Insect Sci. Applic. Vol. 12, No. 4, pp. 443–447, 1991
Printed in Kenya.

0191-9040/91 $3.00 + 0.00

MONITORING *SPODOPTERA LITURA* (F) (LEPIDOPTERA: NOCTUIDAE) USING SEX ATTRACTANT TRAPS: EFFECT OF TRAP HEIGHT AND TIME OF THE NIGHT ON MOTH CATCH*

G. V. RANGA RAO, J. A. WIGHTMAN and D. V. RANGA RAO
International Crops Research Institute for the Semi-Arid Tropics, Patancheru, Andhra Pradesh 502 324, India

(*Received* 4 *January* 1990; *revised* 29 *August* 1990)

Abstract—The Integrated Pest Management (IPM) Programme under development at the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) calls for a proper monitoring system. Experiments conducted in groundnut fields at ICRISAT Center near Hyderabad, in peninsular India, to establish the optimum height for pheromone traps to monitor *Spodoptera litura* (F), indicated that the male flight pattern changes considerably during the cropping period. During the seedling stage (sowing to 6 weeks), most moths were caught at 0.5 and 1.0 m. In the initial growth phase (7–11 weeks), the traps at 4.0 m caught most moths. During the optimum growth phase (12th week to harvest) of the crop the traps at 1.0 m height trapped most moths. After harvest, the traps at 4.0 m again recorded the highest catch. These data are interpreted in terms of the migration pattern of *S. litura* moths during the crop season. We suggest monitoring this species, using 1 m height traps.

Males were found to be more active around 0300 hr, with a small peak after sunset (2000 hr). Irrespective of season, the peak flight activity of this species was around 0300 hr in groundnut fields.

Key Words: *Spodoptera litura*, pheromone traps, IPM

Résumé—Le programme de lutte intégrée développé à l'International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) passe par la mise en place d'un système de surveillance efficace. Des expériences ont été menées dans des parcelles d'arachide au Center ICRISAT près d'Hyderabad (Inde) pour déterminer la hauteur optimum des pièges à phéromones utilisés pour surveiller les populations de *Spodoptera litura* F. Les résultats montrent que l'activité de vol des mâles varie pendant la période de croissance de l'arachide. Au stade plantule (semis à 6 semaines) la plupart des mâles sont capturés dans des pièges placés entre 0,5 et 1,0 de hauteur. Pendant la phase de croissance initiale (7–11 semaines) les pièges placés à 4,0 m, capturent plus de mâles. Après la récolte, les pièges placés à 4,0 m de hauteur capturent à nouveau le plus grand nombre de mâles. Ces résultats sont iterprétés en fonction de l'activité de vol de *S. litura* pendant la période de culture. Les pièges à phéromone placés à 1,0 m de hauteur nous semblent les plus efficaces pour évaluer le niveau d'abondance des populations de ce ravageur.

Les mâles sont plus actifs vers 0300 hr et, dans une moindre mesure, au crépuscule (2000 hr). Le pic d'activité de vol de ce ravageur se situe donc autour de 0300 hr dans les champs d'arachide, indépendemment de la saison.

Mots Clés: *Spodoptera litura*, pièges à phéromones

*Submitted as JA No. 872 by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

INTRODUCTION

The tobacco caterpillar, *Spodoptera litura,* is an important pest of groundnut crop in Asia. It has a wide host range throughout its distribution. Cotton, cabbage, cauliflower, groundnut, tobacco, castor, and chillies are among its favourite hosts. During recent years this species was considered as a major pest on groundnut crop. The caterpillars are found feeding voraciously on leaves, branches, flowers and pegs resulting in marked reduction of yields (Ayyanna et al., 1982). Due to its polyphagous nature and the prevailing favourable climate, this pest is present throughout the year in many parts of India.

The sex pheromone of this species "Litlure" is a mixture of (Z,E) 9,11-tetradecadienyl acetate and (Z,E) 9,12-tetradecadienyl acetate in a ratio of 9:1 (Tamaki et al., 1973; Pawar and Prasad, 1983). A synthetic mixture of these two components attracts roughly the same number of *S. litura* males in the fields as virgin females (Yushima et al., 1974).

Monitoring of *S. litura* moths by pheromone traps was initiated at ICRISAT Center in 1979, using plastic dry funnel traps and pheromone septa obtained from Natural Resources Institute (NRI), Chatham, UK. Subsequently the trap design was modified slightly to suit locally available materials (Ranga Rao et al., 1990). Intensive monitoring of this species was initiated in the 1985 rainy season using pheromone traps to determine the population fluctuations at ICRISAT Center. Pheromone traps had previously shown that males flew up to 203 m above ground level (Arai and Iga, 1985; Krishnanada and Satyanarayana, 1985).

The efficiency of sex pheromone traps depends upon a number of variables, such as trap design, crop season, and height of the trap in relation to the canopy. Of these, the height of the trap above the ground level is critical, since different insect species fly at different elevations to find their mates (Ali Niazee, 1983; Riedl et al., 1979). Riedl and Croft (1974) suggested that the reliable interpretation of pheromone trap catches requires a standardized trapping scheme in terms of trap design, pheromone release system, trap density, maintenance and operation. So far, some workers have attempted to use the sex pheromone traps to monitor the population density of insect pests (Wong et al., 1971; Minks and Jong, 1975) and for making decisions about the timing of insecticidal sprays (Madsen and Vakenti, 1973).

The purpose of the present study was to evaluate the influence of trap height and time of the night on catches of *S. litura* moths in groundnut fields as a contribution to the development of a standardized methodology for the field application of these traps.

MATERIALS AND METHODS

The studies described were conducted during the 1985/86, 1986/87 rainy and post-rainy seasons at ICRISAT Center, A.P., India. The traps were fitted with 1 mg septa and were bolted singly onto poles so that they stood 0.5. 1.0, 1.5, 2.0 and 4.0 m above the ground. Each height (= a treatment) was replicated five times. The traps were positioned in unsprayed groundnut fields around the ICRISAT farm immediately after sowing. Care was taken to avoid interference between traps by keeping them at least 200 m apart. Daily observations were taken for 23 weeks. The septa were replaced once every 4 weeks.

The data were analysed as if the trap had been arranged in a randomized block. The crop season was divided into four phases, i.e., seedling phase (sowing to 6 weeks), initial growth phase (7 to 11 weeks), main growth phase (12th week to harvest), and post-harvest (17th to 23rd week). The data were analysed collectively and for individual growth stages of the crop. The daily light trap catch was collected at ICRISAT farm during the 1985/86 and 1986/87 seasons and compared to the pheromone trap data.

Peak flight period

To find out peak moth activity during nights, hourly observations were made on 10 nights of the five pheromone traps fixed 1.0 m above the ground in groundnut fields. Possibility of seasonal variation was checked by duplicating the observations in the rainy (September) and post-rainy (April) seasons. We also checked the hourly flight activity for 15 nights with an event recorder, a mechanical device developed by Dr. A. B. S. King, ODNRI, Chatham. This device was deployed on one trap for 15 days during April 1986. It consists of a Rustrak graphic channel with a timer, and is fixed to the pheromone trap. The whole system runs on 12 volts battery.

Night observations using night vision goggles

Five nights were spent in the groundnut fields observing moth activity around traps through night vision goggles. Besides moth activity, data on environmental factors like temperature, humidity and wind velocity were recorded at hourly intervals.

RESULTS

Pheromone trap data from different seasons of 1985/86 indicated that there were about 10 generations of this species per year. The catches start low in the early rainy season and build up to a maximum by March, and then tail off by May. The rainy season population was relatively low, compared to the post-rainy season population. The comparative study of pheromone and light traps (Fig. 1) clearly indicated that pheromone traps attracted more moths than light traps in all seasons at both low and high population levels. Light traps, particularly when populations are low during the off-season (summer, May), gave a totally wrong impression of the bionomics of this species.

The results indicated that moth flight height was not the same throughout the crop cycle (Table 1). Soon after sowing, most moths were caught 1.0 m above ground level (AGL). This trend in moth activity changed substantially as the crop grew. Between 36 and 70 days after emergence (DAE), most moths were trapped at 4.0 m AGL. In the advance crop (between 71 DAE and harvest), the traps at 1.0 m and above had the highest catches. After the crop was harvested, the traps at the higher elevation again trapped most moths. These data should be related to the fact that the crop height never exceeded 35 cm.

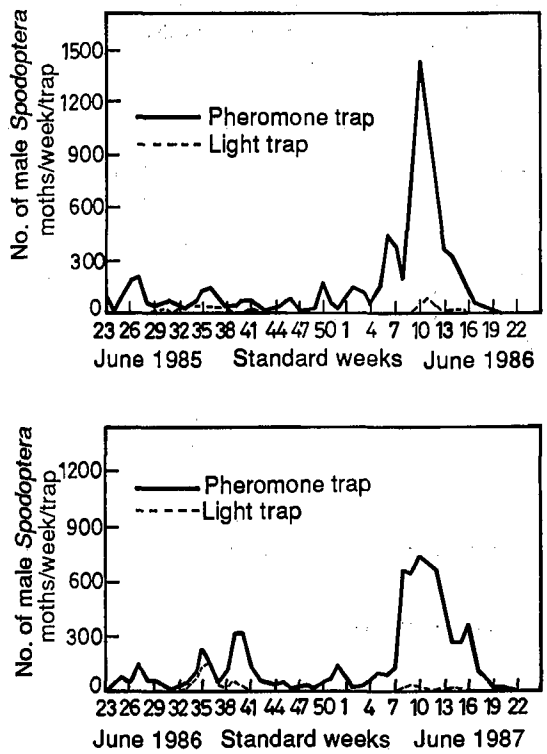

Fig. 1. *Spodoptera litura* flight activity monitored using pheromone and light traps, ICRISAT Center, groundnut seasons, 4 June 1985–3 June 1987.

Table 1. Effect of trap height on no. of *S. litura* pheromone trap catches at four stages of the groundnut growing season (rainy season 1986)

Trap height+ (m)	Stage* Mean number of moths trapped/week				
	Seedling	Initial growth	Later growth	Post-harvest	Season's total
0.5	35 (3.3)# ab	64 (3.9) a	122 (4.5) a	13 (2.3) a	53 (3.4) a
1.0	45 (3.7) b	178 (4.8) b	241 (5.3) b	35 (3.3) b	113 (4.2) b
1.5	16 (2.6) c	162 (4.8) b	193 (5.1) b	45 (3.7) c	95 (3.9) b
2.0	19 (2.8) ac	131 (4.6) b	177 (5.1) b	47 (3.7) c	86 (4.0) b
4.0	20 (2.9) ac	280 (5.2) b	205 (5.1) b	67 (4.1) d	131 (4.2) b
S.E. ±	(0.2)	(0.2)	(0.1)	(0.1)	(0.1)
CV%	(16)	(9)	(6)	(6)	(13)

+Average of five replications.
*Seedling stage sowing to 6 weeks.
Initial growth stage 7th to 11th week.
Later growth stage = 12th week to harvest.
Post-harvest = 17th to 23rd week
#Parentheses indicate log transformed values.

Table 2. Hourly catches of *S. litura* moths in different cropping seasons, using different techniques

Time	Proportion of moths trapped (%)			
	Manual observation*			
	Rainy season (Sept.)	Post-rainy season (Early April)	Rustrak+ timer (Late Apr.–May)	Night vision# goggles (April)
1900	5	0	0	0
2000	10	2	3	7
2100	7	6	2	2
2200	2	7	2	2
2300	3	8	2	0
2400	5	6	2	2
0100	8	9	10	4
0200	15	15	10	20
0300	19	24	26	41
0400	16	17	26	15
0500	9	9	12	7
0600	1	0	4	0

*Average of five traps for 5 days and a total of 740 moths in rainy and 104 moths in post-rainy season.
+Single trap for 15 days and a total of 124 moths.
#Five night observations and a total of 46 moths.

Peak period of male flight

In the first of these trials, the hourly pheromone trap observations indicated that there was a lot of variation in moth activity during the night. In the rainy season, males started responding to pheromone traps soon after the sunset, with a small peak around 2000 hr (contributing only 10% of the total catch), and a small proportion continued to fly all through the night, with a peak around 0300 hr (19% of the catch). The same trend was noticed in the summer, with a peak activity around 0300 hr (24% of the total catch), but the initial activity was a little delayed (Table 2).

The observation with Rustrak flight detector fitted to a pheromone trap in summer also showed the same pattern, with a small peak at 2000 hr and the major activity at 0300 hr. The observation with night vision goggles also revealed the same trend, with 7% of the catch at 2000 hr and 41% of the catch around 0300 hr (Table 2).

DISCUSSION

Effective interpretation of trap catches relies on a sound knowledge of the biological events of the pest, for instance monitoring the emergence and population dynamics of species like *S. litura* with multiple and overlapping generations is a complex process. The monitoring studies using light and pheromone traps clearly indicated the advantage of the latter particularly during off-seasons. Based on these observations, we can further conclude that pheromone traps were better indicators of *S. litura* population fluctuations than light traps. Results from these studies revealed substantial shift in moth flight height in different phases of the crop. Several previous reports related trap height to the relevant crop height. In general, the response of the male moths was optimum when traps were suspended near the top of the foliage, regardless of height (Moshe Kehat and Shaul Greenberg, 1976; Ali Niazee, 1983; Dandapani, 1985). The studies conducted by Krishnananda and Satyanaryana (1985) with *S. litura* in tobacco nurseries recorded that 2.0 m was the optimum height for catching more males, when eight traps were placed on a single pole with a 0.5 m distance among traps. However, they ignored possible plume interference effects. The attractant from each trap coalesced as it travelled downwind, so that the moths presumably sought the centre of the plume. Our studies clearly showed that 1.0 m trap height was optimum along the cropping season, and 4.0 m was best during periods of fallow. At seedling stage, maximum catch was noticed in low height traps, this perhaps suggests the movement of local populations in the field. When the crop was well-established (between 36–70 days) more catch was obtained at 4.0 m traps; these are "high fliers" and probably moths migrating across the farm. In the advanced crop stage (between 71 DAE to harvest) the traps at 1.0 m had the highest catch. After crop harvest the traps at highest elevation again trapped most moths. These moths formed the part of what we consider the "normal" flight pattern which is not related to the crop. When the whole crop period was considered, all the traps that were 1.0 m and above caught significant same number of moths. Thus we suggest that traps should be 1.0 m above ground level in groundnut fields, to maximize catches and simplify trap servicing.

Studies on moth flight during different parts of the night clearly indicated that there are two peaks of activity with a big peak around 0300 hr. However, the early activity of the moths differ slightly from rainy season to summer which could be due to the longer summer days.

Since there was not much variation in temperature, humidity and wind velocity during the experimental period, it seems that under normal conditions the optimum male activity would be around 0300 hr, irrespective of the season. Similar studies conducted at Tamil Nadu Agricultural University, Tamil Nadu, India by Dandapani (1985) with this species showed

highest catch between 2000 and 2200 hr, while Balasubramanian et al. (1985) reported peak catch at 2300-0000 hr and 0300–0400 hr. The present results differ from those of Dandapani (1985). This could be due to the different chemical composition of the pheromone itself. These studies also gave an indication that behaviour of the species was the same in different seasons at different locations.

CONCLUSION

There is evidence to suggest pheromone traps are useful additions to the armoury of the groundnut entomologists involved in monitoring *S. litura*. They are proved to be sensitive at low population densities, selective, cheap and potential monitoring tool. The present studies also provided an understanding of flight pattern of *S. litura* through groundnut crop season. Night observations indicated the activity of males during different seasons. Unless such basic results are available, the pheromone trap monitoring will not make the rightful impact on future pest control strategies.

REFERENCES

Ali Niaze M. T. (1983) Monitoring the filbert worm, *Melissopus latiferreanus* (Lepidoptera: Olethreutidae), with sex attractant traps. Effect of trap design and placement on moth catches. *Environ. Entomol.* 12, 141–146.

Arai S. and Iga M. (1985) Capture of male *Spodoptera litura* (Lepidoptera: Noctuidae) by sex attractant pheromone traps on the roof top of a taller building (203 m height) (in Japan). *Proceedings of the Kanto-Tosan Protection Society* 32, 174–175.

Ayyanna T., Arjuna Rao P., Subbaratnam G. V., Krishna Murthy Rao B. H. and Narayana K. L. (1982) Chemical control of *Spodoptera litura* Fabricius on groundnut crop. *Pesticides* 16, 19–20.

Balasubramanian G., Chelliah S. and Balasubramanian M. (1985) Studies on light trap and pheromome trap catches of *Spodoptera litura* Fabricius. *Behavioural and Physiological Approaches in Pest Management* (Edited by Raghupathy A. and Jayaraj S.), pp. 78–84. Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India.

Dandapani N. (1985) Trapping of *Spodoptera litura* (F.) moths using sex pheromone. *Madras Agric.J.* 72, 236–238.

Krishnananda N. and Satyanarayana S. V. V. (1985) Effect of height of pheromone trap on the capture of *Spodoptera litura* moths in tobacco nurseries. *Phytoparasitica* 13, 59–62.

Madsen F. H. and Vakenti. J. M. (1973) Codling moth: use of codlemone baited traps and visual detection of entries to determine need of sprays. *Environ. Entomol.* 2, 677–679.

Minks A. K., De Jong D. J. (1975) Determination of spraying dates for *Adoxophyes orana* by sex pheromone traps and temperature recordings. *J. econ. Entomol.* 5, 729–732.

Moshe Kehat and Shaul Greenberg (1976) Field evaluation of the synthetic pheromone, as an attractant for males of the cotton leafworm *Spodoptera lituralis* (Boisd) in Israel. *Appl. Entomol. Zool.* 11, 45–52.

Pawar A. D. and Prasad J. (1983) Field evaluation of a sex pheromone "Litlure" as an attractant for males of *Spodoptera litura* (F.) (Lepidoptera: Noctuidae). *Ind. J. Plant.Prot.* 11, 108–109.

Ranga Rao G.V., Wightman J.A., and Ranga Rao D.V. (1990) The development of a standard pheromone trapping procedure for *Spodoptera litura* (F.) (Lepidoptera: Noctuidae) population in groundnut (*Arachis hypogeae*) crop. *Trop. Pest Manage.* (in press).

Riedl H. and Croft B. A. (1974) A study of pheromone traps catches in relation to codling moth damage. *Can. Entomol.* 106, 525–537.

Riedl H., Hoying S. Q., Barnett W. W. and DeTar J. S. (1979) Relationship of within tree placement of pheromone trap to codling moth catches. *Environ. Entomol.* 8, 765–769.

Tamaki Y., Naguchi H. and Yushima T. (1973) Sex pheromone of *Spodoptera litura* (F.) (Lepidoptera: Noctuidae): Isolation, identification and synthesis. *Appl. Entomol. Zool.* 8, 200–203.

Wong T. T. Y., Dolphin R. E., Cleveland M. L., Rolston D. F., Davis D. G. and Morizin T. E. (1971) Distribution and abundance of lesser peachtree borer on Washington Island, Wisconsin. *J. econ. Entomol.* 64, 879–882.

Yushima, T., Tamaki, Y., Kamano S. and Oyama M. (1974) Field evaluation of synthetic sex pheromone "Litlure" as an attractant for males of *Spodoptera litura* (F.) (Lepidoptera: Noctuidae). *Appl. Entomol. Zool.* 9, 147–152.