mediated management technology testing requires fairly large size fields. Evaluation needs to be done on farmers' rice fields in the stem borer prone areas, where farmers intend to apply insecticides unless there is an assurance of no loss with alternative methods of stem borer management. Mass trapping had also been registered as standard practice for management of yellow stem borer. The multi-location trials on pheromones conducted by DRR, Hyderabad revealed the effectiveness of this technology against YSB on par or even superior at times than insecticidal treatments. Therefore, the effectiveness of auto-confusion technique is being judged by comparing with farmers practice involving use of insecticide and with mass trapping.

From each plot dead hearts and white ears incidence was recorded, fairly high levels of dead heart incidence was recorded at 25 and 35 DAT and white ear incidence was noticed at 65 and 75 DAT (Table 2, 5 and Fig.1). At 25 DAT auto-confusion registered significantly lower percent dead hearts (5.80) than that of mass trapping (8.55) and farmers practice (8.91). At 35 DAT the dead heart incidence in Exo sect treatment was on par with farmers practice and slightly higher than in Mass trapping.

The intensity of stem borer incidence at 45 and 55 DAT was very low with less than one per cent mean dead hearts (<1%). At 45 and 55 DAT, all the three treatments were on par with one another in respect of stem borer infestation.

Auto confusion registered lower mean percent white ear incidence than mass trapping and farmers practice both at 65 and 75 DAT with incidence 4.45% and 5.85% respectively (Fig.1). Similar results were found by Cork *et al*, 1996, who reported that the larval damage ranged from 5.7 to 8.1% white heads (WH) in the insecticide-treated plots compared to a significantly lower (2.1 to 2.4%) WHs in the pheromone treated plots. Cork and Basu (1996) reported that the level of white head damage in the pheromone treated plot was significantly lower than that recorded in other treatment plots and that the relative percentage of the larvae of the two major stem borer species, *S. incertulas* and *Chilo polychrysa* (Meyrick) found in the region ranged from 88% *S. incertulas* in the farmers' practice plot to 65% in the pheromone treated plot. The maximum dead heart and white head damage recorded in the pheromone – treated plots in Warangal were 2.8 and 15.7% respectively compared to 7.0 and 20.9% respectively in the farmers' practice plots [6].

YSB male moths were captured in the pheromone trap throughout the crop growth during the season. Comparatively higher capture was recorded during the month of March, particularly in the first and second weeks. Comparatively higher male moth catch per trap was recorded in farmers practice, mass trapping and auto confusion in the descending order. However, trend of capture intensity was similar in all treatments (Table 4, Figure 2). The results obtained are in agreement with the findings of Cork *et al.*, 1996 [7] who reported that the catches of male moths were reduced by 98% in pheromone treated plots compared to catches in the insecticide treated plots, suggesting that the pheromone mediated communication was disrupted. Spiders and coccinellids were the main predators relevant to stem borers that occurred throughout the observational period. They were more abundant in auto confusion (0.292 to 0.625/10hills) and mass trapping treatment (0.263 to 0.663/10hills) than in farmers practice (0.154 to 0.458/10hills) fields throughout the observational period (Table 3 and Figure 3).

Mean grain yields in auto confusion, mass trapping and farmers practice treatments were 5541, 5606 and 5248 kg/ha respectively, and no significant differences were observed (Table 6). However, mass trapping (5606 kg/ha) followed by Auto confusion (5541kg/ha) realizes 300-350 kg higher yield than farmers practice (5248 kg/ha) treatment. However, Cork and Basu (1996) found that the yields of grain and straw recorded in the pheromone treated plot were significantly higher than in the untreated control plot but not significantly different from those recorded in the farmers' practice plot. Differences in *S. incertulas* larval damage estimates obtained from the pheromone-treated and farmers' practice plots in Warangal were reflected in grain yields, 4036 and 3715 kg/ha respectively [8].

CONCLUSIONS

Pheromone mediated Auto confusion technique utilizing Exo-sect pellets has been found effective in managing yellow stem borer. The effectiveness of the technique was either comparable or at times better than chemical control and pheromone mediated male annihilation technique which has been recommended for the management of yellow stem borer in rice. Auto confusion technique was found to be eco-friendly by harbouring a larger number of predator population. Auto confusion technique could be effectively utilized in stem borer prone rice growing areas, particularly to minimize insecticide use and to safeguard the environment.

CONFLICT OF INTEREST:

The authors declare that they have no conflict of interest.

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