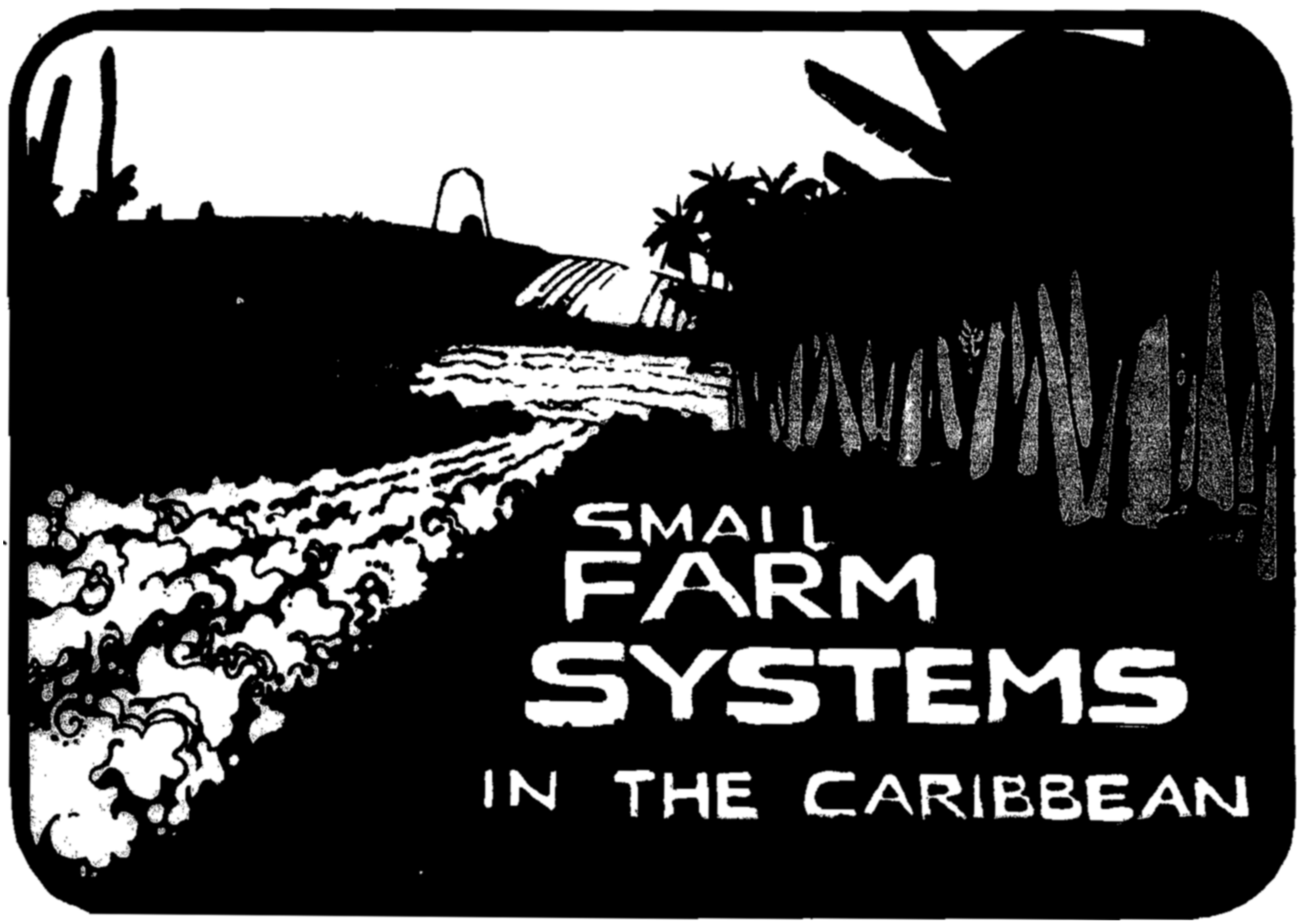
CARIBBEAN FOOD CROPS SOCIETY

Sociedad Caribeña de Cultivos Alimenticios
Association Caraîbe des Plantes Alimentaires

Vol. XX

PROCEEDINGS

OF THE 20th ANNUAL MEETING – ST. CROIX, U.S. VIRGIN ISLANDS – OCTOBER 21-26, 1984



Published by
THE EASTERN CARIBBEAN CENTER, COLLEGE OF THE VIRGIN ISLANDS *and* THE CARIBBEAN FOOD CROPS SOCIETY

Experience with Behavior-Modifying Chemicals for Insect Control

J. W. Jenkins **C.C. Doane**
Pesr Select International Inc.
3131 North 35th Avenue
Phoenix, AZ 85017

Insect behavior-modifying chemicals are being used in pest management programs in two basic ways. Indirect control of pests involves the use of baired traps for detection and monitoring of populations. Pests are controlled direcrly through mating disruption and by drawing adults to attractive sites where they are removed from the population, either with traps or insecticides. Recent advances in combinations of behavior-modifying chemical technology and insecticides have resulted in improved pest control. Examples of techniques for employing pheromone systems and experience with various pests are discussed.
Keywords: Pheromone, maring disruption, traps, attracticide.

Insects employ chemical messages to direct a wide range of behavior. Recent advances in the utilizarion of synthetic chemicals that affect insect behavior have spawned innovative methods for use in integrated pest management programs. Sex pheromones, intraspecific chemical messages, have been investigated more than any other group of behavior-modifying chemicals. These materials mediate sexual behavior and have been used in two basic ways in the management of pests: indirect control through monitoring or surveying pest popularions and direct conrrol via mass trapping, mating disruption and attracticide techniques. When employed for survey and detection, the pheromone is formulated in a lure and placed in traps. These are used to monitor the presence of the pest or fluctuations in its population level so that control measures may be applied. This technique is the most widely used application of sex pheromones and has been a common practice for many pests for more than 15 years.

Although traps and lures are commercially available for many pests, considerable effort must go into their development. Each insect pest may require a distinct trap or lure system, dependent upon its biology, ethology and the chemical nature of its specific pheromone. For instance, a trap sysrem developed for the pink bollworm, *Pectinophora gossypiella* Saunders, utilizes a delra trap design. For maximum efficiency the trap musr be placed at the cotton canopy, the level ar which mating activity occurs. Once inside the trap, the male moth is captured on the sticky lower surface.

For many insects exact release rates of pheromone from the lure must be maintained to achieve trap capture. Lures that are too weak may not atrracr the target pest ro the trap while lures that are too strong may halt searching behavior at some distance from the trap.

Ideally, fluctuation in trap captures should be positively correlated with pest activity and crop damage. Captures of pink bollworm males in delta traps have been positively correlated with mating activity and subsequent larval infestations (Brooks et al., 1980). This correlation allows rhe early prediction of population trends and improved timing for control measures. For many pests, monitoring populations wirh traps and lures is more efficient than visually searching for signs of damage (Saario er al., 1970; Kaae and Shorey, 1973).

A trap system developed for rhe boll weevil, *Anthonomus grandis* Boheman, rakes advantage of the adults' attracrion to specific wavelengths of light and their habit of climbing up upon encountering the trap. Various cotton growing areas within the United States have esrablished trap indexes for determining the need for early season conrrol of the boll weevil.

Researchers are also developing a trap index for *Heliothis* spp. The unique narure of these moths requires a different trap design. After approaching rhe lure, the male moth flies up in an escape response. Because of the moth's size, a sticky trap would be less efficient; therefore, a live rrap wirh sufficient capture space is needed. Also, the chemical nature of the Heliothis sex pheromone requires protection from ultraviolet light for maximum stability.

Traps and lures may also be used for direcr control through rhe mass trapping technique. In this method those individuals responding ro the trap are removed from the population. The success of the rechnique depends upon various factors including sex and mating status of the captured insects. For maximum efficiency rhe system should remove a large proportion of reproductively active adults before mating takes place in the field. If traps remove only males from the population, a much larger proportion of the popularion must be captured, especially if multiple mating is common. Although mass trapping programs have been tried for a number of pests, they have certain limitations: the technique is less effective on moderate to heavy populations, is labor intensive and requires isolation from mated immigrants.

A modification of the mass trapping technique is the use of pheromone traps to enhance the attractiveness of trap crops. A trap crop is a small portion of the principle crop that has been manipulated ro provide protection for the remainder of the planting. Early investigation of this method demonsrrated the porential for use in control of rhe boll weevil (Boyd, 1973; Gilliland er al., 1976). During 1983 this technique was evaluared using the boll weevil pheromone, grandlure, and cotton planr volatiles in microtube formulation. The material was applied along field borders to inrercept and hold weevils as they moved into the field from overwintering sites. These zones were then repeatedly sprayed with a combination of weevil feeding stimulant and insecticide. This treatment reduced or eliminated the need to apply weevil insecticides on 95% of the field. Neighboring check fields treated conventionally required 10 to 13 applications for weevil control compared to 0 to 4 full-field applications for the cotton protected by the trap crop zones (Table 1).

One of the most intriguing methods currently used in pest management is the mating disruption technique. In this method, slow release formulations are used to permeate the atmosphere with the sex pheromone. The treatment disrupts the normal mating behavior in several possible ways. Pheromone released from the microtubes may mask the natural pheromone trails of the female moths so that their trails are not detectable. The microtubes may also outcompete with the females because there are many more distinct sites of the synthetic pheromone and each microtube is continuously releasing pheromone at a much higher rate than the females. Thus, males flying through the field in search of mating partners are attracted by the stronger false trails of the microtubes rather than the true females.

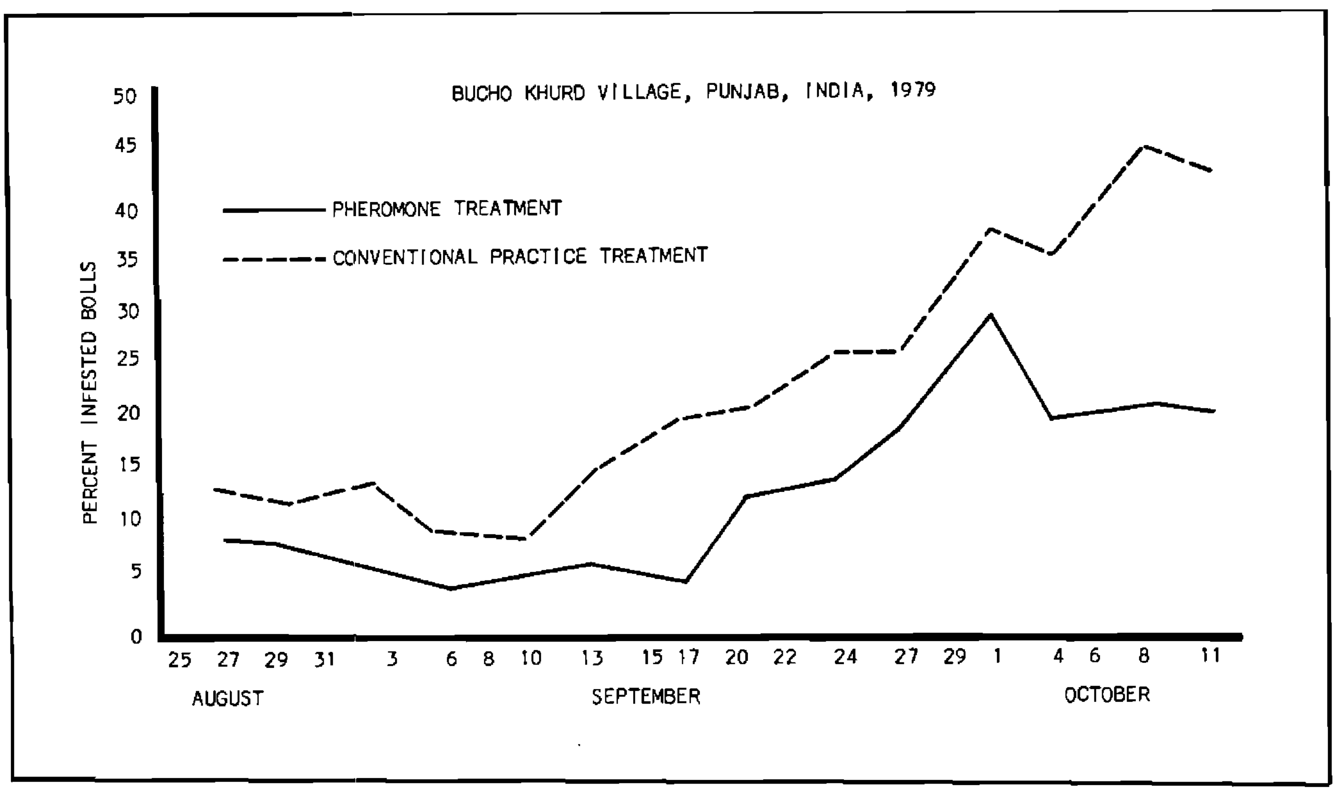
Mating disruption has been most intensively investigated for control of the pin bollworm on cotton in various countries. In 1979 a large-scale test was conducted by the government of India (Pawar et al., 1981). Approximately 80 growers with an average field size of 4 ha each participated in the trial. Populations of the pink bollworm were very heavy in this region partly due to the practice of storing cotton plants for fuel. Pink bollworms emerging from old bolls in these storage piles move back into the new crop after boll formation begins. In spite of heavy population pressure, boll infestation was significantly reduced in the treated block of fields—only 59% of the infestation found in the conventional practice block (Fig. 1). Seed cotton yields were increased by as much as 33.7% in the mating disruption cotton compared to the conventionally treated cotton.

TABLE 1. Comparison of pheromone trap crop technique and conventional insecticide program.

Treatment	Seasonal Average % damaged squares	Average number of weevil insecticide applications required
Pheromone trap crop	5.9	1
Conventional practice	11.5	10.75

1/Azinphos-methyl or methyl parathion at .28/ha

FIG. 1 Boll infestation from pink bollworm in pheromone treated fields and in the conventional practice fields near Bucho Khurd, India.



Observations of the mating disruption process led to further development in 1978. Researchers found that when male moths search for pheromone emitting sources they actually land on the microtubes containing synthetic pheromone and attempt to mate. It was suggested that if insecticides were mixed with the sticker used to adhere the microtubes to the plant foliage, males would receive a lethal dose upon contact. (Staten and Haworth, 1981). This process, termed Attract and Kill technique, would quickly remove males from the population. Male removal through the attracticide technique is more efficient than a mass trapping program because many more of the discrete toxic sites can be distributed in the field compared to the more expensive trap. Labor requirements would be reduced as well.

In comparison to the traditional strategy of crop chemotherapy where the pest's entire environment becomes lethal through broad application of an insecticide, the attracticide strategy lures the pest to distinct sites of the toxicant and permits large reductions in the amount of insecticide needed. A synergistic effect is seen by combination of the pheromone and insecticide and normal rates of both materials can be reduced. Pyrethroid insecticides used in the attracticide system are applied at only 2-5% of the rate used in conventional applications. The rate of pheromone in the attracticide system may be reduced to one half that used in the mating disruption technique. Tests of the attracticide system demonstrated its effectiveness (Butler and Henneberry, 1982; Butler et al., 1983). Other investigation showed little or no adverse effect on major predaceous taxa (Butler and Las, 1983). Beneficial insects are not drawn to the toxic sites.

Because the attracticide strategy is more robust than the mating disruption technique, it can be applied against more intense pest pressure. However, it is not uncommon for pink bollworm infestations to increase to levels that are not effectively controlled by either the attracticide system or conventional insecticide treatments alone. For higher pest pressures typically encountered later in the season, the simultaneous application of the attracticide system with regular insecticide application has given effective control when either treatment alone would have failed.

The combined use of sex pheromone applications with conventional insecticide applications has been studied for a number of insects. In this technique pheromones are applied alone or as the attracticide system: with a small amount of insecticide in the sticker. Simultaneously, a conventional insecticide application is applied at the normal rate. This process has been termed Attract and Kill™ Dual Application or the bio-irritant technique. It is suspected that the pheromone released by females may increase their activity in addition to initiating searching behavior by males (Palaniswamy and Seabrook, 1978; Saad and Scott, 1981). The increased movement of both sexes may enhance exposure of both sexes to the insecticide resulting in higher mortality of the adults.

Early tests of the bio-irritant technique in field cages were conducted in Arizona in 1983. Fenvalerate at the standard rate of 84 gms ai/ha, was applied alone and in combination with the sex pheromone for *Heliothis virescens* Fabricius in microtube formulation. Male and female moths were released into cages and counted at 13 and 37 hours later. Data showed differences in adult survival between pheromone plus insecticide and insecticide alone (Table 2). After 37 hours only 4% of the moths in the pheromone plus insecticide treatment were alive compared to 24% alive in the insecticide only treatment.

Data collected in 1984 from commercial fields demonstrated that pyrethroid sprays alone were unable to suppress pink bollworm moth flights for more than two days (Fig. 2). During

TABLE 2. Comparison of survival rate of *Heliothis virescens* moths released in field cages with cotton foliage treated with pheromone plus fenvalerate versus fenvalerate only.

	Pheromone + Fenvalerate	Fenvalerate
% live after 13 hours	22.0	54.0
% live after 37 hours	4.0	24.0

50 moths released per cage; 2 cages per treatment

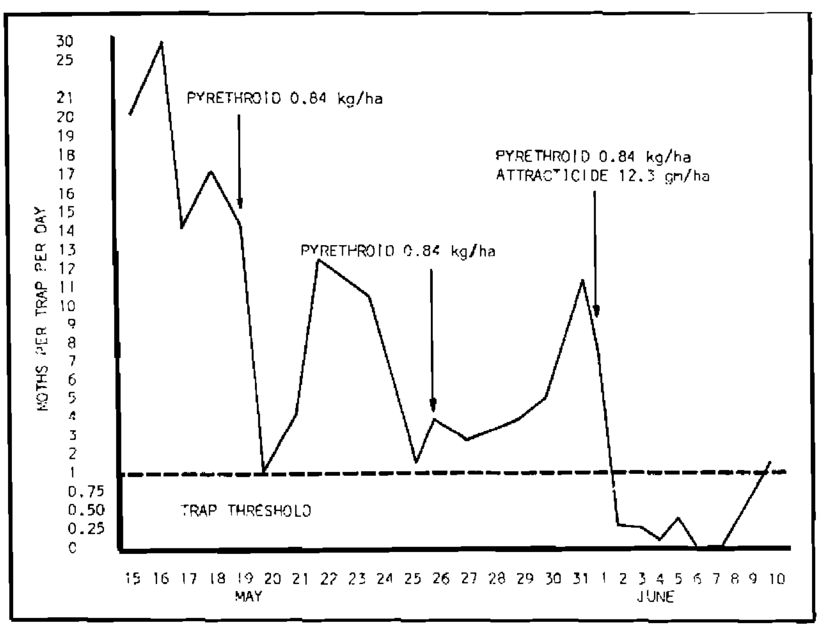


FIG. 2. Mean number of pink bollworm males captured in pheromone traps. Arizona, 1984.

the last five days of the application interval populations continued to multiply. Lack of effective control during this period was later confirmed by high infested bloom counts. A single application of the attracticide system plus an insecticide spray immediately suppressed the morh flight below the trap threshold, providing effective control for nine days.

The simultaneous application of the two systems, attracticide and conventional insecticides, can provide more effective control at a vulnerable point in the insect's life cycle. For example, killing a single adult Heliothis female can protect the crop from 2,000 eggs. Furrhermore, problems with the pest's resistance to pyrethroid insecticides may be reduced because the combined systems attack both larval and adult stages.

Behavior-modifying chemicals are being investigated for use in controlling the western corn rootworm, *Diabrotica virgifera* Leconte. The system uses the insect's sex pheromone in microtube formulation to draw adults into zones treated with arrestants and compulsive feeding stimulants. Small quantities of insecticide are mixed with the phagostimulants to kill the attracted adults. Control equal to that of conventional insecticide programs has been achieved using just 2% of the normal rate of the insecticide. The technique is applicable to orher pests and creates opportunities for more expensive insecticides which are currently not cost effective but may be more suitable for other reasons.

Concern for the quality of our environment has increased the need to develop biorational approaches to pest control. Various techniques employing behavior-modifying chemicals have been integrated into management programs resulting in improved control, both from an economic and environmental viewpoint. The development of these techniques has taken years of careful research with some disappointment that these innovative approaches to pest control have not become commercially available more rapidly. But before these tools can be applied, much knowledge must be obtained on the biology, behavior, chemistry and physiology of the components. Significant improvements of early techniques have improved their performance. The future development and improvement of techniques employing behavior-modifying chemicals will require participation of the agricultural chemical industry, governments and farmers.

References

1. Boyd, F.J. Jr., J.R. Brazzel, W.F. Helms, R.J. Moritz, and R.R. Edwards. 1983. Spring destruction of overwintered boll weevils in west Texas with wing traps. J. Econ. Entomol. 66:507-10.

2. Boyd, F.J. 1973. Progress report on the pilot boll weevil eradicatiun experiment. Proceediogs, 1973 Beltwide Cotton Production Mech. Conf. pp. 20-22.

3. Brooks, T.W., C.C. Doaoe, and J.K. Haworth. 1980. Suppression of *Pectinophora gossypiella* with sex pheromone. Proceedings, 1979 British Crop Protection Conference—Pests and Diseases, The Boots Co., Ltd., Nottingham.

4. Butler, G.D. Jr., and A.S. Las. 1983. Effect of gossyplurepermethrin mixture upon the abundance of predaceous insects in flowering cotton. J. Econ. Entomol. 76:1448-1451.

5. Butler, G.D. Jr., T.J. Henneberry, and R.J. Barker. 1983. Pink bollworm: comparison of commercial control with gossyplure or insecticides. USDA-ARS Agr. Rev. and Man. No. 35. 13pp.

6. Butler, G.D. Jr., and T.J. Henneberry. 1982. Gossyplure for the control of the pink bollworm. Ariz. Agr. Expt. Sta. P-56:125-127.

7. Gilliland, F.R., W.R. Lambert, and R.C. Davis. 1976. Evaluatiun of a trap crop system for boll weevil suppression. ARS-S US Agr. Res. Serv. South Reg. 71:90-94.

8. Kaae, R.S., and H.H. Shorey. 1973. Sex pheromunes of Lepidoptera. 44. Influence of environmental conditions on the location of pheromone communication and mating in *Pectinophora gossypiella.*

9. Pawar, A.D., J. Prasad, R.K. Sharma, K.P. Yadav, C.H. Pickett, C.C. Doane, T.W. Brooks, M.J. Bajikar, and E. Baskaram. 1981. An operational field trial project in India for suppression of the cotton pink bollworm, *Pectinophora gossypiella*, employing gossyplure hollow fiber controlled release sex pheromone formulation. Tech. Rep. 144pp

10. Saad, A., and D.R. Scott. 1981. Repellancy of pheromones released by males of *Heliothis armigera* and *H. zea* to females of each species. Entomol. Exp. Appl. 30:123-127.

11. Saario, C.A., H.H. Shorey, and L.K. Gaston. 1970. Sex pheromones of noctuid moths. XIX. Effect of environmental and seasonal factors on captures of males of *Trichoplusia ni* in pheromone-baited traps. Ann. Entomol. Soc. Am. 63:667-672.

12. Staten, R.T., and J.K. Haworth. 1981. Device for insect control. Patent application. Ser. No. 252,992.