Journal of Entomology and Zoology Studies

Available online at www.entomoljournal.com

E-ISSN: 2320-7078
P-ISSN: 2349-6800
JEZS 2019; 7(6): 222-224

Received: 12-09-2019
Accepted: 16-10-2019

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Dissipation of pheromone from dispensers of specialized pheromone and lure application technology (SPLAT-YSB) formulation used against rice yellow stem borer, *Scirpophaga incertulas* walker (Crambidae: Lepidoptera) in paddy ecosystem

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Abstract
Field experiment was conducted to study the rate of dissipation of pheromone in wax based SPLAT and powder formulation during *kharif* and *rabi* 2018 and 2019 seasons. The results clearly revealed that the formulation can be used effectively for the management of paddy yellow stem borer with slow release of pheromones in the field and proved its presence even after sixteen weeks of exposure in the field with more than 20 per cent of pheromone was still remaining in the formulation.

Keywords: Pheromone, dispensers of specialized, SPLAT-YSB, *Scirpophaga incertulas*

Introduction
Rice, *Oryza sativa* L. is an important cereal crop of the world, known as king of cereals and forms the staple food crop for more than two third of the population of India and more than 65 percent of the world population (Mathur *et al*., 1999) [7].
India, the largest rice growing country in Asia, has an area of about 53.2 million hectares (31% total cultivated area) and produces around 106.29 m t of rice with productivity at 2850 kg ha. In Karnataka, rice is cultivated in 27 districts with an area of 1.54 m ha with a total production of 4.18 m t and productivity of 2719 kg ha (Anonymous, 2014) [1].
The yellow stem borer (YSB), *S. incertulas* (Pyralidae; Lepidoptera) of rice is one of the major pest in all rice growing regions of Asia and in South East Asian region in general and in India particular (Chellaiah *et al.,* 1989) [2]. Unlike other rice stem borers, *S. incertulas* is well adopted to deep water rice environment (Islam and Catling, 1991) [6]. The larvae of *S. incertulas* cause dead hearts during vegetative stage and white ear heads during reproductive stage. Even though rice plant can compensate if dead heart infestation does not exceed 10 percent, but not for white ear loss. It has been reported that the pest can infest 1 to 3 percent of white ears (Velusamy, 1978) [8] causing a loss of about rupees 10 crores every year in India. Several attempts are being made to curb this pest but because of monophagous and cryptic nature it is very difficult to manage with insecticides. So in search of ecofriendly management of this pest use of semiochemicals are found to be a ray of hope in controlling the population of this pest. Use of semiochemicals reduces the chance of mating thereby reduces the oviposition which is depicted by reduction in egg masses of this pest in the treated area. In light of this the present study was conducted to study the dissipation rate of different formulations of pheromones under field condition against rice yellow stem borer.

Material and Methods
Raichur is situated in Northern dry region (Zone-2) of Karnataka between 16º 15′ N latitude, 77º 20′ E longitude and at 398.37 m above mean sea level. The average rainfall of Raichur is 660 mm confined to monsoon period between June to November with occasional showers during pre-monsoon months of April and May. Mean maximum temperature is more than 30 ºC throughout the year except during December.

The relative humidity is high during monsoon months from July to September and uniformly low during summer months from March to May. The procedure involved and methodology followed in carrying out the experiments on persistence and release rates of pheromones in paddy ecosystem are detailed in this chapter.

Pheromones are widely used as prophylactic measures to disrupt mating process in yellow stem borer thereby, reducing the probable loss caused by them. The field performance of these chemicals depends on several abiotic factors which decide the release rate and ultimately the quantity of pheromone required for season long mating disruption of yellow stem borer. Hence, the persistence of active ingredient present in the pheromone was studied and the same has been presented in the following subheadings.

Collection of dispenser

In order to study the rate of dissipation of pheromone in our study, 50 dispensers of powder and wax based SPLAT formulation were placed in a corner of experimental site on the day of transplanting. For pheromone dissipation studies three dispensers containing SPLAT-YSB and powder were collected out of the 50 dispensers kept in the corner of the paddy fields at weekly interval starting from the day of transplanting (Cork and Basu, 1996) [3].

Storage of Dispensers

Each collected dispensers were wrapped immediately in aluminium foil and were placed in thermacool box and stored in refrigerator at 4 ºC temperature. The pheromone present in these dispensers, which contained YSB pheromone as active ingredient blended with wax and water in SPLAT formulation and silica in powder formulation was analysed using Gas Chromatography (GC) at Indian Institute of Chemical Technology, Hyderabad.

Sample extraction procedure for estimation of pheromone in SPLAT-YSB by Gas chromatography (GC)

Preparation of ISTD (Internal Standard)

Fifty mg 12.AC- Dodecyl acetate was added into 100 ml of standard volumetric flask and made up the volume with ethyl acetate.

Preparation of Calibration standard / Reference standard (CS/RS)

Empty bottle was weighed and 10 mg reference standard (pure active) and 20 ml of ISTD was added, weight was noted down.

Sample preparation

Empty bottle was weighed and 200 mg of lure sample (formulation) and 10 ml of ISTD was added and weight was noted down. The contents were vortexed for proper mixing. Then the mixture was sonicated for 30 minutes. The solution was incubated for overnight at room temperature. Next day the solution was transferred to 1 ml GC vials with the use of 0.45 µm nylon syringe filter. Then GC was run at 260 – 280 ºC with a retention time of 25 minutes at Indian Institute of Chemical Technology, Hyderabad.

Analysis of residual pheromone

The residual amount of pheromone was calculated from peak area by means of standard curve. The amount of pheromone released during ageing period was determined by comparing with the amount contained initially versus those remaining after ageing. Weight by per cent of active ingredient (pheromone) was plotted against time (weekly basis) to know the dissipation pattern.

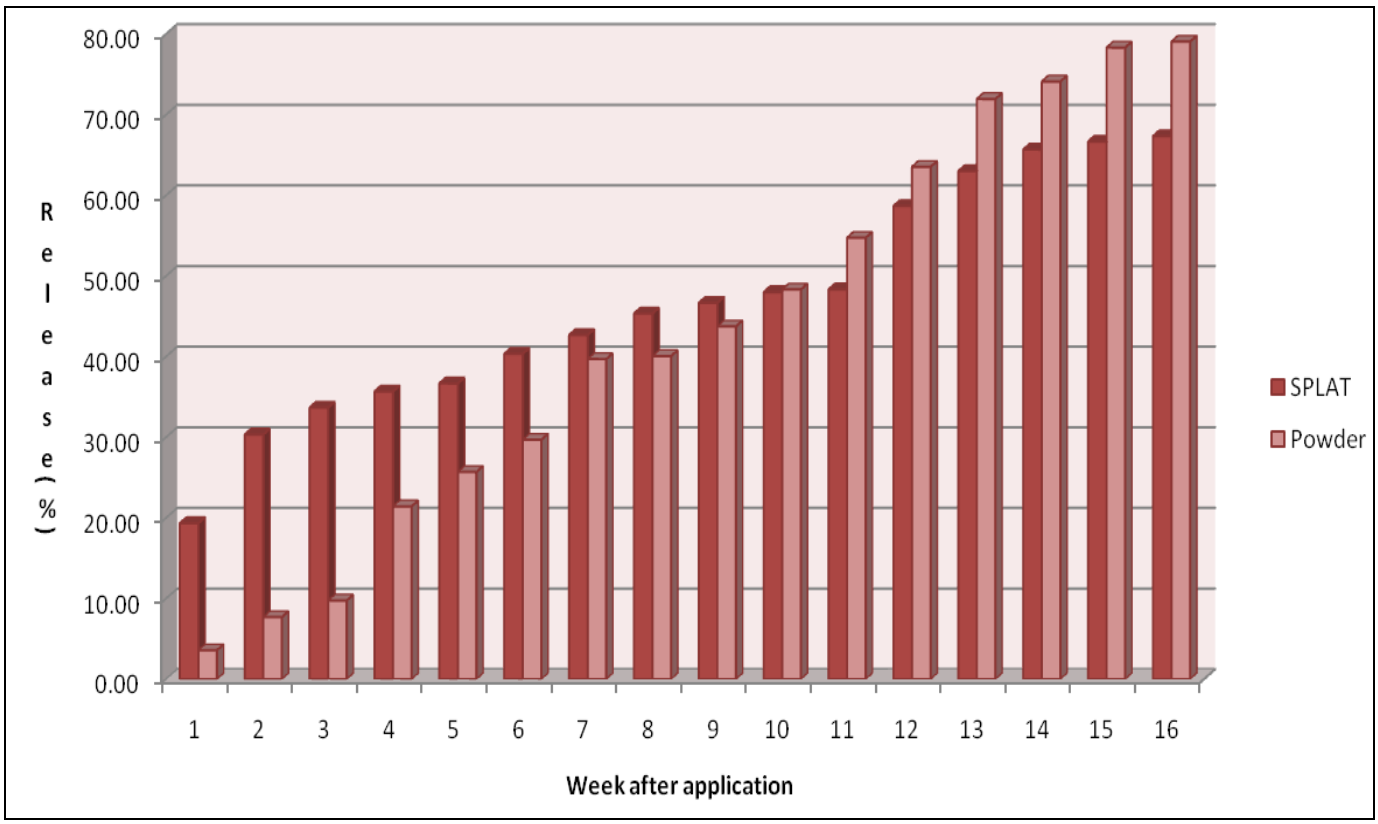

Fig 1: Persistence of pheromone under field condition

Table 1: Pheromone dissipation under field condition

Week	SPLAT-YSB in Rice leaf	Pheromone released (%)	YSB-Powder formulation	Pheromone released (%)
1 Week	2.42	19.33	18.32	3.58
2 week	2.09	30.33	17.54	7.68
3 Week	1.99	33.67	17.15	9.74
4 Week	1.93	35.67	14.93	21.42
5 Week	1.90	36.67	14.12	25.68
6 week	1.79	40.33	13.36	29.68
7 Week	1.72	42.67	11.46	39.68
8 Week	1.64	45.33	11.39	40.05
9 Week	1.60	46.67	10.69	43.74
10 Week	1.56	48.00	9.82	48.32
11 Week	1.55	48.33	8.60	54.74
12 Week	1.24	58.67	6.93	63.53
13Week	1.11	63.00	5.33	71.95
14 Week	1.03	65.67	4.92	74.11
15 Week	1.00	66.67	4.12	78.32
16 Week	0.98	67.33	3.98	79.05

Results and Discussion

Examination of the figures indicated that dissipation is faster in initial days. This may be due to the weaker cohesive forces between pheromone present on the outer surface of the dollop. But with the diffusion of pheromone molecules in the atmosphere, the residual amount of pheromone in dollop decreases this may result in strong adhesive forces between dispenser and pheromone molecules and give a slow release of pheromone with the time (Dixit, 2003) [5]

The release profiles were calculated based on the amount of pheromone left in SPLAT dollop/formulation applied in fields across YSB trial fields in Raichur. The results indicate that the different formulations are equally effective in rice fields (Table1 & Fig. 1). It was evident from the data of complete or partial trap shutdown that the pheromone dissipation from the formulation, maintained enough saturation of female sex pheromone to confuse male months in the field. From the results of dissipation study it was observed that the percent pheromone released ranged from first to sixteenth week as 19.3 to 67.3 and 3.57 to 79 per cent in wax and powder formulation respectively. Hence it is proved that the formulation can be used effectively for the slow release of pheromones in the field because even after sixteen weeks of exposure in the field, more than 20% pheromone was still remaining in the formulation. But it is recommended to apply the formulation at monthly interval to maintain enough pheromone saturation (more than natural female release) to confuse the male moths.

Cork *et al.* (1996) [4] recorded single application of pheromone can lost up to 90 days with pseudo - zero order release rates under field condition against yellow stem borer, *Scirpophaga incertulas.* Further, Alfaro *et al*. (2009) found release of pheromone throughout the field trial but which decreased after 50 days. However, field trials indicated that the reduced emission rates of the pheromone were still high enough to produce good mating disruption in the field. They noticed residual amount of pheromone in the dispenser at the end of the season was approximately 30% of the initial dosage, suggesting unnecessary amount of pheromone was presented in the dispensers and suggested that, this residual amount of unreleased pheromone could be minimized in order to reduce the cost of the mating disruption technique for managing the stem borer pest.

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