Cotton Insects--Management and Biology Unit
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Summary Report

Cotton Insects Genetic Studies

A. C. Bartlett, Research Geneticist

In the pink bollworm, four existing translocation strains, taken through crossing procedures designed to produce homozygosity, carried recessive lethal factors associated with the translocation which made it impossible to maintain the homozygous strains. Thus, these translocation strains must be maintained as heterozygotes. Crosses plus selection designed to eliminate such recessive lethal factors are planned for the coming year. Balanced sex-linked lethal stocks have not yet been recovered from irradiation tests of previous lethal-carrying strains.

In laboratory studies, in the first generation of overflooding the native population with the nondiapause (ND) strain, the control native population did not reproduce, thus no comparisons could be made to indicate the success of the test; however, ND insects constituted about 70% of the experimental populations. New tests were initiated after it was found that diapause response of the nonselected WCRL strain was greater than 97%, thus making it possible to guarantee reproduction of the control populations. In the first generation of these new tests, a differential response of reciprocal crosses was obtained thus indicating at least partial sex linkage of the nondiapause character.

A successful laboratory cage test was conducted of partially sterilized sooty pink bollworms which examined the effect of continuous release of treated insects vs. a single release scheme. At 5-krad treatment, the released insects did not successfully control the population under either release scheme, but at 10-krad treatment continuous release, each generation was significantly better at control than a single release per season. The 10-krad treatment also gave better control than the 5-krad treatment under either release scheme. The presence of the sooty marker allowed close observation of the sterile insects.

Pheromone Studies

H. M. Flint, Research Entomologist

Preliminary studies of the early season distribution and movement of pink bollworms were made during the season. In mark and recapture studies, males moved freely between desert, sugar beets, alfalfa and cotton habitats during April and May. About 80% of female moths captured in light traps during this period were mated regardless of the habitat in which they were captured. Virgin females placed in mini-mating stations in desert and cotton habitats were equally mated in one night exposure (ca. 50% mated).

No significant difference was found in the response of males to the ratios in gossyplure in treated or untreated atmospheres. Thirty-six percent of males captured in treated or untreated fields were caught in traps containing the 1:1 ratio. There was a 90% reduction in the number of males trapped in treated fields.

P. D. Lingren, Research Entomologist

Nine new sprayable formulations of gossyplure were evaluated for attractancy and disruption control capabilities. Two of the formulations provided as good as or better disruption of mating than twice the recommended rate of Conrel fiber. One bait formulation showed considerably better attractancy and longevity than baits formulated in a standard rubber septum. Specific results from all baits and disruption formulations are under proprietary protection for one year.

The effect of wind, humidity and temperature was evaluated on capture of pink bollworms in Malaise traps, funnel live pheromone traps, mini-mating tables and population dynamics (in field emergence, generation cycling, mating and aging of pink bollworm populations). About 15,000 females were captured in the 4 Malaise traps. They are being dissected to determine age structure and relationships of trap catches by comparisons to data obtained by physical collections of adults from the field at night and releases of sooty moths. Catches in directionally oriented Malaise traps indicate wind direction determines direction of population movement over field. Much of the data from this experimentation is still being read out and further reports will be prepared as the data are developed.

T. J. Henneberry, Research Entomologist

Gossyplure (1:1 mixture of Z,Z- and Z,E-isomers of 7,11-hexadecadien-1-ol acetate) in plastic laminated formulations of 35 or 10 gai/ 2.54 cm^2 applied at the rates of 2.96 to 4.94 gai gossyplure per hectare to cotton fields reduced male pink bollworm moth catches in pheromone-baited traps an average of 80-86% (range 40-99%) and clipped-wing female mating in mating stations 90-92% (range 52-100%) for 13-16 nights after application.

There were no significant differences in the results when gossyplure was applied at 1.5 gai/ha in 6782 point sources/ha or 2.0 gai/ha in 31,667 point sources/ha. Results obtained were not significantly different when population densities of pink bollworm males, as measured by captures in pheromone-baited traps, ranged from 1.5 to 28.3 males per trap/night in untreated cotton fields during the experimental periods.

Sterile Pink Bollworm Release Research

T. J. Henneberry and Dan Keaveny

A total of 1,150 clipped-wing, laboratory-reared, virgin females were placed on mating tables during the study period of Nov. 7, 1979 to July 3, 1980, and 991 (86%) were recovered. Fifty-eight percent of the recovered females had mated with native St. Croix males indicating the laboratory-reared females were highly attractive to the native St. Croix males. Mating ranged from 6-100%. The attractiveness and mating of untreated laboratory-reared, irradiated (20-krad) laboratory-reared and untreated St. Croix female moths was compared and there were no significant differences between moth strains.

Insect Parasite-Predator Biology

G. D. Butler, Jr., Research Entomologist

A research report on the development of *Trichogramma pretiosum* in relation to constant and fluctuating temperatures was completed and submitted for publication. A small number of a braconid parasite of *Heliothis virescens*, *Cardiocheles nigriceps*, was received and rearing techniques developed. Experiments are under way to determine its development rate at different temperatures. A study to determine the development time of *Coccinella septempunctata* in relation to constant temperature was completed. It was concluded that the beetles recovered from the New Jersey Meadowlands had a development rate similar to that of the European strain. Studies were conducted to develop methods for holding eggs and young larvae of *Chrysopa carnea* at low temperatures to delay hatching and growth so they could be stored for use in spring aphid control in cold frames. High mortality accompanied storage under different temperature and moisture conditions.

Integrated Cotton Pest Management Studies

L. A. Bariola and T. J. Henneberry

Pink bollworm male moth activity, as measured by gossyplure-baited Delta traps, was not significantly different in nectariless or nectaried cotton nor in the 20" or 40" row plots. Larval infestations in bolls reached ca. 14% during July 23-28 and the first insecticide application was applied. Treatments for the remainder of the season effectively controlled pink bollworm. There were no significant differences between the number of larvae per boll sample from narrow row (20") or standard row (40") plots nor from boll samples from nectaried or nectariless cottons.

Lygus spp. were high in June but decreased in July. Significantly more *Lygus* were found in nectaried cotton than in nectariless cotton. There were no significant differences in the numbers of *Lygus* found in narrow or standard row plots of either type cotton. Total numbers of insect predators, which included *Coccinellids*, *Geocoris* spp., *Nabis* spp., *Chrysopa* spp., *Collops* and *Reduviidae*, were higher in nectaried cotton than in nectariless cotton plots.

Dicamba plus chlorflurenol, applied to reduced overwintering diapause pink bollworms, had no significant effect on the numbers of green bolls until ca. 29-33 days after treatment. Thereafter, the numbers of green bolls in the treated plots were significantly less than the numbers found in the untreated check plots. On November 10, the number of green bolls and diapause pink bollworm larvae found in the dicamba plus chlorflurenol-treated plots were reduced 97% as compared to those found in the check plots. Fewer green bolls were found in Pennwalt TD-1123 treated plots ca. 21-29 days after treatment, and on Nov. 10, the numbers of green bolls and diapause larvae were reduced ca. 90% as compared to those found in the check plots. None of the plant growth regulator treatments affected the numbers of pink bollworm larvae in bolls.

Host Plant Resistance Research

B. W. George and F. D. Wilson

AET-5, a pink bollworm resistant stock, and 24-8ne were grown along with their F_1, F_2 and backcross hybrids. Only additive genetic effects were significant; heritability of seed damage was 24%.

AET-5 was backcrossed to BC_2 and BC_3 plants selected for various combinations of the visible pink bollworm resistance characters, nectariless, Smooth leaf, Okra-leaf, Super Okra-leaf, and early maturity. The objective was to incorporate these visible characters into AET-5 background to study their cumulative effects on pink bollworm resistance.

In the greenhouse, the numbers of pink bollworm entrance holes per boll were lower in AET-5 than in DPL-61, both when pink bollworm moths had a choice of plants upon which to oviposit and when they did not. In a subsequent free-choice test, moths laid more eggs per boll on AET-5 the first week but more on DPL-61 the second week. The mean difference was not significant. The distribution of eggs on different parts of the plant was about the same for both cottons with about one-third to one-half of the eggs being laid in leaf and limb axils and one-third+ on bolls, with lower percentages on other parts of the plant. An unexpected phenomenon was that many eggs were laid at the bases of the stems and in the soil (not included in the eggs per plant totals because we assume at present that larvae hatching from these eggs would not reach squares or bolls). In the field, late in the season, moths laid fewer eggs on AET-5 than on DPL-61, but many more on Pima S-5. Distribution of eggs on AET-5 and DPL-61 was similar to that observed in the greenhouse. On Pima S-5, moths laid 75+% of their eggs on the bolls.

Pink Bollworm Diapause Studies

L. A. Bariola, Research Entomologist

Diapause pink bollworm larvae in bolls were buried under pyramid emergence cages on Feb. 1, Mar. 6, or left on the surface since Feb. 1, 1980. Also, cut-out larvae (in free cocoons in tissue paper) that were collected at different times during the fall of 1979 were buried on Feb. 6. Supplemental irrigation at monthly intervals was applied to half of the cages of each treatment. There were no apparent differences in the emergence patterns among any of the treatments. An average of 15.6% of the cut-out larvae emerged when not irrigated; the supplemental irrigation reduced the survival of 6.7%. Of the larvae remaining in bolls, survival was greatest among those that were left on the soil surface and the least among those buried on Feb. 1. In all cases, the supplemental irrigation reduced the survival about 50%.

"Horseshoe" larvae of the cotton leafperforator were counted weekly for 8 weeks on leaves of 13 test cottons and a commercial cotton check. Leaf hairs were also counted. Seven test cottons had fewer "horseshoe" larvae/g leaf tissue than the check, DPL-61. These included four cottons from the high-tannin, Smooth leaf HT35 family.

Cottons carrying all combinations of Okra-leaf, frego bract, and Smooth leaf were tested for seed damage by pink bollworm for the third year. Combined analysis of the data showed that cottons carrying Okra-leaf had significantly less seed damage than those with normal leaves. Smooth leaf cottons had more damage than hirsute ones but frego-bract strains did not differ in seed damage from normal bract strains.

Eight of 34 cottons that were early maturing or that carried another pink bollworm resistant character had significantly less seed damage than the checks as follows: Stoneville 7A Okra-leaf; La Okra 500-C; Texas 167; 79-IC3; La 1363 Super-okra, nectariless; 7203-14-7; 7203-14-104; AET-5.

Bolls of Stoneville 7A and its Okra-leaf isoline were infested artificially with pink bollworm eggs and entrance holes were counted. The Okra-leaf isoline had fewer entrance holes per boll than the normal-leafed cultivar.

Gossyplure for the Control of the Pink Bollworm

G. D. Butler, Jr. and T. J. Henneberry, Research Entomologist
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Summary

Applications of gossyplure in mating disruption programs gave effective control of pink bollworms in cotton at several locations in Arizona in 1981. A new technique of using gossyplure in combination with an insecticide as an attracticide appears to be very promising.

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For the second year, observations were made on the effectiveness of Gossyplure (as NOMATE PBW and as DISRUPT) for the control of pink bollworm in cotton. Detailed studies were conducted in the Imperial Valley, CA in 64 fields of 5300 acres where pheromone treated fields gave equal or better control of the pink bollworm than conventional insecticides. Observations were also made in Poston, Mohave Valley, and Harquahala, AZ. The NOMATE PBW was applied at a rate of 15 gr per acre with 5 ml of a pyrethroid insecticide added to 1/3 pt of sticker. DISRUPT was applied at 60 gm in 4 oz sticker per acre without pyrethroid. Treatments generally were begun at the time of the appearance of the first 1" bolls. Evaluations of the effectiveness of the treatments were made by inspecting 100 open bolls for pink bollworm damage in each corner of the field (400 bolls) or two 125 open boll samples 20 rows apart in each field corner (1000 bolls).

POSTON, AZ - Ranch A: This grower has used pink bollworm pheromones for several years and used the pheromone program through the 1981 season. Eight fields of 585 acres (Group I) which were planted between April 3 and 11 were treated on June 26 and July 6 with 15 g NOMATE PBW, 1/3 pt Biotac and 5 ml Pydrin. Four fields of 236 acres (Group II) planted between April 11 and 17 were treated on June 29 and July 7. Then all fields were treated on July 17, 27, August 5, 17, 27, and September 3. On August 17, 1000 open bolls were observed in each field (Table 1). Except for a mid-season Temik application and one to two applications of Thuricide, Coax and Galecron or Thuricide, Coax, Galecron and Dimilin on and after August 17 on some of the fields, no insecticide treatments were needed. The pheromone treatments gave excellent pink bollworm control and there should be virtually no diapausing pink bollworm larvae in these fields to initiate 1982 infestations.

Table 1. Percent of pink bollworm infested open cotton bolls. Poston, AZ August 17, 1981

Planting Group	Planting Date	Acres	Percent Infested
Group I	April 3-7	115	1.9 ± 1.9
	April 6	50	1.2 ± 0.8
	April 7	44	1.8 ± 1.2
	April 8	50	2.3 ± 3.8
	April 9	112	0.0
	April 10	112	0.2 ± 0.4
	April 11	48	0.4 ± 0.6
	April 11	54	0.1 ± 0.3
Group II	April 11-13	108	0.0
	April 13-16	49	0.5 ± 0.6
	April 16	40	0.1 ± 0.3
	April 17	39	0.1 ± 0.3
		821	0.7 ± 1.5
Adjacent stub cotton fields (4)			76.8 ± 17.4

POSTON, AZ - Ranch B: Another large ranch used pheromones to control pink bollworm until August 4 - 6 when chemicals were applied for other insect pests. The NOMATE plus pyrethroid treatments were started at the time of the appearance of the 1st 1" bolls and were reapplied at 10-day intervals for a total of 6 applications. The DISRUPT treatments with no pyrethroid insecticides were also started at the 1-in. boll stage and were reapplied at 12 to 14-day intervals. An application of 1.25 lb Dylox was applied on July 20 to coincide with a valley-wide peak of pink bollworm activity as shown by pheromone trap catches and from heat unit projections. It was reported that this treatment had little effect on beneficial insects. Evaluations were made by examining 100 open bolls in each corner of each field. Only the early planting groups were checked as normally the earliest planted fields have the heaviest pink bollworm infestations. The results of the observations on August 3 and 9 are given in Table 2.

Both the NOMATE and DISRUPT treatments gave excellent control of the early season pink bollworm populations.

Table 2. Percent of pink bollworm infested open cotton bolls.
Poston, AZ August 3 and 9, 1981.

Planting Group	Planting Date	Variety	Material	Percent Infested
Group I	Feb. 23	DPL-61	Nomate	0.2
	Feb. 24	DPL-61	Nomate	0.5
	Feb. 26	DPL-61	Nomate	1.0
	Feb. 27	DPL-70	Nomate	1.0
	March 4	DPL-61	Nomate	0.0
	March 4	DPL-61	Nomate	0.0
	March 16	DPL-70	Nomate	0.8
	March 18	DPL-61	Disrupt	0.0
	March 18	DPL-61	Disrupt	0.0
Group II	March 19	DPL-61	Disrupt	0.0
	March 19	DPL-61	Disrupt	0.0
Group III	April 1	DPL-61	Nomate	0.0
	April 1	DPL-61	Nomate	0.0
Group IV	April 10	PimaS5	Nomate	0.2
	April 11	PimaS5	Nomate	0.0
	April 12	PimaS5	Nomate	0.0
North edge of 2 Group I fields				10.0 and 19.0
Adjacent Farm				35.0

MOHAVE VALLEY, AZ Some of the growers in this area have also successfully used pink bollworm pheromones for several years. Observations were made on September 15-16 of the percent of pink bollworm infested open bolls on 9 fields receiving 3 pheromone treatments of NOMATE-PBW without pyrethroid followed by 3 insecticide treatments for bollworm/budworms and 9 fields receiving only insecticide treatments (Table 3). There was no significant difference in the percent of pink bollworm infested open bolls between those fields treated with pheromones and those with standard insecticide treatments.

Table 3. Percent pink bollworm infested open bolls.
Mohave Valley, AZ. September 15-16, 1981.

Treatment	No. fields	No. 100 boll samples	Percent Infested
Pheromone			
Grower A			
center	3	24	0.8 ± 0.3
edge	2	16	2.4 ± 3.1
Grower B	4	32	3.2 ± 2.8
Insecticide			
Grower C	2	16	0.2 ± 0.4
Grower D	2	16	2.1 ± 2.1
Grower E	5	40	1.6 ± 2.2

HARQUAHALA, AZ Pheromones were applied in each case to four fields of Pima cotton on June 24, July 8, 18, and 28. Observations were made on the percent of pink bollworm infestation in open bolls on September 11 (Table 4). The cotton was free from infestation compared with sprayed DPL fields on an adjacent ranch which was checked on August 6.

CONFUSION VS. ATTRACTICIDE

Up to this point our discussion has centered about the use of gossyplure as 15 g of NOMATE-PBW in the confusion technique which makes a fog-like aurora of pheromone over the cotton field in which the male pink bollworms are unable to find females by their usual means of orienting along pheromone concentration gradients. A small amount of pyrethroid insecticide was included in the sticker so that if the males should encounter a fiber, they might be killed or affected by the insecticide.

In 1981 several pest control advisors speculated that perhaps if they used less pheromone, the males might locate fibers easier and either be killed or their sensory systems rendered ineffective. The method of action of the pyrethroid insecticide in the sticker is still unclear but antennal sensory systems of insects appear to be very susceptible to disruption by pyrethroid insecticides. In any case, males would be removed from the chance of future mating as compared with males resuming mating after a confusion treatment had lost its effectiveness. We are not prepared at this time to discuss the details of the attracticide technique but observations were made in Harquahala (Table 4) as well as Gila Bend, AZ and Blythe, CA (not reported here) that indicated that this technique shows excellent promise for effective pink bollworm control.

Table 4. Percent of pink bollworm infested open cotton bolls. Harquahala, AZ. September 11, 1981

Treatment	Percent infested
CONFUSION TECHNIQUE	
Pima Planted Field 1, NOMATE	0.4 ± 0.5
Pima Planted Field 2, NOMATE	0.8 ± 1.4
DPL Stub Spray (checked Aug. 6)	
Field 3	11.0 ± 6.0
Field 4	27.5 ±10.8
ATTRACTICIDE TECHNIQUE	
Pima Planted NOMATE	1.7 ± 2.0
DPL Planted Spray	2.1 ± 2.0
ST-825 Stub NOMATE	1.4 ± 1.8
ST-825 Stub Spray	25.4 ± 20.1
Ranch D (checked Sept 23) 1000 bolls ea	
Field 5 NOMATE	0.1
Field 6 NOMATE	0.1
Field 7 NOMATE	0.3
Field 8 NOMATE	0.3
Field 9 NOMATE	0.8
Field 10 NOMATE	0.9

Breeding for Resistance to Insects in Cotton

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Seed damage caused by pink bollworm (PBW) was not significantly different in eight Smooth leaf and hirsute isolines. Damage by *Lygus hesperus* was significantly higher in four of the eight Smooth leaf lines. Five of eight stocks having high levels of condensed tannin had significantly more seed damage than the Deltapine 61 (DPL-61) check; none had less damage. None had significantly fewer cotton leafperforator (CLP) larvae than the check. Among 33 early maturing and miscellaneous cotton, 10 had less seed damage than DPL-61. Advanced-generation nectariless hybrids between the PBW-resistant AET-5 and nectariless parents showed good resistance to PBW. Individual seed sources of Texas 39 showed differences in resistance to PBW. Bolls of Stoneville 7A Okra leaf had fewer PBW entrance holes and less seed damage than those of Stoneville 7A.

Antixenosis to PBW from AET-5 was inherited additively, heritability was significantly different from zero, and was conditioned by 1-2 gene pairs. Lint percent was also inherited additively, heritability was high, and estimated number of gene pairs was 1. Breeding stocks are under development that combine the PBW resistance characters nectariless, Okra leaf, early maturity, antixenosis from AET-5, and antibiosis from Texas 167.