Asessment of the Use of Sex Pheromone Traps in the Management of *Spodoptera litura* F.

K.N. Singh[1] and G.C. Sachan[2]

[1]ICRISAT, Patancheru, A.P. 502 324, India. [2]G.B. Pant University of Agriculture and Technology, Pantnagar 263 145, Uttar Pradesh

Abstract

The tobacco caterpillar, *Spodoptera litura F.* is one of the most damaging insect pests on several field and vegetable crops. Sex pheromone, 'litlure' was used as an attractant in pheromone traps to monitor male moth activity, and to study the relationship between male moth catches in traps and oviposition in field crops at the Crop Research Centre, Pantnagar, India. Pheromone traps effectively monitored population fluctuations and showed seven peaks during 1988 and 1989. Two peaks were observed during the spring/summer season, three in the rainy season and the remaining two peaks in the postrainy season. Few moths were caught during the winter. Significant correlations were found between number of male moths in traps and number of egg masses laid on sugarbeet during spring, on groundnut and soybean during the rainy season, and on cauliflower during the postrainy season. However, there was no oviposition in *Kharif* sown urdbean and in summer groundnuts. Pheromone traps, therefore, can be used as a monitoring tool to ensure the rational application of insecticides.

Introduction

The tobacco caterpillar, *Spodoptera litura F.* is an important defoliator, often encountered as a sporadic pest on many crops such as tobacco, cotton, soybean, cabbage, cauliflower, sunflower, castor, groundnut, etc. It has been reported to attack 112 species of plants belonging to 44 families (Moussa and Kotbey, 1960). This species has a wide distribution throughout tropical and temperate Asia, Australia and the Pacific basin (Feakin, 1973).

In the past it was known to be a major pest of tobacco and chilies. Recently it has attained the status of 'major pest' of several field and vegetable crops because of its mismanagement - overdosing with insecticides, the destruction of natural enemies, abandoning cultural control practices, and introduction of high yielding, but pest susceptible crop varieties (Ayyanna *et al.*, 1982; Mehrotra, 1989; N.J. Armes, Pers. Comm.).

The current practice used by Indian farmers is to apply insecticides when larvae are mature and the infestation fairly visible, which is usually 3-4 weeks after adult emergence. Sprays are then applied weekly and at times when they may be least beneficial. However, early instar larvae (1st and 2nd instars) feed gregariously and by virtue of their smaller size are easier to kill with pesticides if applied in time.

Although there is a continuing need for pesticides for controlling arthropod pests, the concomitant undesirable effects such as the development of pesticide resistance, effects on non-target organisms and pollution of environment have necessitated and stimulated the exploration of new and more efficient methods for the rationalization of insecticide use. In recent times, one such approach is the use of synthetic insect sex pheromones. Female sex pheromone of *S. litura* has been identified and named 'litlure'. It is a mixture of 9Z, 11E, tetradecadienyl acetate and 9Z, 12E, tetradecadienyl acetate in a ratio of 9:1 (Tamaki *et al.*, 1973).

Experiments were carried out to assess the use of sex pheromones to monitor *S. litura* populations, and to study the correlations between male moth catches in traps and levels of oviposition in the field. Such information would help in estimating the capture threshold of this insect which in turn will assist in timely application of control measures.

Materials and Methods

The studies were conducted at the Crop Research Center (CRC), G.B. Pant University of Agriculture and Technology, Pantnagar, Nainital, Uttar Pradesh, India (29°N, 79.3°E) during 1988 and 1989. The pheromone trap used was an ICRISAT standard type, comprising a single white plastic funnel trap

(Ranga Rao *et al.*, 1991). The trap was fixed with a nut and bolt to an angular metal support pole. The sex attractant, 1 mg impregnated into a white polyethylene vial, was obtained from the Natural Resources Institute (N.R.I.), U.K. through the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India. The pre-baited pheromone vial was hung above the trap funnel from an aluminum plate into the centre of the trap. The trap was fixed 1 m above the ground level and each pheromone vial was replaced with a new one after an exposure of 4 weeks, as no reduction in trap catch occurs over this period (Ranga Rao *et al.*, 1991).

Four pheromone traps were operated through out the year to monitor the population of *S. litura*. Traps were operated from January to May in sugarbeet fields, March to mid November in groundnuts, July to October in soybean, and mid November to December at the sides and parallel to the main approach road. Traps were placed 200 m apart to reduce the possibility of inter-trap interference (Ranga Rao *et al.*, 1991). Captured moths were counted daily, and averaged for each standard week (each calendar year is divided into 52 standard weeks; 1 January to 7 January is week one; in leap year the week no. 9 will be 26 February to 4 March i.e. 8 days instead of 7; and last week will have 8 days, 24 to 31 December) to facilitate the analysis and interpretation of the data.

Influence of Environmental Factors on Pheromone Trap Catches

Data on maximum temperature, minimum temperature, wind velocity, and rainfall were collected from the meteorological centre, CRC, Pantnagar. To study the relationship between moth catches and weather factors, the calendar year was divided into four seasons, summer (March-May), rainy (June-August), postrainy (September-November) and winter (December-February). The relationship between weather factors and the moth catches in the pheromone baited traps were established using correlation analysis.

Relationship Between Pheromone Trap Catches and Oviposition

To determine the correlation between male moth catches in pheromone baited traps and oviposition, the number of egg masses were counted thrice in a week on different crops (Table 1) from 30 randomly selected sites of 1 m each selected in a diagonal transect across the field. Mean weekly moth catches and numbers of egg masses laid in individual crops were correlated.

Results and Discussion

Monitoring

Figure 1 shows the mean population catches of male *S. litura* in pheromone baited traps during 1988 and 1989. A total of seven population peaks were recorded in a year. Only a few moths were caught during winter (December-February). Moth catches during the rainy season (June-August) were relatively low compared to that in summer (March-May) and postrainy (September-November) seasons.

The first peak of male *S. litura* which occurred in 13th standard week (26 Mar-1 Apr) was of high magnitude, followed by four smaller peaks in weeks

Table 1. Schedule of weekly crop surveys for *Spodoptera litura* F. egg masses (1988 and 1989)

Month	Standard week number	Crop(s) surveyed
March	10-13	Sugarbeet
April	14-18	Sugarbeet, Groundnut
May & June	19-26	Groundnut
July	27-31	Groundnut, Soybean
August & September	32-39	Groundnut, Soybean, Urdbean
October	40-44	Groundnut, Soybean, Cauliflower
November	45-48	Cauliflower

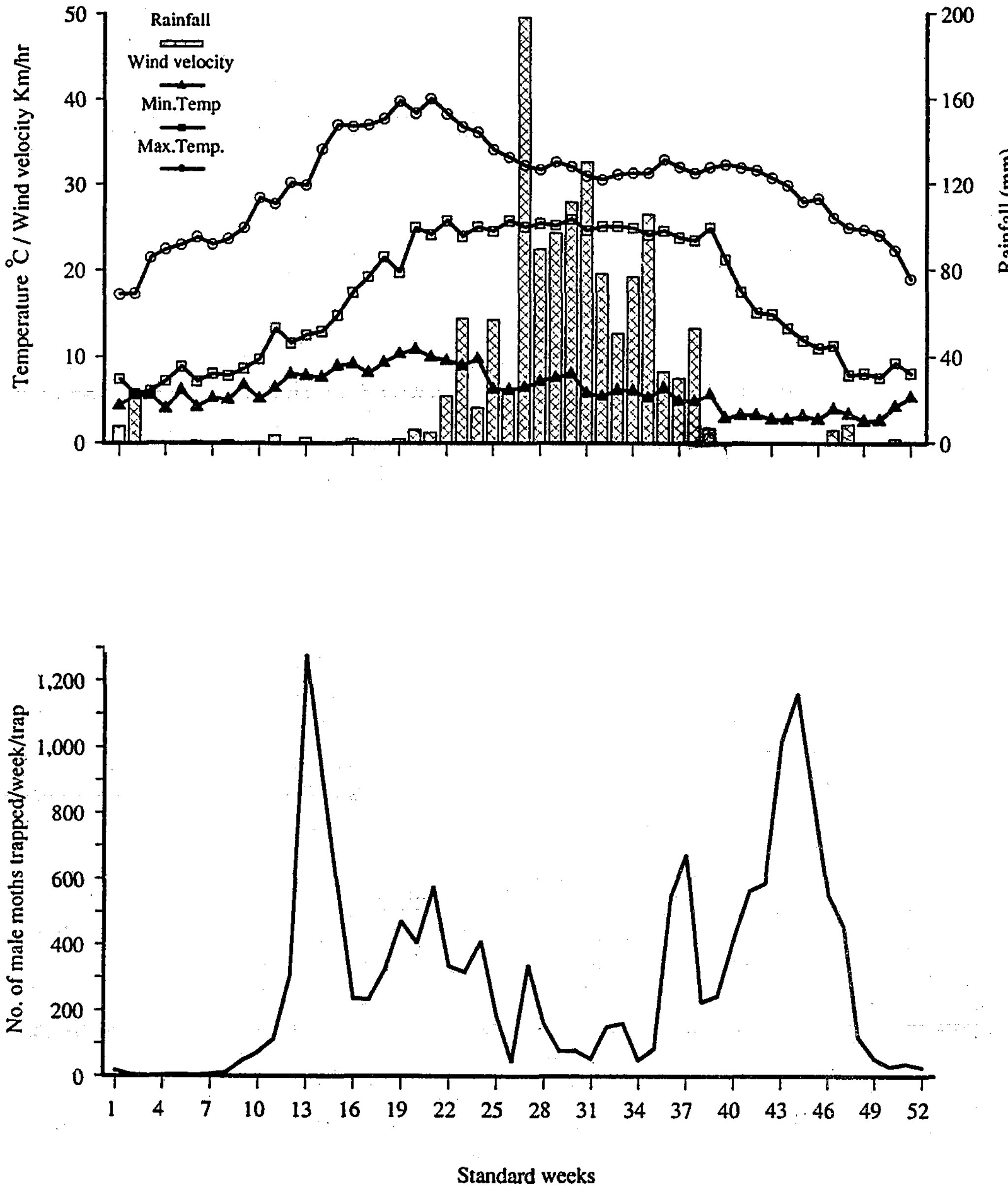

Fig. 1. Influence of abiotic factors on *S. litura* catches in sex pheromone trap for the year 1988 and 1989.

Table 2. Correlation coefficients (r) between weekly pheromone trap catches of *Spodoptera litura F.* and weather factors in different seasons (1988 and 1989)

Weather factors	Seasons			
	Summer (Mar-May)	Rainy (Jun-Aug)	Post-rainy (Sep-Nov)	Winter (Dec-Feb)
Maximum temperature	0.01	0.67*	0.12	0.32
Minimum temperature	-0.12	-0.28	-0.22	0.57*
Wind velocity	0.15	0.62*	-0.42	-0.32
Rainfall	-0.08	-0.05	-0.37	-0.22

* Significant at P = 0.05.

21 (21-27 May), 24 (11-17 June), 27 (2-8 July) and 33 (13-19 Aug). The sixth and seventh peaks occurred in 37 (10-16 Sept) and 44 weeks (29 Oct-4 Nov) were of high magnitude. From December, moth catches begun to decline and only a few moths were trapped during the winter.

Influence of Weather Variables on Trap Catch

The mean weekly moth catch of *S. litura* and the corresponding maximum temperature, minimum temperature, wind velocity and rainfall for the years 1988 and 1989 are given in Fig. 1. It is evident that during winter, when temperature dropped to <10°C, moth catches in traps declined sharply and only few moths were caught. There was a significant positive correlation between trap catches and the minimum temperature (0.57). An increase in moth catches was observed in March with an increase in temperatures, and for peak moth catch observed in week 13, the corresponding maximum and minimum temperatures were 29.9°C and 12.5°C, respectively. In the rainy season, significant positive correlation existed between trap catches and maximum temperature, and wind velocity (Table 2). In general, when heavy rainfall occurred moth catches decreased; however, slight to moderate rainfall during spring/summer seasons in the previous week (week 12) probably enhanced insect emergence as evidenced by peak of moths in standard week 13.

Oviposition/Trap Catch Correlations

From Fig. 1 it is evident that there were 7 adult peaks during the year. Crops were surveyed and number of egg masses found in different crops in 1988 and 1989 were correlated with mean weekly moth catches (Table 3). During spring/summer, peak moth activity between weeks 12-15 coincided with egg laying on sugarbeet. The correlation coefficients were significant in both years (0.90, 1988; 0.83, 1989). Smaller peaks in weeks 21, 24, 27 and 33 in both years were not followed by egg laying. However, peak moth activity in September (weeks 36-39) coincided with egg laying in groundnut and soybean. The correlation coefficients were significant during 1988 in groundnut (0.87) and soybean (0.87), but no significant correlation existed during 1989. The next peak was between weeks 40-43, but no egg laying was found either in groundnuts or soybean. However egg masses were recorded on cauliflower grown in nearby fields. Correlation coefficients were significant in both years (0.96, 1988; 0.75, 1989). However, there was no oviposition in *Kharif* urdbean and summer groundnuts in both years.

Monitoring of *S. litura* male moths with sex pheromone baited traps at Pantnagar, Uttar Pradesh, India indicated seven population peaks in a year. However, at the ICRISAT farm, Patancheru, Spodoptera appears to be present continuously throughout the year and 10 peaks were reported (Ranga Rao *et al.*, 1991a). Trials conducted through the All India Coordinated Research Project on Oilseeds (AICORPO) had shown the major moth activity in August at Dharwad, late September at Jalgaon, July at Junagadh, and 3rd week of June through November at Ludhiana (Annual *Kharif* Oilseeds Workshop, 1987). Miyahara *et al.* (1977) observed 5 generations of this species in a year in Japan. The first peak was observed in late March or early April and adults were active until mid-December. Five peaks of this insect in a year have also been reported by Shin *et al.* (1987) in South Korea. The peaks were reported in early May, mid June, late July, late August, and mid-late September.

Table 3. **Weekly pheromone trap catches of *Spodoptera litura* F. and egg mass counts in two successive years, 1988 and 1989**

	1988			1989		
Standard weeks	Moths caught per trap		Egg masses per 30 m²	Moths caught per trap		Egg masses per 30 m²
Sugarbeet (Spring/summer season)						
10	126		0	18		0
11	193		0	33		0
12	419		1	193		0
13	1371		7	1185		3
14	642		6	1182		10
15	273		1	858		8
16	77		0	392		1
17	284		0	181		0
18	328		0	319		0
Mean	412.6		1.7	484.6		2.4
S.D.	396.4		2.8	467.9		3.9
"r"		0.90**			0.83**	
Groundnuts (Rainy season)						
34	56		0	29		0
35	69		0	97		0
36	513		12	622		6
37	852		17	487		12
38	391		2	97		2
39	172		0	283		1
40	413		0	488		0
Mean	352.		4.4	300.4		3.0
S.D.	283.2		7.1	234.6		4.5
"r"		0.87*			0.59	
Soybean (Rainy season)						
34	59		0	52		0
35	66		0	100		2
36	501		5	548		4
37	881		6	467		2
38	314		2	98		1
39	271		2	242		0
40	376		0	377		0
Mean	352.6		2.1	269.1		1.3
S.D.	282.3		2.5	197.6		1.5
"r"		0.87**			0.56	
Cauliflower (Post-rainy season)						
40	395		0	433		0
41	360		0	764		0
42	563		2	608		1
43	1129		6	905		5
44	1550		12	772		4
45	1118		7	593		2
46	683		3	419		0
47	485		0	424		0
48	50		0	185		0
Mean	703.7		3.3	567.0		1.3
S.D.	471.3		4.2	224.6		1.9
"r"		0.96**			0.75*	

"r" correlation coefficient. *, ** significant at $P = 0.05$, and $P = 0.01$, respectively.

The distribution and abundance of *S. litura* is influenced by both abiotic and biotic factors. Temperature is probably the one which can most influence the population dynamics of *S. litura*. Temperature is known to influence the rate of development of the eggs, larvae, and pupae of *S. litura* with the optimum temperatures for survival between 25-28°C (Ranga Rao *et al.*, 1989). The temperatures at Pantnagar during winter dropped to <10°C and this may have reduced the rate of larval development, decreased the larval survival, and delayed pupal development. Thus only a few moths were caught during winter (December-February). When weather conditions became conducive in late March, moths emerged soon after.

High temperatures may also affect growth, development, and survival of *S. litura* (Ranga Rao *et al.*, 1989). High temperatures experienced in Pantnagar (above 37°C) during summer may cause a decline in moth numbers due to decrease in survival.

The feeding preference of *S. litura* has been studied by Prasad and Bhattacharya (1975). One or the other preferred host plant(s) for oviposition and larval feeding is available throughout the year at CRC farm, viz., sugarbeet, groundnuts, mungbean, urdbean, maize, castor, soybean, sunflower, and some wild host plants after the onset of the monsoons, and winter cauliflower and cabbage grown in nearby fields. In the present study, the major moth peak during spring/summer in sugarbeet and during postrainy in groundnuts, soybean and cauliflower coincided with the egg laying. Females emerged 2-3 days earlier than the males when reared under laboratory conditions (Singh, 1990). Male moths were probably first attracted towards the virgin females rather than to the synthetic pheromone source. Probably because of this fact, maximum trap catches coincided with the oviposition peak. Similar observations were reported by Oyama and Wakamura (1976) for *S. litura* and by Kehat *et al.* (1985) for *S. littoralis* where they found that males were attracted to, and mated with, virgin females before orientation towards pheromone baited traps. Peak trap catches occur very near to, or after harvest of *Kharif* groundnuts and soybean, which suggests the possibility of dispersal of emerging moths, leading to oviposition on the preferred hosts such as cauliflower. This hypothesis is supported by Ranga Rao *et al.* (1991b) who found changes in flight pattern of *S. litura* during the cropping periods of groundnut and maximum moths were caught at 4 m height after the groundnut harvest showing emigration of emergent moths.

The present findings have shown the importance of sex pheromone traps to monitor the population changes of *S. litura*, and have indicated significant relationship between moth catches in traps and oviposition in the fields. However, oviposition/trap catch correlations were not consistent between fields, seasons and years. Information on these factors, therefore, could be used as indicators to pin-point when to make crop inspections for possible larval infestation to ensure the rational application of insecticides.

Acknowledgements

Submitted as Journal Article no. 1349 by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT).

References

Directorate of Oilseeds Research. 1987. 30th *Annual Kharif Oilseeds Workshop of Groundnut, Sesame, Niger and Sunflower, 22-27 April, 1987, Akola.* Directorate of Oilseeds Research, Hederabad, A.P. pp. 367-421.

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

Feakin S.D. (ed.), 1973. Pest Control in Groundnuts. *PANS Manual No. 2.* Centre for Overseas Pest Research, London, U.K. 197 pp.

Kehat, M., Gothilf, S., Dunkelblum, F., Shavit, N.B. and Gordon, D. 1985. Night observations on the cotton leafworm, Spodoptera littoralis: Reliability of pheromone traps for population assessment and efficacy of widely separated pheromone dispensers for mating disruption. *Phytoparasitica* 13: 215-220.

Mehrotra, K.N. 1989. Pesticide resistance in insect-pests Indian scenario. *Pesticides Research Journal* 1:95-103.

Miyahara, Y. Shimazu, M. and Wada, T. 1977. Seasonal occurrence of *Spodoptera litura* (F.) as measured by a virgin female trap. Japanese Journal of Applied Entomology and Zoology 21: 59-65.

Moussa, M.A. and Kotbey, F.A. 1960. Abundance of cotton leaf-worm *Prodenia litura* (F.) (Lepidoptera: Agrotidae) in relation to host plants. 1. Host plants and their effect on biology. Bulletin of Society of Entomologie of Egypte 44: 241-251.

Oyama, M. and Wakamura, S. 1976. Influence of the wild population density and environmental conditions on recapture of the released males *Spodoptera litura* F. (Lepidoptera: Noctuidae) using sex pheromone traps. Japanese Journal of applied Entomology Zoology 20: 151-156.

Prasad, J. and Bhattacharya, A.K. 1975. Growth and development of *Spodoptera littoralis* (Boisd.) on several plants. Zeitschrift fur Angewandte Entomologie 79: 34-48.

Ranga Rao, G.V., Wightman, J.A. and Ranga Rao, D.V. 1989. Threshold temperatures and thermal requirements for the development of *Spodoptera litura* (Lepidoptera: Noctuidae). Environmental Entomology 18: 548-551.

Ranga Rao, G.V., Wightman, J.A. and Ranga Rao, D.V. 1991a. Monitoring *Spodoptera litura* (F) (Lepidoptera: Noctuidae) using sex attractant traps: effect of trap height and time of the night on moth catch. Insect Science and its Application 12: 443-447.

Ranga Rao, G.V., Wightman, J.A. and Ranga Rao, D.V. 1991b. The development of a standard pheromone trapping procedure for *Spodoptera litura* (F) (Lepidoptera: Noctuidae) population in groundnut (*Arachis hypogaea* L) crops. *Tropical Pest Management* 37: 37-40.

Shin, H.Y., Kim, C.H., Park, C.G. and Lee, Y.S. 1987. Biology of tobacco cutworm, *Spodoptera litura* F. (Lepidoptera: Noctuidae). I. Seasonal occurrence of tobacco cutworm in Southern Korea and larval development, pupal period, adult longevity and oviposition on the different food sources. *Research Report, Rural Development Administration, Korea Republic, Plant Environment, Mycology and Farm Products Utilization.* No.29: 301-307.

Singh, K.N., 1990. Population Monitoring and Resistance in Groundnut to *Spodoptera litura* (Fabricius) With Reference to Losses from Insect Pests. Ph. D. Thesis, G.B. Pant University of Agriculture and Technology, Pantnagar 263 145, India. 111 pp.

Tamaki, Y., Noguchi, H. and Yushima, T. 1973. Sex pheromone of *Spodoptera litura* (F.) (Lepidoptera: Noctuidae): Isolation, identification and synthesis. Applied Entomology Zoology 8: 200-203.

Received: 3.7.1992. Revised: 12.8.1993.