SOME FACTORS AFFECTING THE EFFICIENCY OF PHEROMONE TRAPS

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Abstract

To optomize catches of *Heliothis punctigera* and *H. armigera* pheromone blends, dispenser and trap design have been evaluated and modified over a 7 year period.

A laminated plastic lure loaded with appropriate pheromone blends was found to give a high and prolonged attraction of males of both species. A hollow cone (Texas) trap has given higher catches than the standard dry funnel trap, but the latter was more robust and less expensive.

A tendency has been shown for pheromone traps to over estimate the proportion of *H. armigera* in comparison to that found in light trap catches and egg identification of the two species. GLC. analysis of weathered lures indicated a more rapid release of aldehyde than acetate components of pheromone blends. Departure of blends from the optimum ratio is more likely to affect the efficiency of *H. punctigera* lures which contain both components, than those of *H. armigera* lures which contain only aldehydes.

Introduction

Among pests damaging field crops in Australia the two *Heliothis spp.* rank high in importance. *H. punctigera* occurs in all states and the Northern Territory, while *H. armigera* has been reported from everywhere except S. Australia and Tasmania. A particular problem is the propensity of *H. armigera* to develop resistance to insecticides, correct identification of the two species is therefore of importance for pest management but is difficult from morphological characters alone. A simple reliable system of separation provided by specific pheromones would therefore be useful.

An important consideration in control of *Heliothis spp* is the timing of sprays to the most susceptible stage of eggs or small larvae. Subsequently larvae may be concealed under leaves or bolls or be too large to kill with normal pesticide dosages. In intensive crops such as cotton, plants are visually checked for eggs and larvae to determine when sprays should be applied. In less intensive crops,specialist checking services may not be available and sprays may be applied routinely when experience has shown infestations are most likely to develop. Crop checking is expensive while routine spraying is wasteful if damaging infestations are not present. Some semi-automatic sampling method would be advantageous if it provided a reliable indication of pest abundance. Continuing experiments with pheromone and light traps have the ultimate objective of developing such semi automatic sampling methods initially to determine species composition and ultimately to forecast size of infestations. A variety of pheromone dispenser and trap designs have been available and this paper describes tests of their performance in relation to light trap catches.

Methods

Lure Evaluation

Four types of dispenser were compared. A surgical rubber septa tubing dispenser (Rothschild 1981) was used as standard. This was impregnated with the following mixtures:

H. punctigera: A50:50:1 mixture of (Z)-11 hexadecenal (Z-11:16 ALD): (Z)-11 hexadecenyl acetate (Z-11:16Ac) and (Z)-9-tetradecenal (Z-9:14ALD)

H. armigera: a90:10 mixture of (Z)-11 hexadecenal (Z-11:16ALD) and (Z)-9-hexadecenal (Z-9:16ALD).

1000 μg of the major component and corresponding amounts of the minor components were applied to the rubber dispensers. An equal amount of antioxidant was added. Other dispensers examined were of commercial origin. They included a rubber serum stopper; a hollow fibre dispenser consisting of 50 hollow fibres 2cm in length attached to a card and a 1cm square plastic sheet impregnated with pheromone sandwiched between two other plastic squares (plastic laminate) (Hendricks et al, 1977). The above commercial dispensers were treated with the pheromone components in the correct ratio but the volume of pheromone applied and additives varied according to undisclosed company practice.

Five replicate batches of each lure were weathered in a temperature controlled glasshouse (22-36^{o}C min-max) for periods of 4-0 weeks before simultaneous exposure for 7 or 10 days in dry funnel traps in the field. Traps were sited randomly 20 m apart in a 10x10 layout in a cotton crop for H. punctigera and a sorghum crop for H. armigera. The traps were re-randomised at 1 or 2 day intervals at which time trapped moths were counted.

Trap Evaluation

Five types of trap were evaluated over time:

A Sticky trap (Rothschild, 1978) was used initially but discarded, because it became clogged with a variety of insects and the catching surface was not large enough.

A Water trap comprises a 35x30x10cm plastic tray containing water and detergent, mounted on a wooden support and protected by a wooden cover from which the bait was suspended.

A Dry funnel trap (Kehat and Greenberg 1978), comprises a 17.5 cm diameter powder funnel pressed through a hole into a canister containing a piece of pest strip. The funnel is protected by a metal cover 15cm above from which the bait is suspended.

Pie trap A modification of the above is equipped with the same funnel which opens into a plastic bag. The funnel is protected by an inverted pie dish or plate 5 cm above the funnel.

Texas trap (Hardstack et al 1979). The model modified by Albany International is made of white plastic mesh instead of fly wire. It comprises a hollow cone with a 30 cm diameter aperture at the base opening into a collecting bag at the apex through a small cone.

The water and dry funnel traps were compared in 5 replicates alternated along the edge of a cotton field at 30 m intervals. The dry funnel, Texas and Pie trap were compared at four sites in a 50 hectare cotton field between 1 January and 4 April 1984. The traps were spaced 30 m apart at each site, and their order was varied. Trap catches were compared with those in a light trap equipped with a 125 w mercury vapour bulb located ca 300 m from the pheromone trap experiments.

TABLE 1. Moth catches from Pheromone lures weathered for 0-4 weeks.

Heliothis punctigera

Lure Type	Total Days Exposure 7	14	21	28	35	Mean
Laminate	31	46	40	28	48	38.6
Stopper	11	16	19	18	21	17.0
Septa	20	16	25	10	9	16.0
Fibre	27	13	5	17	3	13.0
Mean	22.2	22.7	22.3	18.3	20.3	21.2

L.S.D. (Mean) (p=0.05) 8.3

Heliothis armigera

Days Exp.	11	18	25	32	39	Mean
Laminate	55	21	66	38	41	44.2
Stopper	36	33	15	40	48	34.4
Septa	10	21	11	4	12	11.6
Fibre	11	7	3	1	3	5.0
Mean	28	20.5	23.7	20.7	26.0	23.8

L.S.D. (Mean) (p=0.05) 11.9

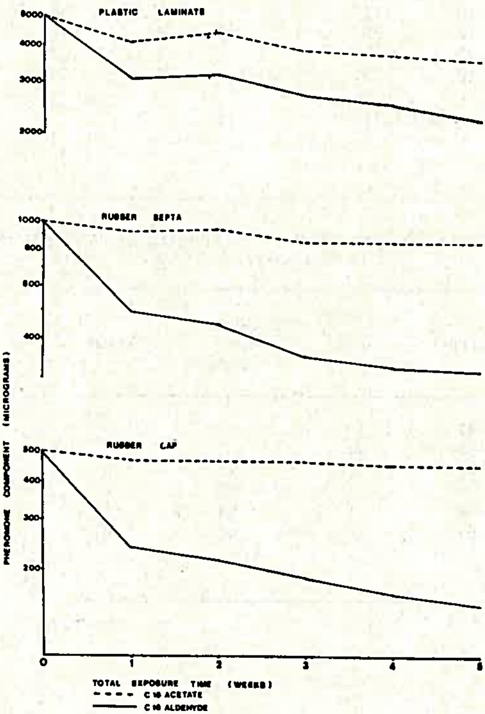
TABLE 2. Relative abundance of *H. punctigera* in total catch, in four types of trap.

Year	% *H. punctigera* Light	Water	Dry Funnel	Texas
78/79	93	91	-	-
79/80	93	86	-	-
80/81	98	86	92	-
81/82	99	-	73	-
82/83	78	-	62	72
83/84	83	-	68	87

TABLE 3. Mean daily catch in three pheromone trap types compared with light trap catch and egg counts

Trap Type	*H. punctigera*	*H. armigera*	% *H. punctigera*
Dry funnel	3.1 ± 2.1	1.5 ± 0.5	67
Pie	3.6 ± 0.2	2.4 ± 1.0	60
Texas	21.0 ± 3.5	3.3 ± 1.1	86
Light	11.5 -	0.8 -	93
Eggs/2m	1.8 -	0.4 -	82

Figure 1. Loss of Pheromone Components over time.



Results

Lure Evaluation

Moth catches from lures weathered for 0-4 weeks and then exposed in traps for 7 or 11 days are shown in Table 1. When loaded with H. punctigera pheromone the plastic laminate lure attracted significantly more moths than the other lures. There was no indicationn of a decline in catch over time with the laminate and stopper but there was some indication of decline with the septa and hollow fibre lures.

When loaded with H. armigera pheromone, the plastic laminate and rubber stopper lures caught significantly more than the septa and fibre lures. The latter two showed some decline in catch over time.

Some light on the above results was thrown by gas chromatograph analysis of the two major components of H. punctigera lures before and after glasshouse and field exposure. The results are illustrated in Figure 1. Initially the plastic laminate contained 5000 μg of each major component per lure, the fibres (not illustrated) 4000 μg the rubber septa 1000 and the stopper 500 μg. After 5 weeks the laminate, fibre, stopper and septa had lost respectively 54, 20, 70 and 68% of the aldehyde and 2.8, 0.7, 9.4 and 13.3% of the acetate. Clearly the aldehyde degraded, or was released, more rapidly than the acetate, altering the ratio of components from the optimum. Losses from the hollow fibre lure were lowest. A polymeric plug was found to have formed at the end of the fibre which probably prevented release of pheromone. The chemists in fact reported that they had to take extreme measures to release the pheromone for analysis. Estimated release per day of aldehyde and acetate was: Laminate 98 and 51 μg fibre 22 and 0.78: cap 12 and 1.7 and rubber septa 24 and 4.7. By far the biggest daily release therefore was by the plastic laminate, which also preserved the best ratio over time of aldehyde and acetate.

Trap Evaluation

In comparison to the light trap, the water and dry funnel traps tended to underestimate the proportion of H. punctigera in the total catch (Table II). The Texas trap tended to give ratios of the two species closer to those in the light trap and also those determined from egg identification during the 1984 season (Table III).

In Table III is also demonstrated the much higher catch per trap of H. punctigera produced by the Texas trap design compared to the "dry funnel" and "Pie" traps. Although the numbers of H. armigera caught were only slightly higher in the Texas trap, than the other types, this was consistent with the ratios of abundance, during the period of the experiment.

Discussion

Over the past eight years a progressive upgrading has taken place in the chemical blends used in the pheromone lures for the two species; in the dispensers and in trap design.

Pheromone blends are discussed by Rothschild (1978) and Rothschild et al (1981). Over short time periods the H. punctigera pheromone appears satisfactory, although as discussed later, the change in ratio of components over time requires further attention. It may be possible to control release more consistently by "propheromones" being developed at Rothamstead Experimental Station UK, which break down into pheromones under the influence of light (Anon 1982). With H. armigera traps a level of contamination by H. punctigera occurred particularly in the spring, which is however usually <5%. It is of interest that Australian H. armigera respond best to a different ratio to that used in Asia where a 97:3 ratio of Z11 to Z9 Hexadecenal is used compared with our otpimum ratio of 90:10. Thus in a comparative study, 178 H. armigera moths were caught with the Australian compared with 45 with the Asian blend.

The trials conducted during 1982/83 season clearly demonstrated the superiority of the laminated plastic lures which have now been adopted as standard. These lures are manufactured by the Hercon division of Health Chemical Corporation in the U.S.A. but may be obtained from SIRATAC Ltd., P.O. Box 117, Wee Waa, N.S.W., 2388.

As in previous seasons (Table II) the 1984 experiment showed a consistently higher proportion of H. armigera were caught by dry funnel traps in comparison to light traps (Table III). The ratios in light trap catches were also found to be consistent with egg ratios elsewhere, (G. Fitt, N. Forrester personal communication). It should be noted however that the inbalance was rarely great enough to affect the overall status of species dominance.

Some explanation for the inbalance was given by the chemical analysis which showed a differential rate of release of aldehydes and acetates in the H. punctigera lures. Thus the original optimum 50:50 ratio changed to a 39:61 ratio in the laminate lures over five weeks, and to 27:73 with the rubber septa. On the other hand the H. armigera lures contain two aldehydes only and these can be expected to have a similar rate of release over time, maintaining the optimum ratio for attractiveness to moths.

A further complication is the apparent reversal of the overestimation of H. armigera which appears to have occurred in the Texas traps, possibly indicating a greater attraction for H. punctigera with that design. It should be possible to fully explore the reasons for the above inconsistences with the rapid egg identification method that has been developed using gel electrophoresis (J. Daly pers. comm.).

Five trap designs have been utilised since monitoring of Heliothis spp by pheromones was commenced in 1977. Initially a sticky trap (Rothschild 1978) was used but discarded for reasons discussed earlier. The sticky trap was replaced for monitoring by the water trap which proved effective but required excessively frequent refilling in hot weather.

The dry funnel trap is the standard used in SIRATAC and a network is maintained from Emerald in central Q'ld. to Trangie in central N.S.W., results are compiled by computer for each district. The trap has proved to be robust in construction, and can be easily assembled from parts which are readily available.

Unlike the other traps, moths enter the Texas trap from below. This design was developed following night observations of moth response to pheromone source (Hardstack et al 1979). Although the Texas trap has been shown to give markedly higher catches of moths, some practical difficulties have prevented its introduction for commercial monitoring of Heliothis species. The commercial version costs over twice as much as the dry funnel trap and these costs are greatly magnified by transport and customs processing costs from the U.S.A. In addition moths are trapped live and daily clearance of the trap is necessary for accurate results. Finally the trap has not proved to be long lasting, tears in the plastic mesh appearing after only a few months in our windy hot conditions. It is hoped to modify both the Texas and dry funnel traps next season, before reaching a conclusion as to which should become the standard.

Light traps have a number of advantages and disadvantages in comparison to pheromone traps. They catch both male and female moths and are therefore one step nearer the important relationship to oviposition. In addition females may be dissected and the stage of ovarian development determined, some indication of the egg laying potential of a given population may then be obtained.

Disadvantages primarly concern the non specific nature of light traps which can, on favourable nights, catch huge numbers of insects which have then to be sifted through to obtain the economic pests. Such procedures can be very time consuming. In addition, the need for a source of electricity, limits their distribution. In practice farmers are unlikely to maintain light traps successfully but are quite capable of monitoring counts of male Heliothis spp caught in the separate pheromone traps.

In addition to intrinsic causes of variation in moth catch associated with trap and lure design, there are a number of extrinsic factors affecting catch. Temperature, windspeed and direction affect both light and pheromone trap performance (Morton et al, 1981), Rothschild et al, 1982) while light trap catches alone are affected by moonlight. Pheromone trap, but not light trap catches are affected by competition between lures and feral females, particularly when the latter are abundant. The combined affect of these factors on trap catch and their relationship to oviposition has not so far been fully researched.

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References

Anon, (1982). Propheromones: Release of pheromonal carbonyl compounds in light. Rothamstead Report for 1982; pt 1; 129-130.

Hardstack, A.W., Witz, J.A. and Buck, D.R. (1979). Moth traps for tobacco budworm. J. Econ. Entomol. 72, 519-522.

Hendricks, D.E., Hardstack, A.W. and Shaver, T.N. (1977). Effect of formulations and dispensers on attractiveness of virelure to the tobacco budworm. J. Chem. Ecol. 3, 497-506.

Kehat, M., Gothilf, S., Dunkelblum, E. and Greenberg, S. (1982). Sex pheromone traps as a means of improving control of the cotton bollworm, Heliothis armigera (Lepidoptera:Noctuidae). Environ. Entomol. 11, 727-729.

Morton, R., Tuart, L.D., and Wardhaugh, K.G. (1981). The analysis and standardization of light trap catches of Heliothis armigera (Hubner) and H. punctigera (Wallengrem). Bull. Ent. Res, 71, 207-225.

Rothschild, G.H.L. (1978). Attractants for Heliothis armigera and H. punctigera. J. Aust. Ent. Soc. 17, 389-390.

Rothschild, G.H.L., Wilson, A.G.L. and Malafant, K.L. (1982). Preliminary studies of the female sex pheromones of Heliothis species and their possible use in control programs in Australia. In 'Proc. Int. Workshop on Heliothis Management', I.C.R.I.S.A.T. Patancheru, A.P. India. 319-327.