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EFFECT of SEVERAL INSECTICIDES and APPLICATION SCHEDULES on COTTON INSECT CONTROL

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INSECT PESTS are generally present in the Wiregrass Area of Alabama in sufficient numbers to seriously affect yields of cotton unless control measures are applied.

Insects of primary importance are the boll weevil, *Anthonomus grandis* Boheman; the bollworm, *Heliothis zea* (Boddie); and the tobacco budworm, *H. virescens* (*Fabricius*). Hereafter in this report both species of *Heliothis* are referred to as bollworms.

Other arthropods that have been implicated as serious cotton pests are: several species of thrips; the cotton aphid, *Aphis gossypii* Glover; the cotton fleahopper, *Psallus seriatus* (Reuter); and spider mites, *Tetranychus* spp. Information gained through research during a number of years, however, has shown that these pests are of minor importance and rarely occur in sufficient numbers to adversely affect cotton production, (*1*) (*4*).

Experiments were conducted at the Wiregrass Substation, Headland, Alabama, from 1961 through 1964 to determine the effectiveness of several insecticidal mixtures against the boll weevil and bollworms. In 1961, emphasis was placed primarily upon application of the following control measures: (1) full-season; (2) at pinhead square stage and thereafter for boll weevils and bollworms; and (3) for boll weevil and bollworms as needed. In 1962 through 1964 this procedure was modified slightly and insecticides were compared at six different application schedules.

METHODS AND MATERIALS

1961 Experiment. The experimental design was a randomized complete block and each treatment was replicated 4 times. Each plot was 16 rows wide and 200 feet long. Data were collected from the center area of each plot.

The experiment involved control of plant bugs, fleahoppers, leafhoppers, thrips, bollworms, and boll weevils. Plant bug, fleahopper, and leafhopper infestation counts were made on selected treatments June 27 and July 3, 10, and 19. These populations were determined by making 10 sweeps with a standard insect net in the center part of each plot.

Thrips population counts were made on selected treatments May 29, June 7, 13, 27, and July 3 from 20 plants that were pulled at random from each plot. The plants were put into ½-pint fruit jars containing 200 ml. of water to which had been added a few drops of formaldehyde. In the laboratory, 2 grams of ordinary detergent were added to each jar and the jar was shaken vigorously for 2 minutes. The jar top

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was replaced with screen wire through which the liquid was poured, leaving the plant tissue in the jar. The detergent solution containing thrips was poured through a piece of thin nylon stretched over an embroidery ring. The contents of each jar were washed five more times with water and the washings were strained through the embroidery ring. The nylon was placed under a binocular microscope and the thrips were counted. Standard square- and terminal-count methods were used during the fruiting period to determine population levels of boll weevil and bollworms, respectively.

All sprays were applied as emulsions with a high-clearance, self-propelled spray machine. Sprays before June 26 were applied with one nozzle per row at 40 p.s.i. pressure, which delivered 2 gallons of finished spray per acre. On June 26 and thereafter, sprays were applied with three nozzles per row at 6 gallons finished spray per acre. Rates of insecticidal concentrates applied corresponded with recommended rates, beginning with minimal amounts and increasing as insect population pressure increased.

1962-64 Experiments. The experimental design was a randomized complete block and each treatment was replicated four times. Each plot was 16 rows wide and 150 feet long. Data were collected from the center 100 feet of the 8 center rows. Analyses of the data were made by the Department of Research Data Analysis and the Computer Laboratory.

Insect infestations were assessed at weekly intervals. Thrips (undetermined species) and cotton aphid population levels were sampled during the early stages of plant growth by vigorously beating young plants over a funnel and allowing the insects to fall into a vial of alcohol attached to the base of the funnel. Standard square- and terminal-counts were made throughout the major fruiting period to ascertain population activity levels of boll weevil and bollworms.

Nineteen treatments were included in the experiment. These were comprised of three recommended insecticidal mixtures, each applied on six different schedules, plus an untreated check. Emulsifiable concentrates were diluted with water and applied with a high-clearance, self-propelled spray machine. Early-, mid-, and late-season rates were applied with 1, 2, and 3 nozzles per row, respectively. This resulted in approximately 2.5, 5.0, and 7.5 gallons of finished spray, respectively, being applied per acre. However, the amount was varied slightly from year to year.

Insecticidal mixtures used in these experiments were toxaphene-DDT, endrin-methyl parathion, and Guthion®-DDT [Guthion = 0,0-dimethyl S-(4-oxo-1,2,3-benzotriazin-3 (4H) - ylmethyl) phosphorodithioate]. Generally, three rates of each material were used during the season, beginning with the minimum recommended and increasing as the pressure from pest species increased.

The six application schedules employed in this series of experiments were as follows:

(1) full-season insect control, i.e., insecticides were applied on an automatic weekly schedule beginning with the two-leaf stage. Later, the interval was shortened to a 4- to 5-day schedule and continued until the cotton was mature.

(2) early-season insect control plus an automatic 4- to 5-day schedule after boll weevils had punctured 10 per cent of the squares. Beginning with the two-leaf stage, three applications of insecticide were made at weekly intervals; thereafter, none was applied until the automatic 4- to 5-day schedule was initiated at the 10 per cent boll weevil level.

(3) automatic 10 per cent schedule, i.e., no insecticides were applied until boll weevils had punctured 10 per cent of the squares; thereafter, applications were made on a 4- to 5-day schedule until the bolls were mature.

(4) ten per cent schedule and as needed, i.e., the spray programs were initiated when 10 per cent of the squares were punctured by boll weevil; applications were continued thereafter as needed to hold infestation levels at or near 10 per cent.

(5) automatic 25 per cent schedule, i.e., no insecticides were applied until 25 per cent of the squares were punctured by boll weevil; thereafter, applications were made on an automatic 4- to 5-day schedule.

(6) twenty-five per cent schedule and as needed, i.e., the initial application was made at the same time as the automatic 25 per cent schedule; subsequent applications were made only as necessary to hold the boll weevil infestation at or near the 25 per cent level.

DISCUSSION AND RESULTS

Minor insect pests were of little or no consequence in this series of experiments. Thrips were not sufficiently abundant to cause noticeable plant damage. Spider mites, aphids, plant bugs, fleahoppers, and leafhoppers were not important in these experiments during the 4-year study. Only one small localized infestation of spider mites was observed and one application of an acaricide (demeton) eliminated this infestation.

With regard to most of these pests, similar results have been reported from several areas of the State, (*1*)(*2*)(*4*)(*5*). However, spider mites are serious pests in many areas of the State during some years.

In 1963, aphids were abundant enough in untreated plots to cause severe stunting and malformation of plants. Injury caused by the early-season aphid infestation was subsequently outgrown and final yields failed to substantiate the need for control of this infestation.

1961 Experiment. Bollworm eggs were prevalent on cotton in late June and continued to be present on untreated cotton for the remainder of the growing season. The greatest numbers occurred from mid-August to mid-September. Worm populations were highest in the untreated cotton during the last 3 weeks of August. All treatments were significantly effective in reducing bollworm populations below that of the untreated check.

The mean seasonal boll weevil infestation on the untreated check was 52.8 per cent, whereas infestations on all other treatments were significantly lower. The lowest mean seasonal infestation, 18.5 per cent, resulted from the toxaphene-DDT schedule begun at the two-leaf stage. The data in Table 1 show the severity of the boll weevil problem in 1961 as compared with that of the following 3 years. Because of an extremely late planting season, a 10 per cent boll weevil population developed only 63 days after the cotton was planted. Therefore, the cotton was under boll weevil attack during most of its major fruiting period.

TABLE 1. INCIDENCE OF BOLL WEEVIL INFESTATION RELATIVE TO STAGE OF COTTON GROWTH, WIREGRASS SUBSTATION, HEADLAND, ALABAMA, 1961-64

Year	Planting date	Date 10% infest. level reached	Days from planting to 10% level	Days from 10% level to total harvest
			No.	*No.*
1961	May 19	July 21	63	128
1962	April 19	July 10	82	128
1963	April 10	July 24	105	90
1964	April 15	July 14	90	126

Yields resulting from all insecticidal treatments were significantly greater than those from the untreated check, Table 2. Three materials were applied on a full-season basis. The highest yield was produced from plots treated with Guthion-DDT. Methyl parathion-DDT produced intermediate results, whereas toxaphene-DDT produced the lowest yields. Yields from methyl parathion-DDT were not significantly different from either of the other two treatments, but there was a significant difference between Guthion-DDT and toxaphene-DDT. Comparable treatments of toxaphene-DDT, endrin-methyl parathion, and endrin-methyl parathion-DDT, requiring 17 applications, produced 1,969, 1,741, and 1,741 pounds of seed cotton per acre, respectively. These yields were not significantly different from each other or from the highest yielding treatment, Table 2. A comparison of the four schedules in which toxaphene-DDT was the insecticide common to all shows that, as the number of insecticidal applications increased from 17 to 22, the yield of cotton decreased from 1,969 to 1,412 pounds of seed cotton per acre, Table 2.

TABLE 2. COMPARISON OF THE EFFECTIVENESS OF VARIOUS APPLICATION SCHEDULES AND INSECTICIDES AGAINST BOLL WEEVIL AND BOLLWORMS, AND ON SUBSEQUENT COTTON YIELDS, WIREGRASS SUBSTATION, HEADLAND, ALABAMA, 1961

Treatment	Range of insect. rates	Total applications	Mean number bollworms per 100 terminals	Weevil infested squares	Yield, seed cotton per acre
	Lb.	*No.*	*No.*	*Pct.*	*Lb.*
Untreated check		0	6.3	52.8	103
Toxaphene, 2-leaf stage; Tox-DDT pinhead squares and subsequently as necessary for worms and weevils[1]	.75-.0 2.0-1.0 3.0-1.5	22	0.2	18.5	1,412
Toxaphene-DDT, begin at pinhead square, continue as necessary for worms or weevils[1]	2.0-1.0 3.0-1.5	20	0.2	19.4	1,668
Toxaphene-DDT, as necessary for worms and weevils except 3-day interval at migration[1]	2.0-1.0 3.0-1.5	18	0.3	19.8	1,790
Toxaphene-DDT, as necessary for worms or weevils	2.0-1.0 3.0-1.5	17	0.2	19.5	1,969
Methyl parathion, 2-leaf stage; M.P.-DDT, pinhead squares and subsequently as necessary for worms or weevils[1]	.125-.0 .25-.5 .5-1.0	22	0.2	23.4	1,873
Endrin-methyl parathion, as necessary for worms or weevils[1]	.2-.25 .3-.375	17	0.1	33.4	1,741
Endrin-methyl parathion-DDT, as necessary for worms or weevils[1]	.2-.25-.5 .3-.375-.75	17	0.3	25.5	1,741
Guthion, 2-leaf stage; Guthion-DDT, at pinhead squares and subsequently as necessary for worms or weevils[1]	.125-.0 .25-.5 .5-1.0	22	0.3	21.8	2,068
LSD .05					528

[1] When bollworm populations reached 4 to 5 per 100 terminals and/or 10 per cent of squares were punctured.

1962-64, Three-year Experiment. Table 1 presents the planting dates, harvest dates, and dates when boll weevil infestations first reached the 10 per cent level. The most severe damage caused by boll weevils was in 1964; slightly less damage was caused in 1962, and practically none in 1963. Table 3 presents the mean seasonal boll weevil infestations for each insecticidal treatment and the untreated check. Although the seasonal infestation was higher in 1963 than in 1962, it caused less damage to cotton. In 1963, boll weevil infestation occurred later than in either of the other years. In addition, the cotton was planted earlier. Thus, the seemingly higher infestation in 1963 resulted from a high late-season population that built up on cotton after it passed its major fruiting period and had fewer squares to puncture. Infestation counts given in Table 3 are the seasonal means of all replications for each insecticidal treatment, regardless of application schedules.

TABLE 3. COMPARISON OF INSECTICIDE MIXTURES FOR BOLL WEEVIL CONTROL, WIREGRASS SUBSTATION, HEADLAND, ALABAMA, 1962-64

Treatments	Infested squares			3-year mean
	1962	1963	1964	
	Pct.	*Pct.*	*Pct.*	*Pct.*
Check	48.5	52.2	59.4	53.4
Toxaphene-DDT	10.9	22.7	14.9	16.2
Endrin-M.P.	19.2	27.2	25.6	24.0
Guthion-DDT	11.1	19.5	15.7	15.4

Bollworms caused economic damage each year that the experiment was in progress. However, bollworm damage was most severe in 1963, and most of the damage to cotton during that year was attributable to bollworms. Table 4 presents the mean seasonal infestation counts.

Yields from the various insecticidal treatments for each schedule are combined and these yields are compared in Table 5. All insecticidal treatments resulted in a highly significant yield of seed cotton when compared with the untreated check. There were no significant increases in production among any of the schedules. However, slightly more seed cotton was produced by the 10 per cent as needed schedule, receiving an average of 13 insecticidal applications. Other than the check, the least amount of seed cotton was produced on the plots receiving full-season control and requiring an average of 23.7 insecticidal applications, Table 6.

The 3-year investigation revealed that insecticidal treatment was essential at some time during the growing season to control either the boll weevil, bollworms, or both. All insecticidal treatments resulted in highly significant yield increases when compared with the untreated check, Table 7. However, dif-

TABLE 4. COMPARISON OF INSECTICIDE MIXTURES FOR BOLLWORM CONTROL, WIREGRASS SUBSTATION, HEADLAND, ALABAMA, 1962-64

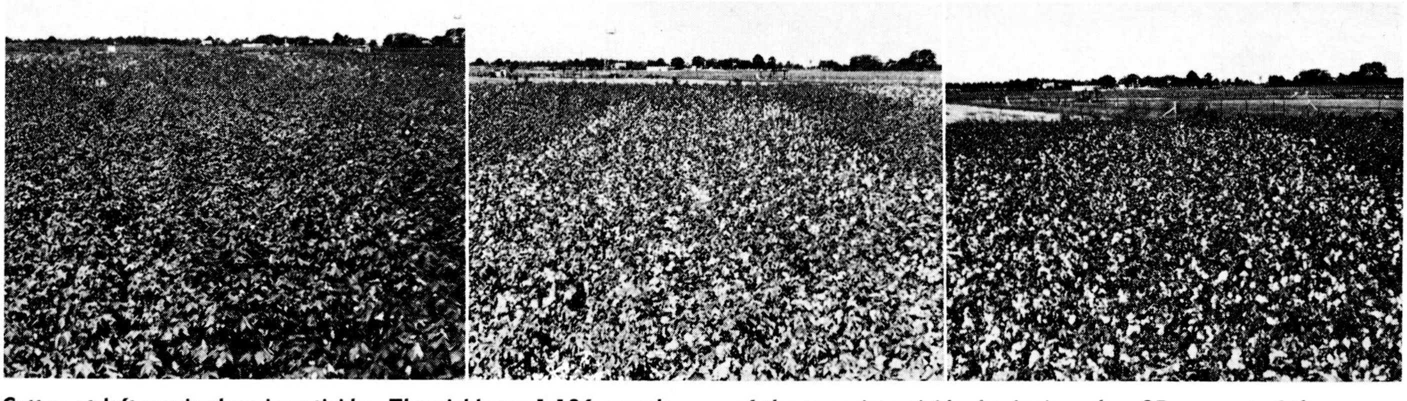
Treatments	Mean bollworms/100 terminals			3-year mean
	1962	1963[1]	1964	
	No.	*No.*	*No.*	*No.*
Check	11.5	37.0	9.8	19.4
Toxaphene-DDT	2.3	5.8	1.7	3.3
Endrin-M.P.	4.0	11.0	2.8	5.9
Guthion-DDT	2.8	6.8	2.7	4.1

[1] The excessively high bollworm counts resulted from a combination of fewer weekly sampling periods in which all plots were evaluated plus the fact that the sampling period occurred during the time when population pressure was greatest.

TABLE 5. COTTON YIELDS OBTAINED FROM INSECTICIDE APPLICATION ON VARIOUS SCHEDULES, WIREGRASS SUBSTATION, HEADLAND, ALABAMA, 1962-64

Schedule	Yield of seed cotton per acre and significance[1]			
	1962	1963	1964	Mean
	Lb.	*Lb.*	*Lb.*	*Lb.*
Check	1,186 a	1,644 a	1,035 a	1,288 a
Full-season	2,520 b	2,339 b	2,449 b	2,436 b
Early-season + 10%	2,396 b	2,569 b c	2,503 b	2,489 b
10%—automatic schedule	2,461 b	2,583 b c	2,492 b	2,512 b
10%—as needed	2,576 b	2,553 b c	2,575 b	2,568 b
25%—automatic schedule	2,297 b	2,593 b c	2,511 b	2,467 b
25%—as needed	2,324 b	2,662 c	2,495 b	2,494 b

[1] Yields followed by the same letter are not significantly different at the 1% level. Duncan's (3) Multiple Range Test.



Cotton at left received no insecticide. The yield was 1,186 pounds per acre. Cotton in center photo received 24 applications of a recommended insecticide in a full-season program. The yield was 2,650 pounds per acre. Cotton at right received 11 applications of the same insecticide, beginning when 25 per cent of the squares were punctured. The yield was 2,523 pounds per acre. (There was no significant difference between the two control schedules).

TABLE 6. NUMBER OF INSECTICIDAL APPLICATIONS REQUIRED ON VARIOUS SCHEDULES, WIREGRASS SUBSTATION, HEADLAND, ALABAMA, 1962-64

Schedules	Applications[1]			
	1962	1963	1964	Mean
	No.	*No.*	*No.*	*No.*
Check	----	----	----	----
Full-season	24(2)	24	23	23.7
Early-season + 10%	17(3)	16(1)	16	16.3
10%—automatic schedule	14(3)	13(1)	13	13.3
10%—as needed	14(3)	12(1)	13	13.0
25%—automatic schedule	11(4)	11(3)	8	10.0
25%—as needed	11(4)	10(3)	8	9.7

[1] Numbers in parentheses indicate the number of DDT applications made for bollworm control prior to buildup of the indicated boll weevil infestation levels. The numbers preceding the parentheses denote the number of applications of insecticide mixture exclusive of applications of DDT alone.

TABLE 7. AVERAGE YIELD OF SEED COTTON OBTAINED FROM THREE INSECTICIDAL TREATMENTS AND AN UNTREATED CHECK, WIREGRASS SUBSTATION, HEADLAND, ALABAMA, 1962-64

Treatment	Yield of seed cotton/a. and significance[1]			
	1962	1963	1964	Mean
	Lb.	*Lb.*	*Lb.*	*Lb.*
Check	1,186 a	1,644 a	1,035 a	1,288 a
Toxaphene-DDT	2,471 b c	2,403 b	2,435 b	2,436 b
Endrin-M.P.	2,302 b	2,677 c	2,377 b	2,452 b
Guthion-DDT	2,515 c	2,570 b c	2,701 c	2,595 c

[1] Yields followed by the same letter are not significantly different at the 1% level. Duncan's *(3)* Multiple Range Test.

ferences occurred among the insecticidal mixtures used. In 1962 and 1964, when both boll weevil and bollworms caused economic damage, higher yields were obtained from the Guthion-DDT mixture; toxaphene-DDT treatments resulted in intermediate yields; lowest yields were obtained from the endrin-methyl parathion treatments. In 1963, however, when bollworms caused most or all of the yield losses, the endrin-methyl parathion treatments resulted in the highest yields, followed by the Guthion-DDT and toxaphene-DDT treatments.

When results of all 3 years were combined and analyzed, the yields of seed cotton from the Guthion-DDT treatments were significantly higher (1% level) than yields from treatments of endrin-methyl parathion or toxaphene-DDT. There was no difference between yields of the latter two treatments.

SUMMARY

The only insects causing serious damage to cotton in the Wiregrass Area of Alabama during the 4-year period of 1961 through 1964 were boll weevil and bollworms. The investigation reported here revealed that insecticidal treatment was essential at some time during the growing season to control these pests. Control during the major fruiting period was of greatest importance. Yields of cotton were not increased by control of minor pests, such as thrips, aphids, and fleahoppers.

In the full-season control program in 1961, the Guthion-DDT treatment resulted in the highest yield; methyl parathion-DDT was intermediate; and, toxaphene-DDT was lowest. Schedules of toxaphene-DDT, endrin-methyl parathion, and endrin-methyl parathion-DDT treatments requiring 17 applications resulted in comparable yields to methyl parathion-DDT applied on a full-season program. A comparison of four toxaphene-DDT programs, ranging from 17 to 22 applications, showed that as the number of insecticidal applications increased, yields decreased.

In 1962-64, six application schedules were evaluated in the tests to determine the best control program to follow. Of the application schedules evaluated (programs ranged from full-season control to those begun only after 25 per cent of the squares were punctured by the boll weevil) the full-season schedule resulted in the lowest yields. Highest yields occurred in the 10 per cent schedules.

Three currently recommended insecticide mixtures were evaluated at each application schedule. All resulted in significantly (1 per cent level) more cotton than was produced in the untreated check. However, the Guthion-DDT treatment resulted in higher yields (1 per cent level) than either endrin-methyl parathion or toxaphene-DDT. There was no statistical difference between the latter two mixtures.

LITERATURE CITED

(1) ARANT, F. S., Cotton Insects and Their Control with Insecticides. Auburn University Agricultural Experiment Station Circular 106. 1951.

(2) ———————— Cotton Insects can Cost State's Growers $50 Million in a Single Year. *Highlights of Agricultural Research* Vol. 2, No. 2. Auburn University Agricultural Experiment Station. 1955.

(3) DUNCAN, D. B., Multiple Range and Multiple F Tests. *Biometrics* 11: 1-42. 1955.

(4) WATSON, T. F., Influence of Thrips Control on Cotton Yields. *Journal of Economic Entomology.* (in press). 1965.

(5) WATSON, T. F., and Sconyers, M. C. Comparison of Insecticide Application Schedules for Control of Cotton Insects. *Journal of Economic Entomology.* (in press). 1965.