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The development of a standard pheromone trapping procedure for *Spodoptera litura* (F) (Lepidoptera: Noctuidae) population in groundnut (*Arachis hyopogaea* L) crops

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Abstract. The efficacy of four pheromone-trap designs was compared for catching male tobacco caterpillar, *Spodoptera litura* (F), moths in groundnut fields. There was no significant difference in the performance of the single- and double-funnel traps, and the single-funnel (20 cm dia) trap captured more moths than any other trap. Septa of 4 weeks or less exposure attracted most moths. One and two traps ha^{-1} caught significantly fewer moths than four and more traps ha^{-1}; however there was no significant improvement in capture when four or more traps ha^{-1} were installed. Night observations indicated that many moths escaped from sleeve traps. Single plastic funnel traps were found suitable and are being used in monitoring *S. litura* in the national monitoring network in India.

1. Introduction

The tobacco caterpillar, *Spodoptera litura* (F), is widely distributed throughout Asia and the Pacific islands (Feakin, 1973). It is polyphagous and is known to cause severe damage to groundnut, cotton, tobacco, chilli, cabbage, cauliflower and a range of legume crops (Ayyanna *et al.*, 1982, Moussa *et al.*, 1960). The integrated pest management (IPM) approach to groundnut pest control, being developed at ICRISAT Center, emphasized the need for improved flight monitoring systems to forecast pest damage. The identification of the male sex pheromone of this species (ZE) 9,11-tetradecadienyl acetate and (ZE) 9,12-tetradecadienyl acetate by Youshima *et al.* (1974), has enabled this species to be monitored with pheromone traps for some years, but there is uncertainty about the best trap design. This has led to a comparison of designs and an evaluation of the efficiency of the trapping procedures for this species. Research on sex-pheromone traps of this species was initiated at International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) Center, Patancheru, India, in 1979. Though sex-pheromone traps for this species are available to farmers in the SAT, knowledge on trap design, septum longevity and trap density for different purposes was inadequate. Hence experiments were carried out to evaluate trap design and to find the active life period of a lure, as well as to study trap spacing, in order to standardize methodology for field application.

2. Material and methods

These studies were conducted in groundnut fields at ICRISAT Center, India (18°N, 78°E). The sex attractant, 1 mg impregnated into a polyethylene septum, was obtained from the Overseas Development Natural Resources Institute (previously Tropical Development Research Institute), UK. The pre-baited septa were fixed into the centre of the traps. Four trap designs were compared to test their efficacy (Figure 1).

1. *The 'small-sleeve trap'* (10 cm dia.). In this trap a plastic or metal ring is riveted to a metal or plastic plate above, at a clearance of 5 cm, and a polythene bag below to collect moths. This is the standard trap used in India by farmers.
2. *'Big-sleeve trap'*. This is the same design as the 'small-sleeve trap'; but with a 20 cm dia. ring.
3. *'Double-funnel trap'*. In this trap a small plastic funnel (15 cm dia.), with vertical slits, is placed around the septum and fixed to an aluminium plate above. Another white plastic funnel (20 cm dia.) is fixed to the plate, leaving 5 cm clearance. A polythene bag is tied below for moth collection.
4. *'Single-funnel trap'*. This design is similar to the 'double-funnel trap', but it has no small funnel inside. These traps were selected either because they are commercially available, easy to make and convenient to use or because they have been recommended for monitoring noctuids in other crops (Pawar *et al.*, 1988; Krishnanada and Satyanarayana, 1985).

In field tests at the ICRISAT Centre, four traps were placed 1·0 m above the ground in groundnut crops, and this was replicated four times. The traps were checked, cleaned every day and re-randomized once a week. The traps were placed at least 200 m apart, to avoid the risk of trap interference. Trapping studies were conducted for 1 month during the peak flight period (Feb.–Mar. 1988).

We watched moth movements in and around the traps during the night with night-vision binoculars. Each trap was observed for 30 min in a randomized fashion for 14 nights.

To determine the effective life of the pheromone septa, 15 fresh septa were exposed in the field for 1, 2, 4, 6 or 8 weeks, after which they were held at −10°C for a week to immobilize the pheromone. After the exposure phase was complete, the septa were re-installed in the field and the moth catch was observed daily for 6 weeks. Each exposure time was replicated thrice.

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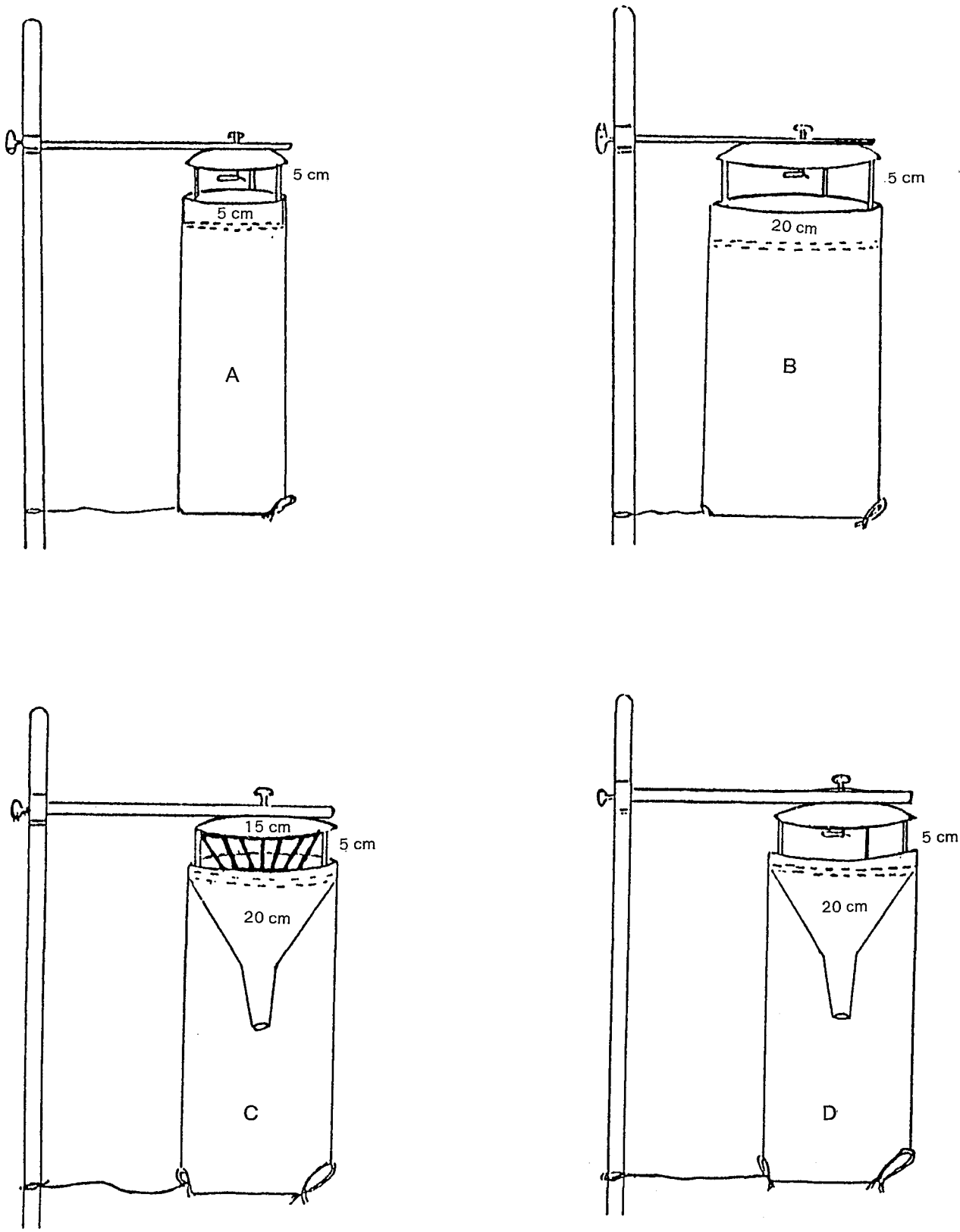

Figure 1. Diagrammatic representation of different traps used in this study. ***A****: Smali-sleeve trap: a small plastic/metal ring (5 cm dia.) hinged to a plastic/metal plate at a clearance of 5 cm. The septum is suspended below the plate. Moths are caught in the polythene bag tied below.* ***B****: Big-sleeve trap: a big plastic/metal ring (20 cm dia.) hinged to a plastic/metal plate at a clearance of 5 cm. The septum is suspended below the plate.* ***C****: Double-funnel trap: a small plastic funnel (15 cm dia.) with vertical slits placed around septum and fixed to an aluminium plate above. Another white plastic funnel (20 cm dia.) is attached outside the plate with a clearance of 5 cm.* ***D****: Single-funnel trap: a single white plastic funnel (20 cm dia.) connected to an aluminium plate with a clearance of 5 cm. The septum is suspended below the plate in the middle of the funnel.*

The optimum trap density was assessed by placing one, two, four, eight or sixteen single-funnel traps ha^{-1} in different groundnut fields. Traps were hung on 1-m poles and operated during March and April 1988. To eliminate any site-specific effects the treatments were re-randomized on alternate days. Daily observations were carried out for 1 month.

3. Results

3.1. Trap designs

The single- and double-funnel traps caught about the same number of moths. The sleeve traps were markedly less effective than the funnel traps (Table 1). Despite the larger trapping area of the large-sleeve trap, there was no corresponding increase in catch. This suggested that traps with the largest trapping surface were not necessarily the most effective. Night observations indicated that sleeve traps were less effective because there was no retaining mechanism. The moths flew in and out of the trap freely (Table 4).

Table 1. Efficacy of different pheromone-trap designs in catching S. litura *males at ICRISAT Center, Feb.–Mar. 1988*

Trap description[a]	Mean weekly moth catch[b]	SE
Small-sleeve trap (10 cm dia.) (A)	84	± 30.3
Big-sleeve trap (20 cm dia.) (B)	60	± 21·7
Double-funnel trap (20 cm dia.) (C)	352	±114·7
Single-funnel trap (20 cm dia.) (D)	356	± 73·3
SE±	60·5	
CD at 5%	193·5	

[a] Letters in parentheses correspond to Figure 1.
[b] Average of four replications when observations were taken on a daily basis for 30 days.

Table 2. Mean catches of S. litura *in pheromone traps baited with septa previously exposed for different periods, ICRISAT Center 1988*

Pheromone exposure time in weeks	Mean weekly moth catch in the weeks following re-exposure					
	1st week	SE	2nd week	SE	3rd week	SE
Fresh septa[a]	32	±9·0	22	±5·2	23	±3·7
1	42	±4·3	27	±4·7	25	±3·4
2	31	±7·3	20	±4·8	17	±3·3
4	22	±3·0	15	±2·6	13	±2·0
6	13	±2·4	8	±1·8	6	±1·3
8	19	±5·3	11	±3·5	8	±2·4
SE±	4·0		2·2		1·7	
CD at 5%	11·6		6·2		4·7	

[a] Average of three replications and 6-week trapping period.

3.2. Longevity of pheromone septa

The septa were still attracting males after 11 weeks (Table 2). However, the data indicated that the septa were significantly more effective up to 4 weeks. The continuous exposure of septa in the field led to a decline in catch, but a 4-week exposure is indicated to be effective. A significant reduction took place after the 4-week exposure.

3.3. Trap density

The data in Table 3 reveal that the moth catch was significantly lower when one or two traps ha^{-1} were installed than with four or more traps ha^{-1}. There was no significant improvement in the catch when the trap number ha^{-1} increased from four to sixteen.

4. Discussion

The results presented in this paper emphasize that trap design, pheromone longevity and trap density are important factors in determining the efficiency of *S. litura* moth catches in sex-attractant traps. The catch in traps of different sleeve sizes clearly indicated that traps with the largest trapping area need not be the most efficient. A similar catch pattern was also noticed by Macaulay and Lewis (1977) for the peamoth, *Cydia nigricana* (Stephen). Krishna Prasad *et al.* (1985), who worked with the sex attractant of *S. litura*, evaluated five different water traps with pheromone septa

Table 3. Effect of pheromone trap density on attraction of S. litura *at ICRISAT Center, Mar.–Apr. 1988*

Trap number[a] (ha^{-1})	mean weekly moth catch (ha^{-1})	SE
One	161	± 35·4
Two	230	± 47·5
Four	445	±110·8
Eight	571	±155.0
Sixteen	690	±192·5
SE±	88	
CD at 5%	264·7	

[a] Average of four replications over a 1-month period.

Table 4. Effect of trap design on escape of moths that had been trapped

Trap type	Mean percentage moth escape after trapping (30 min)[a]	SE
Small-sleeve trap (A)	70	±12·3
Big-sleeve trap (B)	62	±12·9
Double-funnel trap (C)	0	± 0·0
Single-funnel trap (D)	0	± 0·0
SE±	8·2	
CD at 5%	23·3	

[a] Each trap was observed for 30 min each night in a radomized design for 14 days.

and showed that water traps with pheromone septa and insecticides were superior to others. Hirano (1980), while studying the capture efficiency of box-type as well as water-pan traps baited with pheromone septa, concluded that the efficiency of a trap depends on the ability to attract the moths from a distance and to capture them once they have been attracted. Pawar *et al.* (1988) indicated that placement of a small plastic funnel around the septa can significantly improve the *Helicoverpa armigera* catch. Although we used the same double-funnel trap, there was no significant improvement in the catch of *S. litura*. Ali Niazee (1976), who worked with *Archips rosanus* in the Pacific northwestern United States, concluded that trap effectiveness will differ from insect to insect. In this study, though the sleeve traps are relatively cheap, keeping in view the efficacy and the ease with which moths fly out of the trap, it is suggested that one needs to look for a better trap than this to ensure an efficient monitoring system.

In the case of *S. litura*, the most effective response of males to the pheromone plume was noticed up to a 4-week exposure period. Thus, for monitoring purposes, septum replacement should be on a 4-week basis.

Examination of trap density indicated no statistical difference in moth catch when there were four or more traps ha^{-1}: no decline was noticed in moth catch with increase in trap density. This indirectly suggests a limitation in utilizing this pheromone in mass trapping operations, due to multiple mating and high fecundity of this species. Similar results were also noticed by Oyama *et al.* (1978), who worked with the same species in taro fields in Japan. They concluded that mass trapping and release of synthetic mating disruptants did not significantly suppress larval population. But they supported the feasibility of forecasting population density by this means. Records from efficient traps might be of value in monitoring populations of *S. litura* and to develop future forecasting systems for timing insecticide applications.

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