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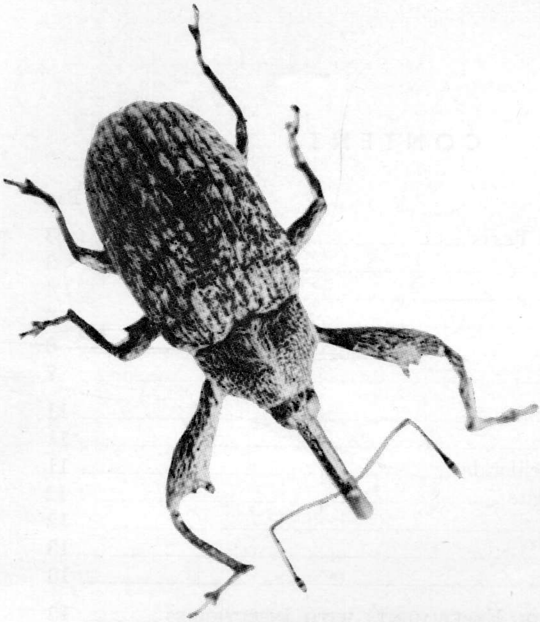

# COTTON INSECTS *and* THEIR CONTROL *with* INSECTICIDES

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# COTTON INSECTS *and* THEIR CONTROL *with* INSECTICIDES

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The boll weevil and other cotton insects have destroyed more than one bale of cotton for every three harvested during the past few years in Alabama. These losses occurred in spite of the fact that information is available for successful control of the pests, even during seasons of extreme insect abundance and heavy rainfall. Control measures properly applied can increase the cash income of Alabama farmers by many millions of dollars annually.

This circular contains information on the important pests of cotton, results of experiments in the control of cotton insects, and insect control procedures for use in a program of profitable cotton production.

## PRINCIPAL COTTON PESTS

The most important pests of cotton in Alabama are boll weevil, bollworms, cotton aphid, and spider mites and thrips.

### Thrips

Several species of thrips feed in buds of seedling cotton, causing the leaves to become ragged and distorted in appearance. In rare instances, enough thrips may be present to seriously damage the stand of cotton. Species involved include onion thrips, *Thrips tabaci* Lind; tobacco thrips, *Frankliniella fusca* (Hinds); flower thrips, *F. tritici* (Fitch); and others. These tiny insects (Figure 1-A) may breed on weeds and wild plants, vegetables, grains, and many other crops. When the cotton emerges, they may move to the seedling plants.

Much so-called early insect control is aimed at thrips control. However, there is some question as to benefits resulting from control of these insects. In some sections of the country where cotton is

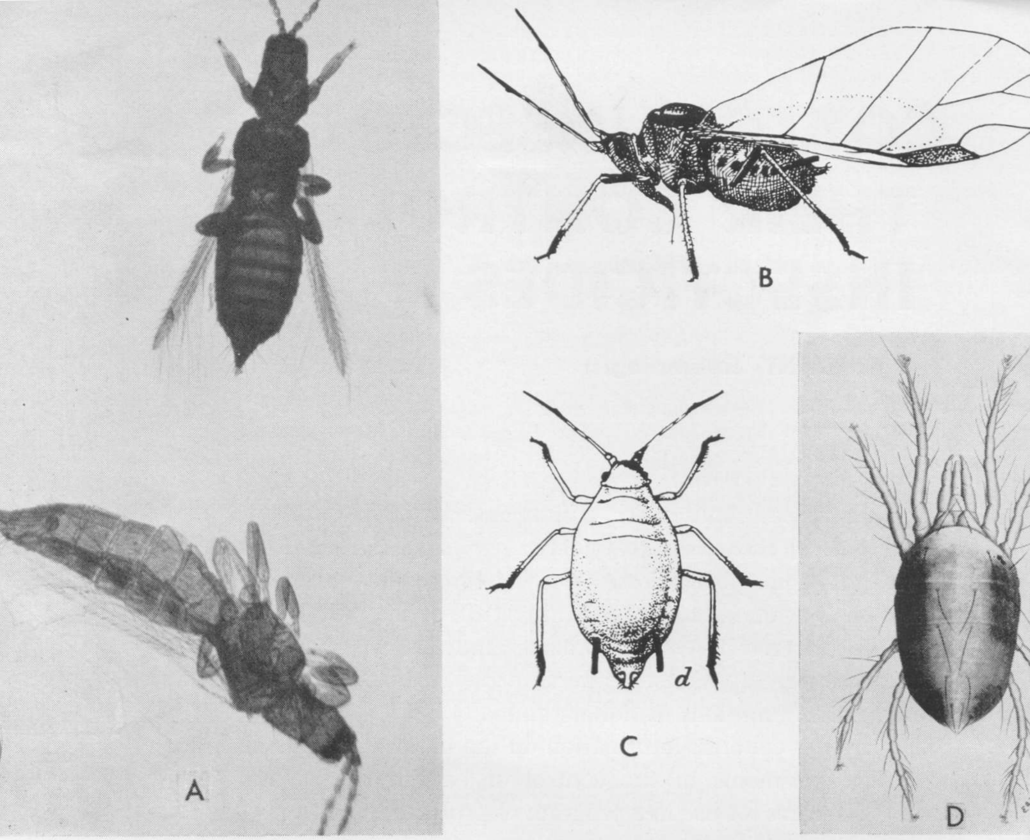


**FIGURE 1. Three of the important cotton pests: (A) thrips (about 50X enlargement), (B) aphid, winged stage, and (C) wingless (about 10X enlargement); (D) spider mite (100X enlargement). (B, C, and D courtesy of the USDA Bureau of Entomology and Plant Quarantine.)**

planted between rows of onions, serious damage to stands results from the transfer of thrips from the onions to the cotton. In Alabama, serious damage may occur locally during some seasons. Experiments indicate that thrips control usually does not increase the yield of cotton unless insects are numerous enough to damage the stand. Control of moderate to heavy infestations on seedling cotton does contribute to somewhat earlier maturity of the cotton. At present thrips control is not generally recommended in Alabama unless there is danger of damage to the stand of cotton.

## Spider Mites

Several species of spider mites, including *Tetranychus bimaculatus* Harvey, infest cotton in Alabama (Figure 1-D). These mites, also known as red spiders, breed on numerous wild and cultivated plants, including pokeweed, Caley pea, vetches, clovers, beans, weeds of many kinds, and other plants. Infestation is spread largely by mechanical means, such as by cultivation, from infested to uninfested plants. Different species respond in somewhat different ways to environmental conditions. In general, however, spider mites are most numerous during seasons of hot, dry weather. Heavy, washing rains usually reduce mite infestations. Gentle rains are less effective.

Most of the new insecticides applied to cotton will not control spider mites. In fact, they tend to cause a build-up in the mite population, although under Alabama conditions this build-up is usually not very great. During 4 years of experimental work with new organic compounds, it has not been necessary to control spider mites in any experiment.[1] However, if the infestation becomes extensive in a cotton field during the fruiting period, the yield of cotton may be reduced by this pest. Parathion is one of the most effective insecticides for eleminating spider mite infestations. This material is hazardous to use and is recommended only where adequate precautions will be taken. Two to three applications of a 1.5 per cent dust applied 3 days apart at the rate of 20 to 25 pounds per acre will usually control spider mite infestations. Two to three applications of sulphur applied in the same manner is also a standard treatment but is less effective than parathion for eliminating heavy infestations.

## Cotton Aphid

The cotton aphid, *Aphis gossypii* Glov. (Figure 1, B and C), attacks cotton in the seedling as well as in later stages of growth. During cool weather, seedling cotton may be stunted by heavy aphid infestations. However, the most serious damage from this insect results when heavy infestations develop during the time the crop is being set and matured. Heavy infestations at that time may develop from applications of such insecticides as calcium arsenate and DDT for control of other pests. Aldrin and dieldrin may also create conditions favorable for development of aphid populations, although information on this point is limited.

Serious reduction in yield of cotton results from heavy aphid infestations during the fruiting period. Control of the insect with benzene hexachloride, nicotine, or other aphicides is highly profitable.

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[1]Extensive infestations of strawberry spider mite, *Tetranychus atlanticus* McG., developed on cotton in northern Alabama in the late summer of 1951. However, the infestations were associated with extremely dry, hot weather rather than with repeated applications of organic insecticides.

## Bollworms

The bollworms are second only to boll weevil in importance in Alabama. At least two species are commonly referred to as bollworms. One is the tobacco budworm, *Heliothis virescens* (F.), which attacks cotton during the early part of the summer, and the other is the true bollworm or corn earworm, *H. armigera* (Hbn.) (Figure 2), which may be abundant in late summer. The true bollworm possibly causes the most serious damage.

Bollworms appear to be increasing in importance as pests of cotton as a result of changes in the cropping systems. A succession of suitable host plants for the insects is being grown throughout the year. These plants include clovers, vetches, alfalfa, peanuts, and other legumes, corn, cotton, and grain sorghum.

The moths of the bollworm are strong fliers and may fly northward for several miles before depositing eggs. When corn begins to harden in the field, these moths usually migrate to cotton fields in considerable numbers. They are attracted particularly to cotton infested with aphids. The moths feed on the honeydew and deposit their eggs on

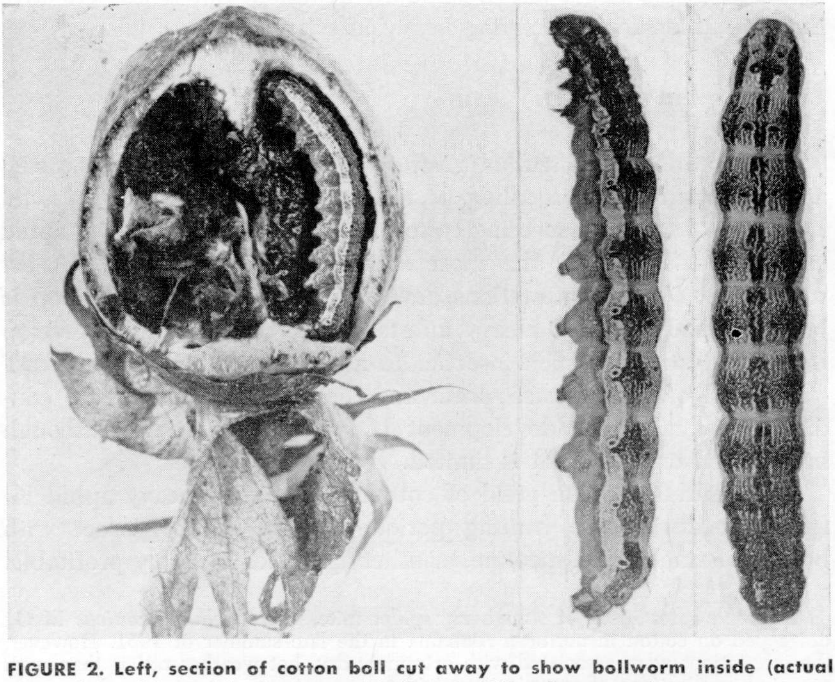


**FIGURE 2. Left, section of cotton boll cut away to show bollworm inside (actual size); right, side and back views of bollworm (2X enlargement).**

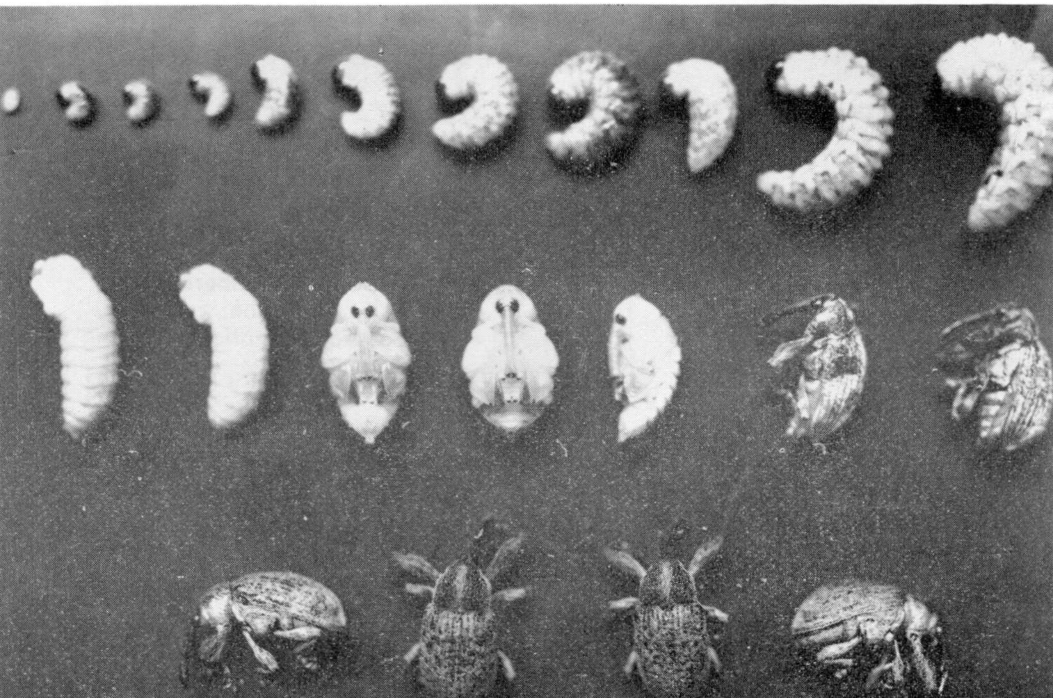
leaves and buds of the cotton plants. The eggs hatch in 2 or 3 days and the young larvae feed first on the tender leaves. Later they bore into squares and bolls. After feeding for a period of 2 to 3 weeks, the larvae reach a length of 1½ inches, drop to the ground, and pupate in the soil. Development from egg to moth requires a period of approximately 30 days.

Bollworms can reduce greatly the yield of cotton, particularly if they are numerous in bolls. Bollworm damage may be increased by the application of benzene hexachloride, aldrin, or dieldrin unless DDT is added to the formulation. Bollworm infestations are frequently worse where applications of insecticides have been made early in the season and then discontinued. Irregular applications, with too great an interval between treatments, also tend to buildup bollworm populations. Toxaphene and DDT are the only insecticides commonly used on cotton that are effective in bollworm control. These materials are most effective against the insect while it is small. Large caterpillars are difficult to kill.

## Boll Weevil

**Hibernation and Temperature Relationship.** Boll weevil, *Anthonomus grandis* Boh., is the most important pest of cotton (Figure 3). Adults overwinter in old cotton burs, under grass and weeds, in litter and along fence rows; in cotton houses, barns, and other out-

**FIGURE 3. Life stages of the boll weevil (about 3X enlargement).**



buildings, particularly under loose boards and shingles; along the edges of woods, in trash or under loose bark; and in other protected places. Temperature has an important bearing on winter survival. In general, many adults are killed by temperatures of 10° F. and below. This refers to the temperature of the insect and not of the atmosphere. Adults hibernating in trash on the ground and protected by snow may survive, even though the air temperatures may be below 10° F. Intermittent cold periods and thaws will kill more weevils than continuous cold.

Adults begin to emerge from hibernation as the weather becomes warm in the spring. The period of emergence may extend from March to the middle of July. The peak emergence usually occurs in June, although there is some variation from northern to southern Alabama. A hypothetical example of boll weevil emergence is illustrated in Figure 4.

**Longevity.** Most of the adult weevils emerging from hibernation before the plants begin squaring live for only 7 to 14 days. Those that emerge after squaring begins may live 3 to 4 weeks, although many of them die in a shorter time. Overwintering females usually

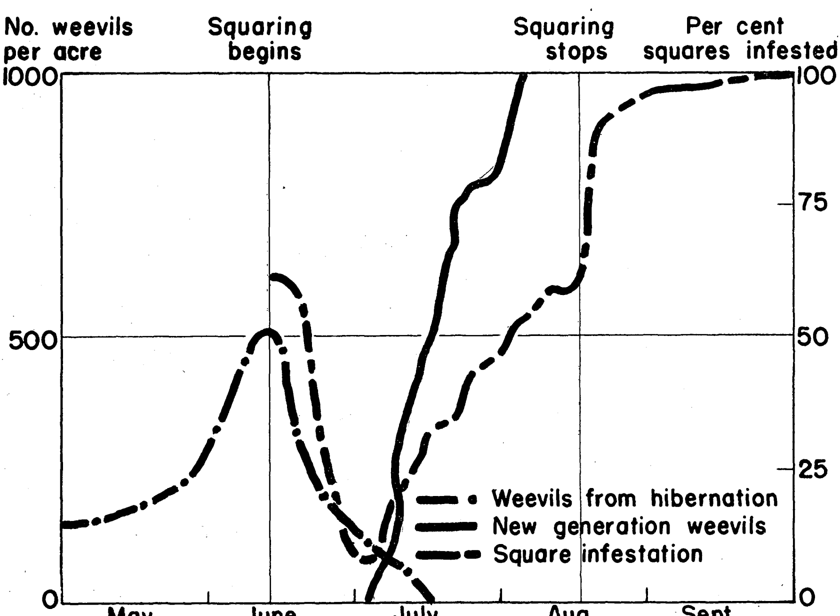



**FIGURE 4. Hypothetical curves indicating boll weevil populations and square infestations in relation to fruiting of cotton during a season of average insect abundance.**

deposit less than 100 eggs. Later in the season females live about 60 days and deposit 150 to 300 eggs each.

**Feeding and Infestation Punctures.** In the spring before squares are formed, boll weevil adults feed in the buds of cotton and cause a wilting of the developing leaves. Later in the season, both males and females feed in squares. Feeding punctures are usually made toward the tip of the squares where pollen may be eaten. Males continue to puncture the flower part of the square throughout their lives. After a short period of feeding, females begin puncturing at the base of the square where eggs are deposited (Figure 5). Usually, only one egg is deposited in a square unless the population is heavy and squares are scarce.

When the cotton first begins to fruit and squares are scarce, a small population of overwintered weevils can puncture a high percentage of the squares present. As the rate of squaring increases and more forms are present on the plant, the infestation caused by a constant number of weevils drops sharply. This means that during a normal year the square infestation declines as the rate of fruiting increases and the overwintered adults die (Figure 4). Such a decline in infestation did not occur in 1950 in most fields, because the overwintered adults continued to emerge from hibernation in large numbers well into July; the damage by overwintered weevils overlapped that caused by the new generation emerging from infested squares.

Sometimes farmers apply insecticides to cotton just as it begins to fruit. The infestation nearly always declines from natural causes, which is often mistaken to be the result of the insecticidal treatment.

Development of the boll weevil takes place within the square (Figure 5), which may drop to the ground. A period of 18 to 21 days is required for development under average conditions. Upon emergence from squares, the new weevils feed a few days, mate, and the females begin to lay eggs.

Infestation of squares from the new generation may be successfully suppressed (kept below 50 per cent) by proper application of insecticides as long as the cotton is squaring freely. However, when the crop has been set and squares become scarce late in the summer, the infestation rises sharply (Figure 4), regardless of properly timed applications of insecticides. This rise in infestation should cause no alarm. However, it should indicate the need for continuing applications in order to protect young bolls from weevil damage.

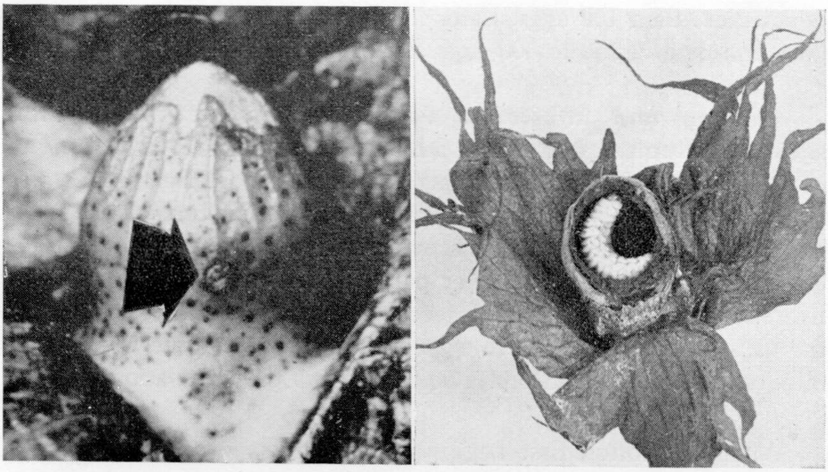


**FIGURE 5. Left, cotton square showing egg puncture of weevil (about 4X enlargement); right, section of cotton square cut away to show boll weevil grub inside (about 1½X enlargement).**

**Flight.** Upon emergence from hibernation, boll weevil adults may travel for considerable distances in locating fields. After they become established in fields of fruiting cotton, they do not fly very much until late in the season when squares become scarce. At that time they begin migrating or swarming, traveling for miles during late summer and early fall. They are rather difficult to kill at that time. Therefore, it is necessary to increase the dosage of the insecticide and shorten the interval between applications.

**Effect of Weather on Abundance.** Weather conditions are the most important factors influencing boll weevil abundance. Winter temperatures influence survival and determine to a great extent the population of adults emerging from hibernation. Weather conditions during June and the first half of July determine largely the extent to which overwintered adults may multiply. High temperatures (near 100° F.) and dry weather tend to shorten the life of overwintered adults and also to kill developing grubs in the squares. Moderate temperatures and cloudy weather favor multiplication of the insect. After the plants have attained enough size to shade the middles, high temperature is of less importance.

## COTTON INSECTICIDES

### Aldrin

Aldrin is an effective insecticide against boll weevil. In speed of action, it is faster than any other commercial cotton insecticide except benzene hexachloride. Aldrin will not control bollworm or cotton aphid. When it is applied to cotton, it should be mixed with DDT. As a dust, the mixture should contain 2.5 per cent aldrin and 5 per cent DDT, and it should be applied at the rate of 8 to 15 pounds per acre. The rate of application of the spray is not less than 0.25 pound of aldrin and 0.5 pound of DDT in 2 to 10 gallons of finished spray per acre.

Where DDT is applied with aldrin, aphid populations may build up to damaging levels. If the leaves begin to get sticky with honeydew, an aphicide should be applied to control aphids. Three per cent nicotine dust at the rate of 15 to 20 pounds per acre will usually eliminate aphids. Parathion and tetraethyl pyrophosphate (TEP) are also effective, but both are hazardous to use, especially where spray concentrates are handled.

Aldrin is a highly toxic material. Although it is not as dangerous in low concentrations as it had appeared previously, the material can be absorbed through the skin even from dust formulations. It should not be applied under conditions where the operator is covered with the insecticide during the process of application. Operators of machinery applying aldrin should wear long-sleeved coveralls, buttoned around the neck. When the dusting or spraying operation is over, the clothing should be removed, and the operator should bathe. If proper precautions are taken, aldrin can be used with reasonable safety.

### Benzene Hexachloride

Benzene hexachloride, known as BHC, is a quick-acting and effective insecticide against boll weevil, cotton aphid, thrips, flea hopper, and most of the other pests of cotton. However, it will not control bollworm or spider mites. Where it is used without DDT, a build-up in the population of bollworm is likely to occur. BHC is used in a mixed dust containing 3 per cent gamma isomer and 5 per cent DDT[2] for control of cotton insects. Applications are made at the

[2]This dust is referred to as BHC-DDT, 3-5 mixture in this report.

rate of 8 to 15 pounds per acre per application. BHC-DDT may also be applied as a spray at the rate of 2 to 10 gallons per acre. The amount of technical material per acre should be not less than 0.3 pound of gamma isomer and 0.5 pound of DDT per acre.

BHC containing 3 per cent gamma isomer applied at the rate of 15 pounds per acre is one of the best treatments known for eliminating heavy cotton aphid infestations.

### Calcium Arsenate

Calcium arsenate is an economical and effective material for control of boll weevil. It is most effective during seasons of light rainfall. Since calcium arsenate is slow in action, it must remain on the plants at least 24 hours to kill insects. During periods of extremely hot weather with little rainfall, it is probably the most effective insecticide against boll weevil. It is also the most destructive of all the cotton insecticides to honeybees.

Calcium arsenate applied without an aphicide causes a build-up in aphid population. At the rate normally used, it is not effective against bollworm. In a control program, it should be applied alternately with BHC-DDT mixture or with calcium arsenate that contains 2 per cent nicotine.

There has been developed in recent years a lime-free calcium arsenate that may be mixed with some of the synthetic organic aphicides. One such product on the market in 1950 was lime-free calcium arsenate plus 1 per cent parathion. This combination is effective against boll weevil, cotton aphid, spider mites, and some other cotton pests. However, parathion is a very poisonous insecticide, **particularly in concentrated forms.** It may be absorbed through the skin. It is also deadly if inhaled. When diluted to 1 or 1.5 per cent for use on cotton, the hazards are much less than those involved in the use of concentrates. However, the material should not be used except by persons who will take proper precautions in applying it.

### DDT

DDT will not control boll weevil or cotton aphid. Its use without an aphicide results in a build-up of aphid populations. However, it is the most effective insecticide available for control of bollworm. Usually it is not applied alone to cotton in Alabama except for emergency measures to control bollworm in the absence of boll weevil damage. DDT is commonly mixed with BHC, aldrin, or dieldrin to form a dust suitable for the control of major insect pests of cotton. The rate of application is not less than 0.5 pound of technical DDT per acre. For control of heavy populations of large bollworms, the rate of application should be 1 to 1.5 pounds of technical DDT per acre.

### Dieldrin

As a cotton insecticide, dieldrin is in about the same category as aldrin. It is newer than aldrin and less is known about the material. From limited data, it appears to be somewhat more effective on cotton than aldrin. As a dust, dieldrin is applied in a mixture containing not less than 1.5 per cent dieldrin and 5 per cent DDT at the rate of 8 to 15 pounds per acre. As a spray, it is applied at the rate of not less than 0.15 pound of dieldrin and 0.5 pound of DDT in 2 to 10 gallons of diluted spray per acre. The same precautions recommended for aldrin should be taken in applying dieldrin. Extra applications of aphicides may be necessary for aphid control.

### Toxaphene

Toxaphene is effective against boll weevil, bollworm, thrips, and most of the other pests of cotton except spider mites. While it suppresses cotton aphid when applied at regular intervals, toxaphene is not highly effective in eliminating heavy infestations of aphids once they have developed.

Toxaphene may be applied as a 20 per cent dust at the rate of 8 to 15 pounds per acre per application. It may also be applied as a spray at the rate of 2 to 3 pounds of technical toxaphene in 2 to 10 gallons of finished spray per acre. The effectiveness of toxaphene spray appears to be increased somewhat by the addition of 1 pound of technical DDT for each 2 pounds technical toxaphene used.

## RESULTS *of* CONTROL EXPERIMENTS *with* INSECTICIDES

Boll weevil is the most important insect pest of cotton, and any insecticidal control program must be planned around control of this pest. However, to be effective, it must include insecticides or mixtures of insecticides properly timed to control the other major cotton pests in a single operation. Experiments have been conducted on boll weevil control in Alabama over a period of 24 years. In the earlier tests, little consideration was given to insects other than boll weevil. Recently, it has been found necessary to control bollworm and cotton aphid in any insecticidal control program and, in a few instances, other pests must be controlled.

Since 1950 was an extremely severe boll weevil year, it is desirable to review briefly results of experiments with various insecticidal treatments and to summarize results of previous experiments.

## Experiments With Various Insecticidal Treatments

**Spraying Experiment, Tallassee, 1950.** Five insecticidal treatments were tested on small plots at the Plant Breeding Unit to compare the effectiveness of various materials applied as sprays. Each of the treatments was replicated four times in randomized blocks. The insecticides were applied with high-clearance, self-propelled sprayer with three nozzles per row. The sprayer was adjusted to deliver 6 gallons of spray per acre per application. Twelve applications of the insecticides were made during the time the cotton crop was being set and matured, July 8 to August 26. Heavy winds blew down the cotton plants to such an extent that the applications had to be discontinued before the top crop matured.

Summarized results of the spraying experiment are presented in Table 1 and Figure 6. **All insecticides used were effective in controlling boll weevil and bollworm.** Cotton aphid and red spider mites

TABLE 1. AVERAGE INSECT INFESTATION ON SPRAYED AND UNSPRAYED PLOTS, FOUR REPLICATIONS, PLANT BREEDING UNIT, TALLASSEE, 1950

| Treatment[1] | Technical material per acre | | Insect infestation | |
|---|---|---|---|---|
| | | | Boll weevil | Bollworm |
| | *Pounds* | | *Per cent* | *Per cent* |
| Unsprayed check | | 0 | 78.0 | 7.4 |
| Toxaphene | | 2.0 | 56.2 | 1.1 |
| Aldrin-DDT | Ald.,<br>DDT, | 0.25<br>0.50 | 42.2 | 0.3 |
| BHC-DDT | Gamma,<br>DDT, | 0.36<br>0.60 | 45.4 | 0.5 |
| Dieldrin-DDT | Diel.,<br>DDT, | 0.15<br>0.50 | 35.8 | 0.8 |
| Toxaphene-DDT | Tox.,<br>DDT, | 2.0<br>1.0 | 40.1 | 0.4 |

[1]Sprays applied: July 8 (rain within 24 hours), 18, 22 (rain within 24 hours), 29 (rain within 24 hours), 31; August 4, 9, 11, 15, 19, 23, 26.

were not serious problems in this experiment. Average yields of seed cotton ranged from 289 pounds per acre on the untreated checks to 1,887 pounds on the plots sprayed with toxaphene-DDT mixture (Figure 7).

| *Treatment* | *Bales* |
|---|---|
| Unsprayed check | 2.1 |
| Toxaphene | 9.8 |
| Aldrin-DDT | 11.1 |
| BHC-DDT | 12.3 |
| Dieldrin-DDT | 12.3 |
| Toxaphene-DDT | 13.5 |
| *L.S.D., 5 per cent level* | *1.3* |

**FIGURE 6. Cotton yields from sprayed and unsprayed plots, Plant Breeding Unit, Tallassee, 1950. (Four replications, yields calculated on 10-acre basis.)**

**FIGURE 7. Effects of insect control on yields of seed cotton; untreated check at left yielded 289 pounds per acre; cotton at right sprayed 12 times with toxaphene-DDT while crop was being set and matured produced an average yield of 1,887 pounds per acre.**

**Dusting Experiment, Tallassee, 1950.** A dusting experiment was conducted in a portion of the field used in the spraying experiment previously described. Six insecticidal treatments were tested in the form of dusts, which were applied with an 8-row tractor duster at the rate of 10 to 15 pounds per acre per application. All treatments were replicated four times. Twelve applications were made during the period July 8 to August 26, when the operation had to be discontinued because the cotton stalks were blown down by heavy winds.

Summarized results of the cotton-dusting experiment are presented in Table 2 and Figure 8. **All insecticides used were effective in control of boll weevil and all reduced bollworm infestation to a**

TABLE 2. AVERAGE INSECT INFESTATIONS ON DUSTED AND UNDUSTED PLOTS, FOUR REPLICATIONS, PLANT BREEDING UNIT, TALLASSEE, 1950

| Treatment[1] | Per cent Infestation: Boll weevil | Per cent Infestation: Bollworm |
|---|---|---|
| | *Per cent* | *Per cent* |
| Undusted check | 78.9 | 8.0 |
| Calcium arsenate alternated with calcium arsenate-nicotine | 56.8 | 4.2 |
| 2.5% aldrin-5% DDT | 50.0 | 1.1 |
| Calcium arsenate alternated with BHC-DDT | 54.9 | 1.4 |
| 20% toxaphene | 52.1 | 1.6 |
| 3% (gamma) BHC-5% DDT | 53.5 | 1.0 |
| 1.5% dieldrin-5% DDT | 44.6 | 1.4 |

[1]Dusts applied July 8 (rain), 18, 22 (rain), 29 (rain), 31; August 4, 9, 11, 15, 19, 23, 26.

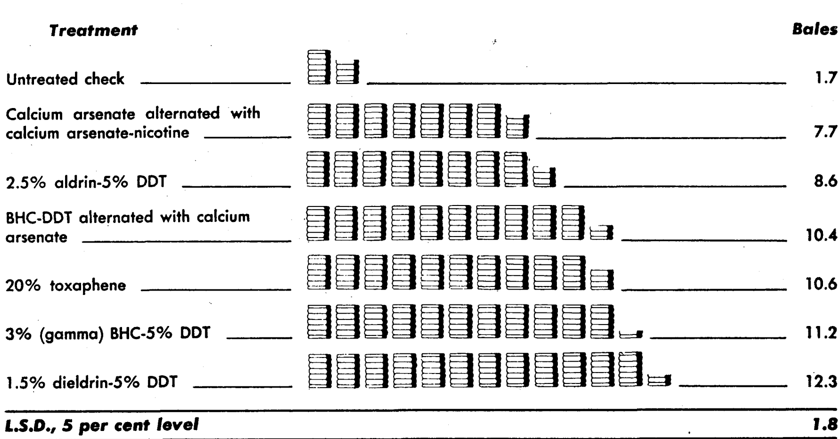



**FIGURE 8. Cotton yields from dusted and undusted plots, Plant Breeding Unit, Tallassee, 1950. (Four replications, yields calculated on 10-acre basis.)**

**satisfactory level,** although calcium arsenate appeared less effective against bollworm than other materials used. Spider mites were not a major pest in this experiment. Heavy aphid populations developed late in the season on the plots receiving alternate applications of calcium arsenate and calcium arsenate-nicotine. Average yields of seed cotton varied from 263 pounds per acre on the check plots to 1,718 pounds on the areas treated with dieldrin-DDT.

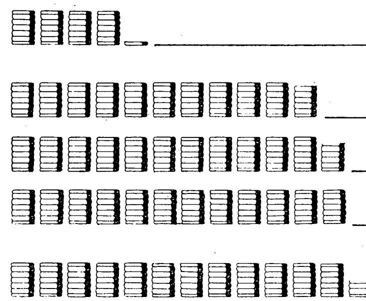
**Dusting Experiment, Monroeville, 1950.** A dusting experiment was conducted at the Experiment Field near Monroeville in southwestern Alabama to determine effectiveness of various insecticides applied as dusts during the fruiting period of cotton. Treatments were replicated five times on small plots, and the insecticides were applied with a rotary type hand-duster at the rate of 8 to 15 pounds per acre, depending upon size of cotton. Rainfall was frequent at the beginning of the experiment. However, the weather was extremely dry in August and as a result the yield of the top crop of cotton was reduced. Summarized results of the experiment at Monroeville are presented in Table 3 and Figure 9.

BHC-DDT mixture, calcium arsenate alternated with BHC-DDT, and 20 per cent toxaphene were equally effective in controlling cotton insects. Where calcium arsenate was alternated with calcium arsenate-2 per cent nicotine, the yield of cotton was significantly lower than on other dusted plots. Gains from the best treatments were approximately three-fourths of a bale per acre. These data show

TABLE 3. INSECT INFESTATION ON DUSTED AND UNDUSTED PLOTS, MONROEVILLE EXPERIMENT FIELD, 1950

| Treatment[1] | Insect infestation: Boll weevil | Insect infestation: Boll-worm | Aphids per square inch (Aug. 14) |
|---|---|---|---|
| | *Per cent* | *Per cent* | *Number* |
| Untreated check | 87.1 | 6.6 | 11.4 |
| 7 applications calcium arsenate alternated with 7 applications calcium arsenate-nicotine | 60.3 | 2.1 | 10.9 |
| 14 applications toxaphene during maximum fruiting | 61.0 | 1.1 | 0.5 |
| 14 applications BHC-DDT during maximum fruiting | 61.7 | 0.4 | 0.2 |
| 7 applications calcium arsenate alternated with 7 applications BHC-DDT during maximum fruiting | 57.3 | 1.3 | 8.3 |

[1]July 3, 8 (rain), 18, 22, 25, 29 (rain); August 1, 5, 9, 14, 18, 22, 25 (rain), 28 (rain).



| Treatment | Bales |
|---|---|
| Untreated check | 4.1 |
| 7 applications calcium arsenate alternated with 7 applications calicum arsenate-nicotine, maximum fruiting | 10.9 |
| 14 applications toxaphene during maximum fruiting | 11.8 |
| 14 applications BHC-DDT during maximum fruiting | 12.0 |
| 7 applications calcium arsenate alternated with 7 applications BHC-DDT during maximum fruiting | 12.5 |
| *L.S.D., 5 per cent level* | *1.0* |

**FIGURE 9. Cotton yields from plots receiving various insecticidal dusts, Monroeville Experiment Field, 1950. (Five replications, yields calculated on 10-acre basis.)**

that calcium arsenate and calcium arsenate-nicotine were moderately effective in control of cotton insects. All other insecticidal treatments were highly effective.

## Timing of Applications

Entomologists and farmers have been interested for many years in the possibility of controlling boll weevil by applying insecticides early to kill overwintered adults. However, experiments have shown that profitable control has not resulted from the use of calcium arsenate in the form of pre-square mopping and pre-square dusting. Introduction of new organics again focused attention upon early application of insecticides. Results of experiments on timing of applications of new organics in Alabama over a 4-year period are presented here. To date, pre-square applications have not been effective in reducing later damage or increasing yield.

### *Dusting before and just after squaring begins*

Experiments were conducted in Alabama during the 3-year period, 1947-1949, to determine effectiveness of early applications of newer organic insecticides. In general, the procedure was to apply three to four applications of insecticides at 5- to 7-day intervals, beginning just as the first squares were formed. This procedure should allow time for a maximum number of overwintered weevils to emerge and then permit kill with insecticides before the insects can infest cotton squares.

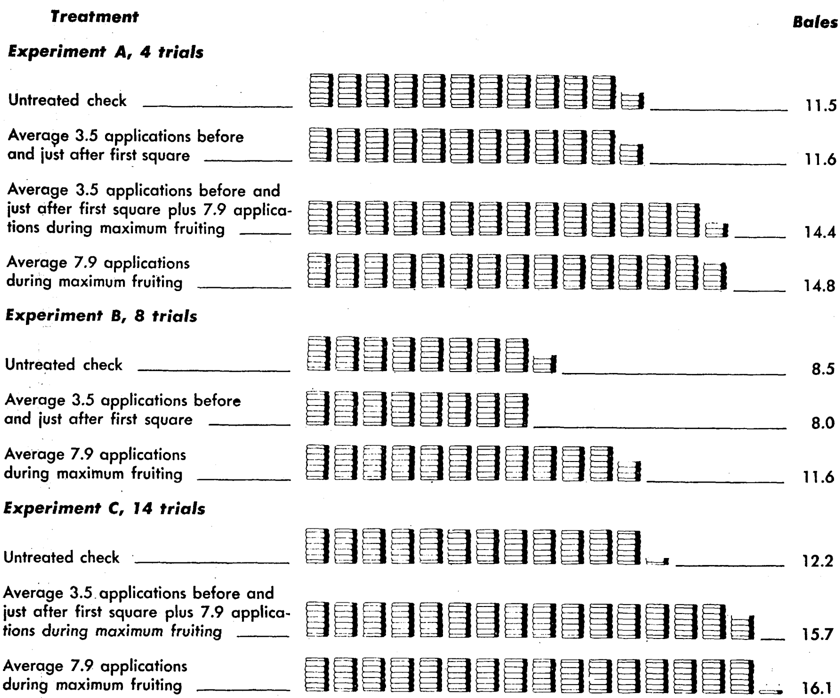



**FIGURE 10. Cotton yields from time-of-application experiments using 20 per cent toxaphene dust for cotton insect control, 3-year average, 1947-49. (Yields calculated on 10-acre basis.)**

Results of field-scale and small plot experiments on timing of applications are presented graphically in Figure 10. No yield gains resulted from applications made before and just after squaring began in 1947, 1948, or 1949 in Alabama. During one season, the plots receiving three such dustings produced less cotton than undusted checks in each of four fields near Prattville. The reduction in yield resulted from bollworms coming into the area after the dusting operation had ceased. Insect predators had been destroyed by the insecticides, and bollworms caused more damage on dusted plots than on undusted areas. In several tests cotton yields from plots treated before squares were numerous were slightly but not significantly lower than those on the corresponding plots receiving no early application.

### *Preventive insect control*

During the past several years, a program of so-called preventive insect control has been developed in some sections. In this program, insecticides are applied usually as sprays when the cotton is in the

2- to 4-leaf stage, regardless of whether insects are present. Two to three applications are made at weekly intervals to control thrips, aphids, flea hoppers, and any boll weevils that may be present.

Several experiments were conducted in Alabama in 1950 to test the effectiveness of this procedure during a season when the boll weevil was very abundant on small cotton.

**Preventive Spraying With Tractor Equipment at Prattville.** A field-scale spraying experiment was conducted in 1950 on the Murfee and Dismukes farms near Prattville to determine the effect of timing sprays on control of cotton insects and seed cotton yield. All sprays used were prepared from commercial emulsifiable concentrates. Pre-square applications were at the rate of 1 pound of toxaphene per acre per application, while later applications were at the rate of 2 pounds. The sprays were applied with tractor equipment at rates ranging from 2 to 6 gallons per acre per application, depending upon the size of the cotton and number of nozzles used. All treatments were replicated five times on plots that varied from 1 to 5 acres in size, depending upon the length of the rows in the field. A dust treatment of 20 per cent toxaphene was used for comparative purposes.

Treatments used in this experiment were as follows:

(1) Untreated check.

(2) Toxaphene spray, 4 applications, beginning when the cotton was in the 2- to 4-leaf stage; no further treatment.

(3) Toxaphene spray, 4 applications, beginning when cotton was in 2- to 4-leaf stage followed by 13 applications while the crop was being set and matured, beginning at 25 per cent infestation.

(4) Toxaphene spray, 13 applications, while the crop was being set and matured, beginning at 25 per cent infestation.

(5) Toxaphene dust, 13 applications, while the crop was being set and matured, beginning at 25 per cent infestation.

Population counts of boll weevil adults are presented in Table 4.

TABLE 4. AVERAGE BOLL WEEVIL POPULATIONS ON SPRAYED AND UNSPRAYED COTTON IN FIVE FIELDS, MURFEE AND DISMUKES FARMS, TALLASSEE, 1950

| Date of count | Treatments and average number boll weevils per acre | |
|---|---|---|
| | Unsprayed Check | 4 sprayings[1] beginning 2- to 4-leaf stage |
| | *Number* | *Number* |
| May 11 | 0 | 0 |
| May 26 | 828 | 816 |
| June 3 | 1,300 | 581 |
| June 13 | 2,459 | 1,390 |

[1]Applied May 11 (after count), 19, 26 (after count), June 5 (preventive insect control).

No adults were found at the time the first application of spray was made. Following the second application, boll weevil adults were as numerous on the sprayed as on the unsprayed plots, the average number per acre being over 800. The number of adults continued to increase as a result of emergence from hibernation until the time of the last count, June 13, when an average of 1,390 boll weevil adults per acre were found on the plots sprayed four times at weekly intervals. The number on the checks had increased to an average of 2,459.

Summarized results of insect infestations and cotton yields are presented in Table 5 and Figure 11. Yields ranged from 337 pounds of

TABLE 5. AVERAGE INSECT INFESTATIONS, FIVE REPLICATIONS, MURFEE AND DISMUKES FARMS, 1950

| Treatment | Average infestation | | | |
|---|---|---|---|---|
| | Boll weevil | | Boll-worm | Aphids per sq. inch |
| | Before July 7 | After July 7 | | |
| | *Per cent* | *Per cent* | *Per cent* | *Number* |
| Untreated check | 72.8 | 79.9 | 7.9 | 0.78 |
| 4 applications toxaphene spray[1] beginning at 2- 4-leaf stage | 72.2 | 75.5 | 8.6 | 1.02 |
| 13 applications toxaphene dust[2] during maximum fruiting | 73.3 | 23.9 | 2.7 | 0.26 |
| 13 applications toxaphene spray[2] during maximum fruiting | 71.4 | 31.5 | 2.0 | 0.26 |
| 4 applications toxaphene spray[1] at 2- 4-leaf stage plus 13 applications[2] during maximum fruiting | 70.0 | 30.1 | 1.6 | 0.18 |

[1]May 11, 19, 26; June 5 (preventive insect control).
[2]July 7, 11 (rain), 17 (rain), 21 (rain), 24, 29 (rain); August 1, 5, 16, 21, 25, 29; September 4.

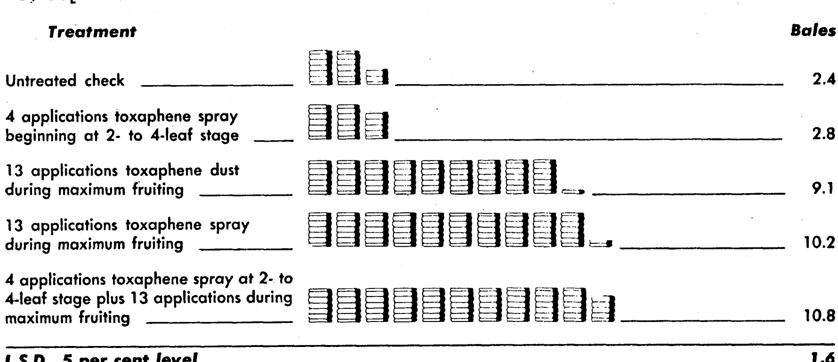



**FIGURE 11. Cotton yields from untreated checks and from areas receiving pre-square and mid-season treatments, Murfee and Dismukes Farms, Prattville, 1950. (Five replications, yields calculated on 10-acre basis.)**

seed cotton on the untreated check to 1,507 pounds per acre on areas sprayed 17 times with toxaphene. Four "preventive" applications made at weekly intervals prior to fruiting of the cotton failed to increase the yield significantly above that of the untreated check. Where four pre-square applications were followed by 13 additional sprayings during the fruiting period of the cotton, the yield was not significantly higher than on areas where 13 applications were made only during the fruiting period without pre-square treatment, Figure 12-ABCD.

**FIGURE 12. Effects of timing applications of insecticides on seed cotton yields; (A) untreated check, average yield 337 pounds per acre; (B) cotton treated with toxaphene at four weekly intervals beginning at 2- to 4-leaf stage with no further treatments, average yield 390 pounds per acre; (C) cotton treated the same as (B) plus 13 applications during maximum fruiting, average yield 1,170 pounds per acre; (D) cotton treated 13 times during maximum fruiting, average yield 1,089 pounds per acre.**

**Preventive Spraying With Airplane Equipment on Dismukes Farm.** A large-scale experiment using aerial equipment was done on the Dismukes farm to determine effects of timing applications of aldrin and toxaphene on the control of cotton insects. Each treated area consisted of a 7-acre block of cotton. Four applications of aldrin were made at weekly intervals, beginning when the cotton was in the 2-leaf stage on one 7-acre block. Toxaphene was applied to an adjacent 7-acre block at the same time. The original plan of this experiment was to apply no further treatments unless necessary and in order to compare results with applications made during the fruiting period of cotton in 7-acre blocks in the same field. When the cotton began fruiting freely, it was found that the boll weevil infestation on the areas receiving the four pre-square applications was as high as on the untreated areas. Twelve additional applications, beginning at 25 per cent infestation, were made on these areas receiving pre-square treatment. Twelve applications were also made on 7-acre blocks that had no pre-square treatments.

Results of this experiment are presented in Table 6 and Figure 13. All insecticidal treatments gave satisfactory control of boll weevil and bollworm. It should be noted that DDT was included in the aldrin spray for bollworm control. A heavy population of aphids developed

TABLE 6. EFFECT OF TIMING ALDRIN AND TOXAPHENE SPRAYS ON INSECT INFESTATION, AIRPLANE APPLICATOINS, DISMUKES FARM, 1950

| Treatment | Amount of technical per acre | Average infestation | | Insects per square inch | |
|---|---|---|---|---|---|
| | | Boll weevil | Bollworm | Aphids | Spider mites |
| | *Pound* | *Pct.* | *Pct.* | *No.* | *No.* |
| Unsprayed check[1] | 0.0 | 61.7 | 10.6 | 8.6 | 2.9 |
| Aldrin-DDT, 4 applications[2] 2- to 4-leaf stage plus 12 applications during maximum fruiting | Ald., 0.25 DDT, 0.50 | 11.0 | 0.8 | 15.3 | 10.1 |
| Aldrin-DDT, 12 applications during maximum fruiting[3] | Ald., 0.25 DDT, 0.50 | 14.7 | 1.2 | 12.2 | 2.5 |
| Toxaphene, 14 applications during maximum fruiting[3] | 2.0 | 23.7 | 4.6 | 2.1 | 0.9 |
| Toxaphene, 4 applications[2] 2- to 4-leaf stage plus 12 applications during maximum fruiting[3] | 2.0 | 14.3 | 2.8 | 6.1 | 2.9 |

[1]Small corner left for check partly treated by drift; no picking record made.
[2]May 11, 19, 26; June 5 (preventive insect control).
[3]July 7, 11 (rain), 17 (rain), 21 (rain), 24, 29 (rain); August 1, 5, 16, 21, 29; September 4.

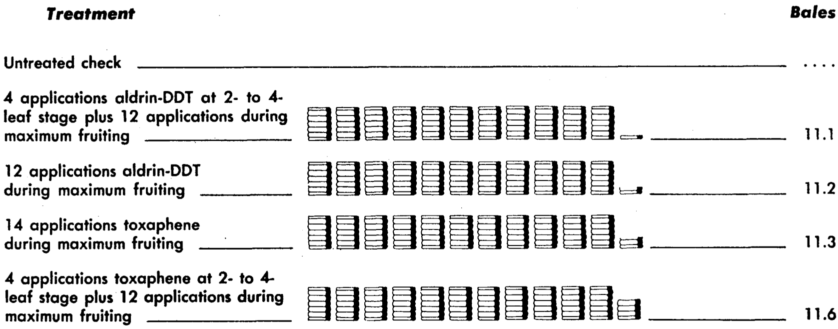



**FIGURE 13. Cotton yields from treated and untreated blocks in time-of-application experiment using toxaphene and aldrin sprays applied by airplane, Dismukes Farm, Prattville, 1950. (Yields calculated on 10-acre basis.)**

on the areas treated with aldrin-DDT and spread to some extent to other areas. Late in the season, there was also a build-up of spider mites where aldrin was applied 16 times. The entire field was dusted with 3 per cent nicotine in order to control cotton aphid. There were no appreciable differences between yields of cotton on the areas receiving the different insecticides or different timing of applications.

**Preventive Spraying With Airplane Equipment on Murfee Farm.** A large-scale spraying experiment was conducted on the Murfee farm in 1950 to determine the effects of timing of toxaphene spray on insect infestations and seed cotton yields. Each treatment was on a 5-acre block of cotton. The same general procedure described under the experiment on the Dismukes farm was followed in this experiment. Summarized results are presented in Table 7 and Figure

TABLE 7. EFFECT OF TIMING TOXAPHENE SPRAYS ON INSECT INFESTATIONS, AIRPLANE APPLICATIONS, MURFEE FARM, 1950

| Treatment | Amount of technical per acre | Average infestation | | Insects per square inch | |
|---|---|---|---|---|---|
| | | Boll weevil | Boll-worm | Aphids | Spider mites |
| | *Pound* | *Pct.* | *Pct.* | *No.* | *No.* |
| Untreated check | 0.0 | 81.7 | 6.0 | 5.4 | 4.9 |
| 13 applications during maximum fruiting[1] | 2.0 | 60.0 | 3.8 | 0.8 | 2.5 |
| 4 applications 2- to 4-leaf stage[2] plus 13 applications during maximum fruiting[1] | 2.0 | 54.0 | 2.2 | 2.0 | 4.5 |

[1]July 7, 11 (rain), 17 (rain), 21 (rain), 24, 29 (rain); August 1, 5, 16, 21, 25, 29; September 4.
[2]May 11, 19, 26; June 3 (preventive insect control).

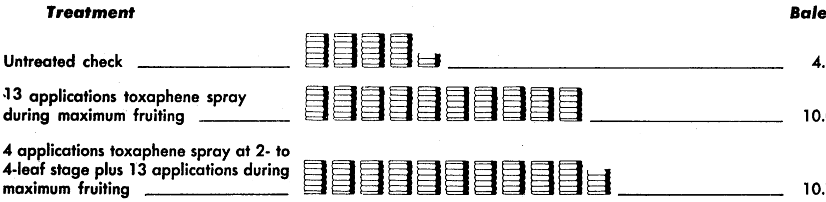



**FIGURE 14. Cotton yields from treated and untreated blocks in time-of-application experiment using toxaphene spray applied by airplane, Murfee Farm, Prattville, 1950. (Yields calculated on 10-acre basis.)**

14. The cotton yields on the sprayed areas were approximately twice that of the check plot. The two insecticidal treatments appeared equal in effectiveness. Some control from drift was obtained on the check.

**Preventive Dusting at Monroeville.** A small-plot dusting experiment was conducted in 1950 at Monroeville Experiment Field in southwestern Alabama to determine the effect of timing applications on insect control. All treatments were replicated five times in randomized blocks. Twenty per cent toxaphene dust was used in this time-of-application experiment. In one treatment, three dustings were made at weekly intervals, beginning when the cotton was in the 4-leaf stage (preventive control). These applications were followed by 14 additional dustings during the fruiting period of the cotton. In a second treatment three applications of 20 per cent toxaphene were made at weekly intervals, beginning just after squaring began (when the first squares were large enough for infestation punctures). These applications were followed by 14 dustings later in the season. In a third treatment, 14 applications of 20 per cent toxaphene were applied during the time the cotton was setting and maturing a crop. All applications were made with hand-dusters at the rate of 8 to 15 pounds per acre per application.

Summarized results of the experiment at Monroeville are presented in Table 8 and Figure 15. Where the insecticide was applied during the fruiting period of the cotton, the boll weevil was controlled and satisfactory yields resulted. **Three preventive applications at weekly intervals, beginning at the 4-leaf stage, did not increase the yield significantly over plots receiving no preventive control. Three applications** applied soon **after squaring began increased the yield significantly** over plots receiving no treatment until maximum fruiting of cotton occurred. This increase in yield is the only one ever recorded by the Alabama Station where so-called early applications were profitable. The insecticide in this instance was applied during

Table 8. Effect of Timing Applications of Insecticides on Insect Infestation, Monroeville Experiment Field, 1950

| Treatment | Insect infestation: Boll weevil | Insect infestation: Boll-worm | Aphids per square inch (Aug. 14) |
|---|---|---|---|
| | *Per cent* | *Per cent* | *Number* |
| Untreated check | 87.1 | 6.6 | 11.4 |
| 14 applications[2] toxaphene during maximum fruiting | 61.0 | 1.1 | 0.5 |
| 3 applications toxaphene at 4-leaf stage[1] plus 14 applications[2] during maximum fruiting | 59.3 | 0.8 | 0.2 |
| 3 applications toxaphene just after squaring began[3] plus 14 applications during maximum fruiting[2] | 56.6 | 1.0 | 0.9 |

[1]May 4, 12, 19 (preventive insect control).
[2]July 3, 8 (rain), 18, 22, 25, 29 (rain); August 1, 5, 9, 14, 18, 22, 25 (rain), 28 (rain).
[3]June 6, 14, 21.

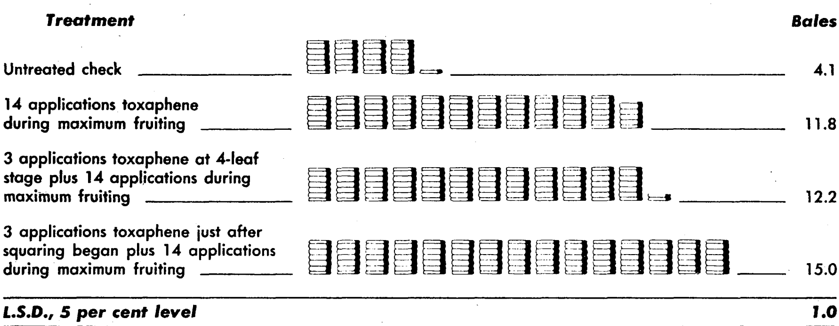



**FIGURE 15. Cotton yields from dusted and undusted plots in time-of-application experiment, Monroeville Experiment Field, 1950. (Five replications, yields calculated on 10-acre basis.)**

the early part of the fruiting period of the cotton. A severe drought in August followed by storms prevented maturing a top crop.

## Interval Between Applications

For many years the recommended interval between applications of insecticides has been 5 days. This was established as the maximum for effective control with calcium arsenate under average conditions. An experiment was conducted at the Wiregrass Substation in 1948 to determine the effect of organic insecticides applied at various intervals on infestation and yield of seed cotton during a period of exceptionally heavy boll weevil infestation late in the season.

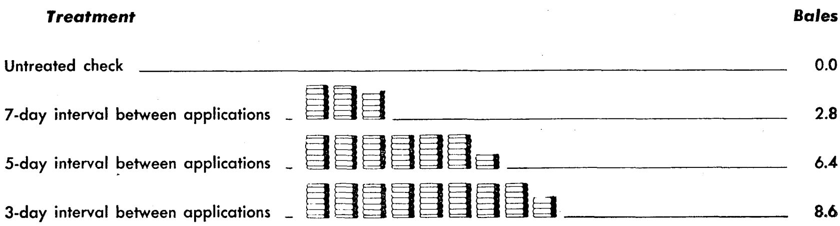



**FIGURE 16. Cotton yields from untreated checks and plots dusted with toxaphene and BHC-DDT at 3-, 5-, and 7-day intervals between August 13 and September 22, Wiregrass Substation, Headland, 1948. (Yields calculated on 10-acre basis.)**

The weather had been extremely dry and the cotton crop was almost a complete failure. A few bolls opened and were picked. Late in July, rainfall stimulated rapid growth and fruiting of the cotton. Adults of the boll weevil swarmed in from nearby fields where rain had occurred earlier in the season. The infestation in the experimental field was almost 100 per cent at the beginning of the experiment.

Insecticides were applied at the rate of 12 to 15 pounds per acre at intervals of approximately 3 days, 5 days, and 7 days. Twenty per cent toxaphene and BHC-DDT, 3-5 dusts were used. Results of the experiment are presented in Figure 16. It is obvious from these results that the interval between dustings should not exceed 5 days. Where the insects were migrating in large numbers as occurred in this experiment, the highest yields were obtained on plots receiving application at 3-day intervals. From a practical point of view, this short interval is not feasible over a long period. However, when insects are extremely numerous and rainfall is frequent, twice-a-week applications may be necessary.

## Four-Year Average Results of Experiments With Insecticides

The new organic insecticides have been used experimentally in Alabama over a 4-year period, 1947-50. Results reported here are from experiments where the insecticides were applied during the time the cotton crop was being set and matured. Treatments were begun after the plants were fruiting freely and 25 per cent of the squares were punctured.

Four-year average yield of cotton from the treated and untreated areas are presented in Figure 17. Plots receiving the four treatments were located in the same field 30 times over the 4-year period. Twenty per cent toxaphene dust and BHC-DDT, 3-5 mixture, were equally effective in these experiments. Each increased the yield one-

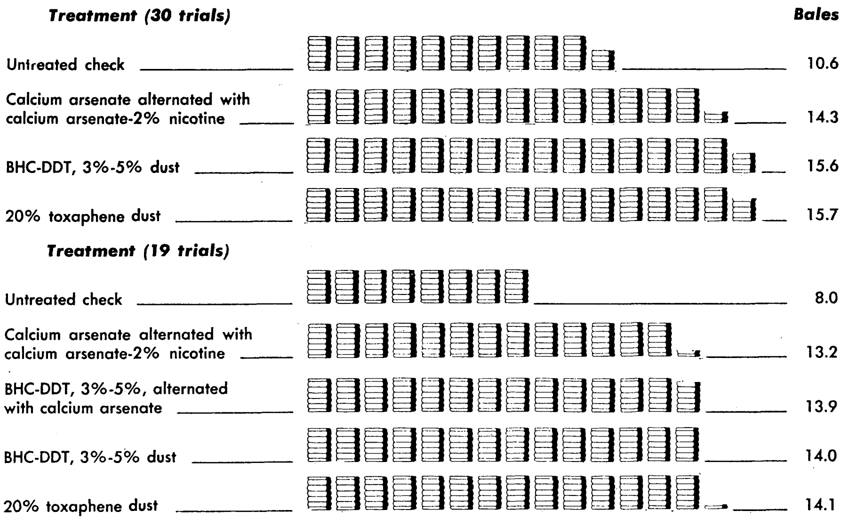



**FIGURE 17. Average cotton yields from untreated checks and areas receiving different treatments in the 4-year period, 1947-50, at several locations in central and southern Alabama. (Yields calculated on 10-acre basis.)**

half bale per acre. Calcium arsenate alternated with calcium arsenate-2 per cent nicotine was slightly less effective.

Plots receiving the five treatments were located in the same field 19 times over the 4-year period. BHC-DDT, 3-5 mixture; BHC-DDT, 3-5, alternated with calcium arsenate; and 20 per cent toxaphene dust were approximately of equal effectiveness. Each material in these experiments increased the yield of cotton more than one-half bale per acre. It is obvious from these results that satisfactory control of cotton insects can be had with any one of these treatments if proper procedures are followed.

## Effectiveness of Dusts and Sprays

For many years cotton insecticides have been applied as dusts. With the introduction of new organic insecticides and the principle of low-gallonage sprays, control of cotton insects with sprays became feasible for the first time. Experiments were conducted in 1949 and 1950 to test recommended insecticides in the form of sprays. Results of some of these experiments performed in 1950 have been presented. Summarized results from the use of toxaphene spray and dust, each applied at the rate of 2 pounds technical per acre, over the 2-year period are presented in Figure 18. Toxaphene is used here as an example because more information is available on this material than any other.

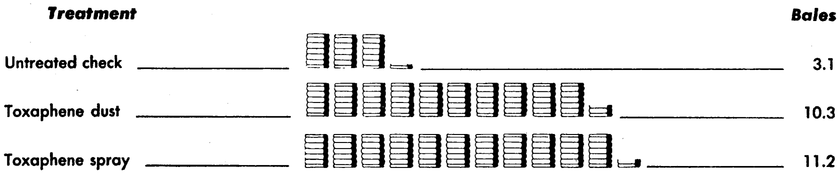



**FIGURE 18. Average cotton yields from untreated and dusted and sprayed areas, Murfee Farm, Prattville, 1949-50. (Nine replications, yields calculated on 10-acre basis.)**

It is apparent from the yield data that sprays were as effective as dusts in the control of major cotton insects. Sprayed plots yielded slightly more cotton than the dusted areas, but the differences were not significant.

## PROCEDURES *in* CONTROL *of* COTTON INSECTS

Procedures based on experimental results have been developed for cotton insect control. These procedures have been tested under various conditions and should be followed for profitable results.

Application of the right amount of insecticide at proper intervals is the most important factor in control of cotton insects. It is more important than deciding which of the recommended insecticides to use, whether to apply dust or spray, or whether to use ground or aerial equipment.

### When to Begin Applications

The time to **begin** applications of insecticides can be and frequently is over-emphasized. It is possible to make an excellent crop in Alabama, **beginning** any time from 2-leaf stage until the cotton has 15 to 30 squares per plant. However, once treatment is begun, it is hazardous to discontinue the operation until the top bolls are nearly mature. Bollworm damage may be much more severe where dusting or spraying has been discontinued than in fields where no insecticide has been applied. No gains in yield have resulted from pre-square applications over a period of years (Figure 10, page 19). For these reasons, pre-square applications are not generally recommended in Alabama unless the stand of cotton is being damaged by insects. It is pointed out, however, that fruit is set a little earlier where insecticides are applied before and just after squaring begins.

**Highest yields at lowest cost result from controlling cotton insects while the crop is being set and matured.** After the plants are fruiting freely, 100 squares should be examined in several places in each field for boll weevil punctures. On good land, the time to begin treatment is when 25 per cent of the squares are punctured. Applications may begin at 10 per cent infestation on poor soil, but control in Alabama is not very profitable on cotton grown on infertile soils.

### Application Intervals and Number of Treatments

During a normal season, three applications of dust or spray should be made at 5-day intervals. The cotton should be examined again for punctures. When infestation exceeds 25 per cent, additional applications should be made at 5-day intervals.

During seasons of very heavy boll weevil infestation or during migration, the interval between applications should be shortened to 4 days. If weevils are extremely numerous and rainfall frequent, it may be necessary to apply insecticides twice a week until the insects are brought under control (Figure 16, page 27). Applications washed off by rainfall within 24 hours must be repeated. It is essential that the insecticide be kept on the plant in spite of unfavorable weather until the top bolls are two-thirds grown. Seven or eight applications may be enough to protect the crop during years of moderate infestation. Ten to 15 treatments were needed in 1950.

### Rate Per Acre

The insecticide may be applied either as a dust or as a spray. Where dusts are used, the rate is 8 to 12 pounds per acre per application, depending upon the size of the cotton. Late in the season when cotton plants are very large and weevils are migrating, it may be necessary to increase the rate to 15 pounds.

Sprays are applied usually at the rate of approximately 2 to 6 gallons per acre per application. Aerial sprayers usually deliver 2 gallons. Ground machines with three nozzles per row usually deliver approximately 6 gallons per acre. The correct amount of emulsifiable concentrate must be mixed with water to insure the proper amount of toxic material. Spray concentrates available together with the recommended dosage per acre are listed below as follows:

**Aldrin.** Emulsifiable concentrate usually contains 1 pound aldrin and 2 pounds DDT per gallon. Dilute with water and apply at the rate of at least 0.25 pound aldrin and 0.5 pound DDT per acre (Table 9).

**Benzene Hexachloride.** Emulsifiable concentrate usually contains 10 per cent gamma isomer and 16.7 per cent DDT. Dilute with water and apply at the rate of not less than 0.3 pound gamma and 0.5 pound DDT per acre (Table 9).

**Dieldrin.** Emulsified concentrate usually contains 2 pounds dieldrin per gallon. Dilute with water, add emulsifiable DDT, and apply at the rate of 0.15 to 0.25 pound dieldrin and 0.5 pound DDT (Table 9).

**Toxaphene.** Emulsifiable concentrate usually contains 4 or 8 pounds of toxaphene per gallon. Dilute with water and apply at the rate of 2 to 3 pounds per acre (Table 9). (Emulsifiable concentrates are also available containing 4 pounds toxaphene and 2 pounds DDT per gallon. Apply at the rate of 2 pounds toxaphene and 1 pound DDT per acre.)

## How to Apply

Where ground dusters are used for applying insecticides, an outlet should be adjusted just above the center of each row of cotton (Figure 19). For ground sprayers, three nozzles should be used per row (Figure 19). In applying by airplane (Figure 19), flagmen are

TABLE 9. EXAMPLES OF PROPORTIONS COMMONLY USED TO FORMULATE MIXTURES FOR SPRAYING ONE ACRE OF COTTON

| Kind and amount of insecticide per gallon of emulsifiable concentrate | Rate per acre | Output of sprayer per acre: 2 gallons — Amount of concentrate | Output of sprayer per acre: 2 gallons — Amount of water | Output of sprayer per acre: 6 gallons — Amount of concentrate | Output of sprayer per acre: 6 gallons — Amount of water |
|---|---|---|---|---|---|
| | *Pounds* | | *Gal.* | | *Gal.* |
| Aldrin, 1lb., plus<br>DDT, 2 lb. | 0.25 aldrin<br>0.50 DDT | 1 qt. | 1¾ | 1 qt. | 5¾ |
| BHC, 0.8 lb. gamma, plus<br>DDT, 1.33 lb. | 0.3 gamma<br>0.5 DDT | 3 pt. | 1⅝ | 3 pt. | 5⅝ |
| Dieldrin, 1 lb., plus<br>DDT, 2 lb. | 0.25 dieldrin<br>0.50 DDT | 1 qt. | 1¾ | 1 qt. | 5¾ |
| Toxephene, 4 lb. | 2.0 | 2 qt. | 1½ | 2 qt. | 5½ |
| Toxaphene, 8 lb. | 2.0 | 1 qt. | 1¾ | 1 qt. | 5¾ |
| Toxaphene, 4 lb. | 3.0 | 3 qt. | 1¼ | 3 qt. | 5¼ |
| Toxaphene, 8 lb. | 3.0 | 3 pt. | 1⅝ | 3 pt. | 5⅝ |
| Toxaphene, 4 lb., plus<br>DDT, 2 lb. | 2.0 toxaphene<br>1.0 DDT | 2 qt. | 1½ | 2 qt. | 5½ |

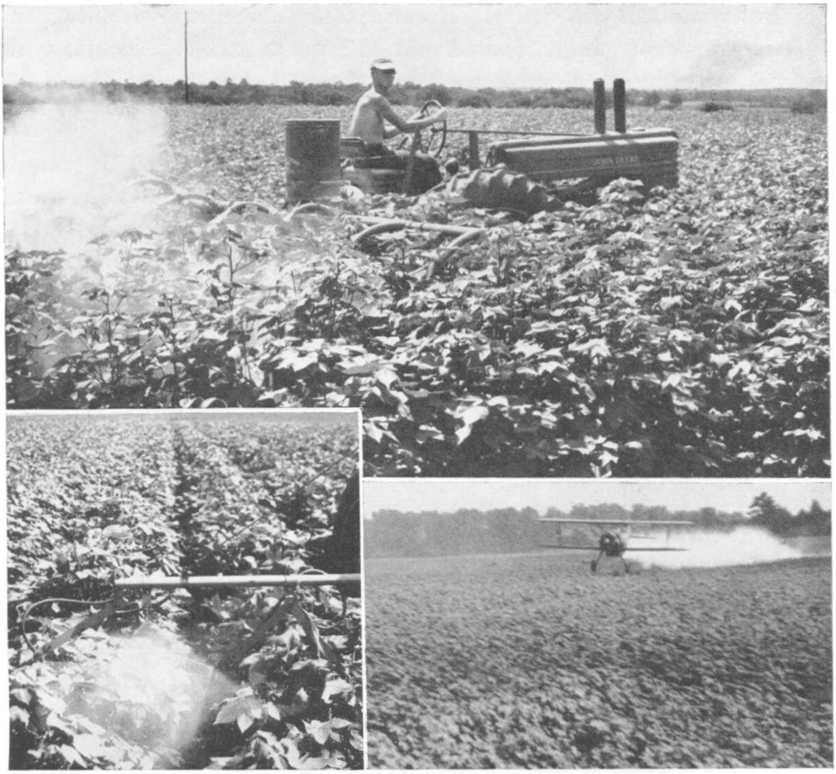


**FIGURE 19. Application of insecticides with ground and aerial equipment; above, eight-row tractor duster; left, close-up of boom of a six-row tractor sprayer; right, dust application by plane.**

used to locate swaths which should not be more than 12 rows wide. Dusts must be applied when the air is calm, usually in the early morning or late afternoon. It is desirable, though not absolutely essential, that the foliage be dry at the time of the application. Sprays may be applied even when air currents are fairly strong. It is usually possible to make application throughout the day, although late afternoon is perhaps the preferred time for applying either dusts or sprays. Foliage of the cotton must be dry when sprays are applied.

Ground sprayers must be tested or calibrated to determine the output in gallons per acre. The easiest way to test a sprayer is to measure the output of one nozzle in a spray meter with the sprayer operated at 50 pounds pressure and at normal speed. In using one of the commonest types of spray meters, the calibrating jar is held under the nozzle while the sprayer moves at normal speed for a distance of 110 yards. The rate per acre is then read direct from a scale on the calibrating jar. By raising or lowering the pressure, the output of the pump can be adjusted to approximately 6 gallons per acre for a sprayer with three nozzles per row. It is advisable generally to operate at a pressure of 40 to 60 pounds. When the output of the sprayer has been accurately determined, the amount of emulsifiable concentrate per tank of spray can then be readily determined. Examples of dilutions are given in Table 9.

### Evaluation of Dusts and Sprays

Sprays are well suited for large-scale operations. They are not generally suitable for small farmers having 5 to 10 acres of cotton. Effective application may be made with tractor or aerial equipment. A tractor sprayer usually operates with a pressure of 40 to 60 pounds. The spray is delivered through hollow-cone nozzles. A satisfactory rig will cover 6 to 8 rows. Plane sprayers vary greatly in the number of nozzles but will usually cover effectively only 10 to 12 rows.

At present, spray rigs are rather expensive. In addition, many are not as durable as dusters under farm use. These are among the chief disadvantages of spraying, together with the complications of figuring dilutions for concentrates. Also availability of water may be a limiting factor.

Farmers are more familiar with dusts than with sprays. Dusts come ready for use and require no mixing. They may be applied successfully with hand-dusters, mule-drawn outfits, tractor equipment, or airplane. It is easy to apply the right amount per acre.

Dusts may be used by any farmer, but they are particularly well suited for those having only 5 to 10 acres of cotton. Small farmers can select a time when the air is calm and obtain good coverage. Larger operators who have to apply insecticides throughout most of the day may have trouble with strong air currents. Dusts do not give good control if applied when the air is moving. Up-currents are especially bad.

### Precautions

Cotton insecticides are poisons. They should be handled with care. The emulsifiable concentrates are particularly hazardous and should not be allowed to remain in contact with the skin. If they are accidentally spilled on any part of the body, wash the material off at once with soap and water and remove soaked clothes. Precaution should be taken to prevent the drifting of insecticides into dwelling houses, vegetable gardens, pastures, and dairy barns. Insecticides should be stored where they are not accessible to livestock or irresponsible persons. Empty containers should be burned or disposed of in some other suitable manner.

Cotton insecticides should not be applied adjacent to fish ponds. Toxaphene is especially toxic to fish. Calcium arsenate is much less harmful.

Cotton insecticides should not be applied in the vicinity of bee yards. Beekeepers should be notified when control operations are to begin in a community. Insecticides applied in the late afternoon kill fewer bees than those applied in the morning. Calcium arsenate is particularly destructive to bees. The new organics, particularly toxaphene, are less harmful.

## SUMMARY *and* CONCLUSIONS

(1) The most important pests of cotton in Alabama, in order of importance, are boll weevil, bollworms, cotton aphid, and spider mites and thrips. Unless the stand of cotton is being damaged by insects, applications of insecticides before squaring begins have not increased the yield of cotton in Alabama. Applications before and just after squaring begins may cause the crop to be set a few days earlier.

(2) After the plants are squaring freely, apply 8 to 15 pounds per acre of a recommended dust or equivalent amount of spray at 5-day intervals when boll weevil infests 25 per cent or more of the squares.

(3) When boll weevil infestation is extremely heavy or when the insects are migrating late in the summer, reduce the interval between applications to 4 days, or in extreme instances to twice a week, and increase the rate of application to 15 pounds of dust per acre or an equivalent amount of spray.

(4) Continue the control operation until the top bolls are two-thirds grown.

(5) Keep the insecticide on the cotton when the boll weevil or other pests are abundant regardless of weather. If washed off within 24 hours, repeat the application.

(6) Dusts and sprays are about equally effective. Sprays are excellent for custom operators and farmers growing large acreages of cotton. Dusts at present are more practical for farmers having 5 to 10 acres of cotton.

(7) Recommended insecticides include aldrin-DDT, BHC-DDT, calcium arsenate alternated with BHC-DDT, dieldrin-DDT, and toxaphene. All may be applied as dusts and all except calcium arsenate may be applied as sprays. A mixture of toxaphene and DDT, 2 to 1, is also recommended as a spray.

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