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A Pest Management System For Cotton Insect Pest Suppression

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RECOGNITION OF THE PROBLEMS associated with excessive insecticide use for cotton insect control, such as insecticide resistance, high production costs, and environmental contamination, has prompted research for more ecologically sound techniques for controlling insect pests, particularly the boll weevil, *Anthonomus grandis* Boheman and the bollworm complex, *Heliothis* spp. Brazzel *(2)* originated the concept of diapause control, in which insecticides are applied in the autumn to reduce overwintering boll weevil populations. The identification and synthesis of a male-produced aggregating pheromone suggested by Tumlinson and others *(21)* and the development of traps baited with male weevils or the synthetic pheromone by Cross *(5)*, Hardee *(7,8,9)*, Leggett and others *(16)* made it possible to trap many of the spring-emerging overwintered boll weevils before they could infest cotton fields. Hopkins and Taft *(10)* and later Cowan *(4)*, Coppedge *(3)*, Ridgeway and others *(19)* reported that the systemic insecticide aldicarb (Temik) was very effective against populations of overwintered boll weevil.

The use of early-planted cotton as a trap crop to protect the regular planted cotton crop was suggested by Hunter *(11)*, Coad *(12)*, Fenton and Dunnam *(6)*, Isley *(13,14)* and others. More recently, result of experiments conducted in Louisiana by Bradley *(1)* have revealed that a trap crop of early-planted cotton located adjacent to overwintering habitat and treated periodically with foliar sprays of methyl parathion protected the remainder of the field from boll weevil invasion until mid-season. Taft et al. *(20)* reported promising results from experiments in which pheromone-baited traps, in-furrow and sidedress applications of aldicarb, and sprays of toxaphene plus DDT plus methyl parathion were combined in an integrated program for boll weevil suppression. Lloyd and others *(17)* designed an integrated system for boll weevil control in which sterilized male boll weevils were confined on plants adjacent to rows of aldicarb-treated cotton. They suggested that the aggregating pheromone produced by confined males would attract emerging overwintered weevils to the aldicarb-treated cotton where they would be killed. Their data indicated the potential effectiveness of the combination against low-density populations of overwintered weevils. However, bollworm populations were significantly greater in the aldicarb-treated rows than in untreated portions of the field. Cowan *(4)*, Ridgeway and others *(19)* have observed similar increases of bollworm populations on aldicarb-treated cotton. The increase is attributable, at least in part, to increased oviposition by bollworm moths on the aldicarb-treated plants (R. L. Ridgeway, pers. comm.) Thus, while progress has been made to develop integrated systems for boll weevil suppression, the practices employed, such as aldicarb treatments, often encourage or intensify problems with potentially important pests such as bollworms.

An integrated system designed to take advantage of the several boll weevil suppression techniques available and to minimize the possibility of *Heliothis* spp. population increases was tested in 1972. The experiments were conducted as part of a research program being conducted in conjunction with the Pilot Boll Weevil Eradication Experiment underway in parts of Mississippi, Alabama, and Louisiana (Knipling, 15). The insect suppression techniques employed in the integrated pest management system included: (1) Reproduction diapause control; (2)

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early-planted, aldicarb-treated cotton as a trap crop; (3) aggregation pheromone bait stations in the trap plots; (4) pheromone-baited traps around the periphery of the cotton fields; and (5) foliar sprays of chlordimeform (Galecron or Fundal). The first four are boll weevil suppression techniques being used in the eradication experiment and the fifth (chlordimeform) was included for *Heliothis* spp. suppression.

The rationale for the above combination of suppression techniques was as follows: (1) The combined use of reproduction diapause control, aldicarb, early-planted trap plots, and the boll weevil aggregating pheromone should achieve effective boll weevil suppression; (2) the use of aldicarb and the early-planting procedure should create differential attractiveness of the trap plots for adult *Heliothis* feeding and oviposition; (3) chlordimeform is an insecticide known to be ovicidal for *Heliothis* eggs, and workers in Arkansas have observed that when chlordimeform is ingested by *Heliothis* moths, their fecundity and fertility are reduced. Therefore, if adult bollworm activity, such as feeding and oviposition, could be concentrated in the trap plots, the chlordimeform sprays should kill a high percentage of the eggs deposited. If female moths could be induced to feed on the droplets of the chlordimeform spray, their fecundity and fertility would be reduced even though they might oviposit in other parts of the field.

PROCEDURES

A four-row trap crop of an early-fruiting cotton variety (Quapaw) was planted in each of nine cotton fields (8-15 acres each) in Covington County, Mississippi. Each trap plot was planted 2 to 3 weeks prior to the remainder of the crop. The trap plots were not planted along the edge of the field; they were planted toward the center of each field in a site that was considered optimum for achieving good seed germination, seedling emergence, and attractiveness for boll weevils entering the field from hibernation quarters. Aldicarb at 1.0 lb active/acre was applied in-furrow at planting. At the pinhead square stage (about 6 weeks after planting), additional aldicarb was applied to the trap crop as a sidedress application at 2.0 lb active/acre. The nine fields used in this test treatment were located in the 1st Buffer Zone of the Pilot Boll Weevil Eradication Experiment area (Knipling *(15)*) and had received a 13-application reproduction diapause control program the previous fall. Pheromone traps (Leggett and Cross *(16)*) baited with a formulation of the synthetic male-produced aggregating pheromone were maintained around each field as part of the operational procedure of the eradication experiment. Also, pheromone bait stations, consisting of one unit of the formulated pheromone, were placed at about 200-ft intervals in each trap plot. The pheromone traps and bait stations were serviced weekly.

In nine other fields located approximately 10 miles away in Smith County, a somewhat different pest management system was implemented. In these fields the trap plots received aldicarb in the same manner as the first nine fields, but were planted only 2 to 3 days prior to the remainder of the field. These fields were located in the 2nd Buffer Zone of the eradication experiment; thus, they received only eight reproduction diapause control treatments; no pheromone traps were maintained around the fields, and no pheromone bait stations were maintained in the trap plots.

Chlordimeform sprays were applied to the trap plots in six of the nine fields in each of the two locations when potentially damaging infestations of bollworm were indicated. Applications were made with a high clearance sprayer at a rate of 0.25 lb active/acre in a total spray volume of 6-10 gallons. Sugar was added to the chlordimeform mixture (5 lb/gal) in an effort to increase the attractiveness of the trap crops as a site for feeding and oviposition by *Heliothis* adults. Applications were made in the late afternoon and early evening (4:00-7:00 p.m.) so that the spray droplets would persist on the foliage as long as possible.

Insect populations were assessed by examining whole plants in trap plots and regular cotton, starting from seedling emergence and ending with termination of the test (July 27). Sampling sites in the trap plots were selected so that the influence of the pheromone bait stations could be measured; sites in the regular crop were selected both adjacent to (within 1-5 rows) and at a distance (50 or more feet) from the trap crop. Additional sampling was conducted from June 14, until termination of the test with a mechanical sampler mounted on a high clearance spray machine developed by McCoy *(18)*. These samples were returned to the laboratory for subsequent examination.

RESULTS AND DISCUSSION

Emerging overwintered boll weevils were captured in the pheromone-baited Leggett traps around the periphery of the fields throughout the test period. However, the majority of emerging weevils were captured from early to mid-June (Figure 1).

Whole plant counts (Table 1) indicated that the early planted trap crops were very effective in attracting the over-wintered weevils that missed the pheromone traps and entered the fields. No weevils

SUMMARY

In summary, the aldicarb-treated, early planted trap crop system was very effective in attracting and concentrating early-season boll weevil and bollworm populations in cotton. Damaging infestations of these pests were not sustained in the regular crop throughout the test period. Although further research is needed to clarify the role of each of the insect suppression factors involved in the experiment, and while improvements must be made in mid-season suppression of *Heliothis,* it seems obvious from these studies that the pest management system tested has great potential for cotton insect pest suppression.

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the late May sidedress application of aldicarb in the trap plots.

In general, *Heliothis* infestations reached a significant level only during a 2-week period in mid-June. Egg counts (Table 5) show the differential attractiveness of the trap crops for *Heliothis* oviposition, especially in June. A decrease in differential attractiveness in favor of the trap crops was observed as the regular crops grew and overcame the difference in size and maturity. By mid-July the regular crops appeared to be at least as attractive for oviposition.

Egg counts in the trap crops treated with foliar sprays of chlordimeform plus sugar-water indicated that the addition of sugar did not generate additional *Heliothis* oviposition. However, this conclusion, based on weekly egg counts, may be erroneous because the weekly egg counts were made prior to each spray application. Eggs deposited subsequent to the sprays would have hatched or been killed by the chlordimeform or beneficial organisms before the next count was made.

Infestations of *Heliothis* larvae (Table 6) appeared to follow the same general trends established by egg counts. However, destruction of eggs and small larvae by beneficial arthropods appeared to be a more significant factor in the regular crops. Although larval counts in the trap crops sprayed with chlordimeform plus sugar-water were consistently less than in the control trap crops, a comparison of egg and larval counts in the two trap crop systems indicated little *Heliothis* suppression by the chlordimeform. Counts of bollworm-damaged squares (Table 7) indicated better results from the chlordimeform sprays.

Counts of predaceous insects, i.e., big-eyed bugs, *Geocoris* spp. (Table 8) and lady beetles, Coccinellidae (Table 9), revealed dramatic differences in the numbers of these beneficial organisms in the aldicarb-treated trap crops and the non-treated crop.

TABLE 5. *Heliothis* SPP. EGGS IN FIELDS USED FOR ALDICARB-TREATED TRAP CROP EVALUATION, COVINGTON AND SMITH COUNTIES, MISSISSIPPI, 1972

Location-Treatment	Av. no. eggs/acre on indicated date[1]					
Covington Co.	6/14	6/22	6/28	7/5	7/13	7/21
Trap crop	10,400	5,265	0	867	0	433
Regular crop	0	1,510	0	867	0	2,167
Trap crop + Chlordimeform[2]	3,216	4,959	1,950	1,083	0	433
Regular crop	1,818	1,003	867	433	433	433
Smith Co.	6/14	6/21	6/28	7/6	7/12	7/19
Trap crop	----	5,494	----	0	2,167	1,733
Regular crop	----	3,900	----	0	----	----
Trap crop + Chlordimeform[2]	1,485	8,456	----	1,733	1,083	0
Regular crop	3,293	4,024	----	217	1,300	0

[1] Dashes indicate data were not collected.
[2] Chlordimeform-sugar-water sprays applied following egg counts on 6/14, 6/21, and 6/28 in Covington County and 6/15 and 6/22 in Smith County.

These differences occurred despite the greater abundance of *Heliothis* eggs and larvae on plants in the trap crops (tables 5, 6). The differences in number of predators in the trap crops versus the regular crop might have been even greater had there been more *Heliothis* forms in the regular crop to serve as predator hosts.

TABLE 6. *Heliothis* SPP. LARVAL INFESTATIONS IN FIELDS USED FOR ALDICARB-TREATED TRAP CROP EVALUATION, COVINGTON AND SMITH COUNTIES, MISSISSIPPI, 1972

Location-Treatment	Av. no. larvae/acre on indicated date[1]					
Covington Co.	6/14	6/22	6/28	7/5	7/13	7/21
Trap crop	18,200	8,343	3,900	3,900	867	1,733
Regular crop	0	0	867	0	0	1,733
Trap crop + Chlordimeform[2]	8,450	6,702	5,200	1,300	1,517	650
Regular crop	0	361	217	867	217	650
Smith Co.	6/14	6/21	6/28	7/6	7/12	7/19
Trap crop	----	3,852	----	2,600	867	1,300
Regular crop	----	4,333	----	433	0	0
Trap crop + Chlordimeform[2]	2,476	4,879	----	433	867	1,300
Regular crop	0	843	----	0	433	217

[1] Dashes indicate data were not collected.
[2] Chlordimeform-sugar-water sprays applied 6.14, 6/21, and 6/28 in Covington County and 6/15 and 6/22 in Smith County.

TABLE 7. PERCENTAGE *Heliothis* DAMAGED SQUARES IN FIELDS USED FOR ALDICARB-TREATED TRAP CROP EVALUATION, COVINGTON AND SMITH COUNTIES, MISSISSIPPI, 1972

Location-Treatment	Av. percentage damaged squares on indicated date[1]					
Covington Co.	6/14	6/22	6/28	7/5	7/13	7/21
Trap crop	20	28	27	10	3	1
Regular crop	0	11	6	2	1	2
Trap crop + Chlordimeform[2]	28	11	16	7	3	1
Regular crop	0	4	8	7	2	2
Smith Co.	6/14	6/21	6/28	7/6	7/12	7/19
Trap crop	----	21	----	7	3	2
Regular crop	----	12	----	3	1	0.5
Trap crop + Chlordimeform[2]	13	12	----	4	3	1
Regular crop	0	7	----	2	0.5	0.2

[1] Dashes indicate data were not collected.
[2] Chlordimeform-sugar-water sprays applied 6/14, 6/21, and 6/28 in Covington County and 6/15 and 6/22 in Smith County.

TABLE 8. MECHANICALLY-COLLECTED SAMPLES OF BIG-EYED BUGS, *Geocoris* SPP., IN ALDICARB-TREATED TRAP CROP EVALUATION, COVINGTON AND SMITH COUNTIES, MISSISSIPPI, 1972

Location-Treatment	Av. no. *Geocoris*/acre on indicated date					
Covington Co.	6/14	6/22	6/28	7/6	7/19	
Trap crop	748	339	311	194	20	
Regular crop	276	737	835	352	32	
Smith Co.	6/15	6/21	7/5	7/12	7/20	7/26
Trap crop	358	316	401	375	342	637
Regular crop	715	1,486	543	940	1,044	1,339

TABLE 9. MECHANICALLY-COLLECTED SAMPLES OF LADY BEETLES, COCCINELLIDAE, IN ALDICARB-TREATED TRAP CROP EVALUATION, COVINGTON AND SMITH COUNTIES, MISSISSIPPI, 1972

Location-Treatment	Av. no. Coccinellidae/acre on indicated date					
Covington Co.	6/14	6/22	6/28	7/6	7/19	
Trap crop	1,203	636	568	656	40	
Regular crop	528	1,228	1,073	803	81	
Smith Co.	6/15	6/21	7/5	7/12	7/20	7/26
Trap crop	406	511	424	342	355	312
Regular crop	504	1,040	535	572	745	780

TABLE 1. WHOLE PLANT COUNTS OF BOLL WEEVIL POPULATIONS IN ALDICARB-TREATED TRAP CROP EVALUATION, COVINGTON AND SMITH COUNTIES, MISSISSIPPI, 1972

Treatment	Av. no. weevils/acre on indicated date[1]												
	4/27	5/4	5/18	5/24	5/31	6/7	6/14	6/21	6/28	7/5	7/13	7/20	7/27
Covington Co.													
Trap crop	0	0	9	50	14	14	0	0	0	1,296	1,296	576	----
Regular crop	----	----	----	----	----	0	0	0	0	0	0	0	----
Smith Co.													
Trap crop	----	----	0	0	7	0	0	0	0	144	576	1,296	0
Regular Crop	----	----	----	----	----	7	0	0	0	0	1,152	1,152	0

[1] Dashes indicate cotton was not large enough to make counts.

were found in whole plant samples in the non-treated regular crops during the entire sampling period in the Covington County fields. In the Smith County fields however, weevil populations in the trap crops and regular crops did not differ appreciably. The lack of any difference in the two treatments in Smith County fields was especially evident in early July, when F_1 generation weevils began emerging. The effectiveness of the Covington County trap crops was attributed to the fact that they were planted and fruited much earlier than the regular cotton (Table 2). The pheromone bait stations maintained in these trap crops undoubtedly enhanced their attractiveness; almost all weevils located by the whole plant sampling method prior to F_1 emergence were found within 15 feet of the bait stations. Conversely, in the Smith County fields the differential in the trap plots and the regular crop was only temporary; by early July no appreciable difference in size and fruiting was apparent. The absence of pheromone bait stations in the Smith County trap plots further reduced the chances for differential attractiveness in favor of the trap plots. However, effectiveness of the trap plot system in both locations could not be accurately measured by live weevil counts alone. The aldicarb treatments in the trap crops undoubtedly killed many of the weevils feeding on cotton plants in the four treated rows. Since a practical method for finding and counting the dead weevils was unavailable, the live weevil counts made during whole plant sampling were biased against the trap plots.

Mechanically collected samples of live weevils (Table 3) and damaged square counts (Table 4) confirmed the effectiveness of the trap-crop system in Covington County and the relative ineffectiveness of the Smith County system for boll weevil suppression. Weevil infestations were slow to develop in the Smith County fields, but subsequently reached higher levels than in the Covington County fields. It seems probable that the higher July infestations in Smith County were the result of a more general distribution of overwintered weevils in the regular crop. However, most of the overwintered weevils entering the fields in Covington County were attracted to the trap crop and died after feeding on the aldicarb-treated cotton.

Heliothis infestations in the aldicarb-treated trap crops were appreciably greater than in the regular crop during most of the sampling period (tables 5-7). These differences appeared greatest soon after

TABLE 2. COTTON SQUARE PRODUCTION IN FIELDS USED FOR ALDICARB-TREATED TRAP CROP EVALUATION, COVINGTON AND SMITH COUNTIES, MISSISSIPPI, 1972

Location-Treatment	Av. sqs/acre (thousands) on indicated date[1]					
Covington Co.	6/14	6/22	6/28	7/5	7/13	7/21
Trap crop	158.6	175.9	129.2	197.2	262.2	315.0
Regular crop	1.7	33.6	40.7	78.4	182.9	198.5
Trap crop + Chlordimeform[2]	116.2	269.1	176.4	253.9	247.9	177.5
Regular crop	8.7	27.0	62.8	80.8	138.8	172.5
Smith Co.	6/14	6/21	6/28	7/6	7/12	7/19
Trap crop	----	106.1	----	149.9	218.8	239.6
Regular crop	----	14.7	----	126.5	153.8	198.9
Trap crop + Chlordimeform[2]	58.4	110.6	----	178.8	230.1	193.1
Regular crop	4.0	23.6	----	114.4	203.8	211.9

[1] Dashes indicate data were not collected.
[2] Chlordimeform-sugar-water sprays applied 6/14, 6/21, and 6/28 in Covington County and 6/15 and 6/22 in Smith County.

TABLE 3. MECHANICALLY-COLLECTED SAMPLES OF BOLL WEEVIL POPULATIONS IN ALDICARB-TREATED TRAP CROP EVALUATION, COVINGTON AND SMITH COUNTIES, MISSISSIPPI, 1972

Location-Treatment	Av. no. weevils/acre on indicated date[1]				
Covington Co.	6/14	6/22	6/28	7/8	7/19
Trap crop	14.4	72.0	14.4	54.9	46.2
Regular crop	7.2	0	8.7	5.7	8.7
Smith Co.	6/15	6/21	6/28	7/5	7/20
Trap crop	0	0	----	18.6	78.0
Regular crop	0	0	----	18.6	69.3

[1] Dashes indicate data were not collected.

TABLE 4. BOLL WEEVIL DAMAGED SQUARES IN FIELDS USED FOR ALDICARB-TREATED CROP EVALUATION, COVINGTON AND SMITH COUNTIES, MISSISSIPPI, 1972

Location-Treatment	Av. percentage ovip.-punct. sqs. on indicated date[1]					
Covington Co.	6/14	6/22	6/28	7/5	7/13	7/21
Trap crop	0	0.5	4.9	4.2	10.0	8.7
Regular crop	0.1	0	0	1.4	2.6	3.7
Smith Co.	6/14	6/21	6/28	7/6	7/12	7/19
Trap crop	0	0	----	8.1	6.5	16.7
Regular crop	0	0	----	7.1	5.4	15.8

[1] Dashes indicate data were not collected.

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