AN EVALUATION OF THRIPS POPULATIONS AND CONTROL METHODS ON COTTON IN YUMA COUNTY, 1953

by

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INTRODUCTION

Thrips are capable of causing serious damage to cotton seedlings by feeding activities which may lower plant vitality, distort leaf tissues, destroy apical buds, and reduce stands. This may be followed by delayed and shortened blossoming and fruiting periods and by reductions in the amount and quality of harvested cotton. The degree of injury appears to vary between different cotton growing areas and with local conditions.

This is a report of original observations made in 1953 near Yuma, Arizona, on the effects of insecticides applied for thrips control upon the growth, fruiting and yields of cotton. The work done by the writer began in the latter part of May, 1953. The required insecticide applications and earlier field observations were made by Dr. Donald M. Tuttle of the University of Arizona Agricultural Experiment Station.

REVIEW OF LITERATURE

A number of species of thrips have been found to attack cotton in Southern United States. Eyer and Medler (1941) reported specimens collected on cotton in New Mexico to be the western flower thrips *Frankliniella occidentalis* (Perg.). Bailey (1938) reported *Frankliniella occidentalis* (Perg.) and *Frankliniella moultoni* (Hood) as being responsible for injury to seedling cotton in California. In his studies of the distribution of injurious thrips in the United States, Bailey (1940) listed the following species of thrips of economic importance in Arizona and California, not necessarily attacking cotton: *Frankliniella gossypiana* Hood, *Frankliniella occidentalis* (Perg.), *Frankliniella moultoni* (Hood), and the Arizona cotton thrips, *Anaphothrips arizonensis* Morgan. Another species, *Frankliniella insularis* (Franklin), is listed as occurring only in Arizona, Florida, and Texas. The species reported attacking seedling cotton with the greatest severity in Arizona, California, and New Mexico is the western flower thrips, *Frankliniella occidentalis* (Perg.). Eddy and Clark (1930) reported the onion thrips, *Thrips tabaci* Lind., as the most injurious of species on cotton in South Carolina. Watts (1937) listed *Frankliniella tritici* (Fitch), the tobacco thrips, *Frankliniella fusca* Hinds, *Thrips tabaci*, and *Sericothrips variabilis* (Beach) as causing appreciable damage to cotton at irregular intervals in South Carolina. Dunnam and Clark (1937) reported *Frankliniella tritici* Fitch, *Frankliniella fusca* Hinds, *Frankliniella runneri* Morgan, and *Sericothrips variabilis*

(Beach) as the species of thrips most responsible for injury in Mississippi. Newsom et al (1953) reported the tobacco thrips Frankliniella fusca Hinds as the most injurious species in Louisiana. He found that only three per cent of the total adult populations taken from cotton were Frankliniella tritici (Fitch), but reported that this species often develops heavy populations in the blossoms. The onion thrips, Thrips tabaci Lind., made up a very small percentage of the total population. In Texas, Gaines et al (1934, 1951) and Fletcher and Gaines (1939) reported the most common species found attacking cotton to be Frankliniella tritici Fitch and Sericothrips variabilis (Beach), with Frankliniella fusca Hinds and Frankliniella exigua Hood present in small numbers.

The life cycle of Frankliniella occidentalis (Perg.) has been carefully described by Bryan (1952). The eggs are inserted in leaves, flower parts, or in fruits and hatch in about four days under optimum conditions. The first instar nymphs begin feeding almost immediately. The first molt occurs within from one to three days, and in this stage mobility quickly increases. Second instar nymphs are golden yellow, and often seek enclosed areas for feeding. After three days second instar nymphs become sluggish, molt, and transform into early pseudo-pupae. This stage lasts one day and is characterized by the appearance of wing pads and erect antennae. At the end of the early pseudo-pupal period the antennae are extended back over the head and remain so until the final molt. The adult emerges two to nine days later, according to temperature. The newly emerged adult female is white to light yellow and soon becomes extremely active. Oviposition normally begins within

72 hours and continues intermittently throughout the adult period. The number of eggs laid per day per female varies from 0.66 to 1.63. The longevity of a female adult is about forty days under laboratory conditions. Bryan's foregoing observations of the developmental stages apply equally to males, except that the latter have approximately half the life expectancy of the females.

The biology of the tobacco thrips, Frankliniella fusca Hinds, was investigated by Eddy and Livingston (1931) under South Carolina conditions. Development from egg to adult required about two weeks under laboratory conditions. The eggs hatched in five days, while the first and second nymphal stages each extended for two or three days. The pseudo-pupal stage extended for one and one-half days, with a three-day pupal period before adult emergence. They reported winged (macropterous) and wingless (brachypterous) forms of both sexes. Females hatched from fertilized eggs, although only males hatched from unfertilized eggs. Adult females deposited an average of 14 eggs in 8 days. The length of the life cycle varied from 15 days in July to 26 days in August.

Bryan (1952) found differentiation of species in the genus Frankliniella to be extremely difficult. Some taxonomists have been misled by short study series. With an abundance of specimens intergradation between species is so common that clearly delineated species are the exception rather than the rule. Widely used morphologic differences such as setal length and patterns, length and width of antennal segments, and relative body measurements vary within such ranges as to prohibit their use as specific characters. Coloration is even less reliable.

In the Frankliniella occidentalis complex Bryan (1952) reported three color forms which he designated as pale, intermediate, and dark. The relative abundance of these forms varies according to the season of the year, with the pale form dominant in the fall and winter and the dark form predominating during wet springs. The intermediate form maintains a fairly constant level throughout the year. All forms were observed to interbreed freely.

Injury to seedling cotton is caused by the feeding adult and immature thrips. Adults attack plants as soon as they emerge from the soil, feeding and depositing eggs in the cotyledons and leaves. Heavy feeding on cotyledons gives them a silvery appearance (Newsom et al, 1953). Feeding injury to leaf buds results in ragged, crinkled leaves that are often tightly curled (Smith, 1942).

When the infestations are severe, buds may be killed outright. Fletcher and Gaines (1939) reported that thrips frequently destroyed terminal buds of cotton seedlings in Texas and that plants so injured ceased further development and died within a short time. When the terminal bud is injured and plants have developed beyond the seedling stage, new growth is greatly retarded until other buds develop. This often causes excessive branching. These workers found that when one of the branches assumes dominance and grows more rapidly than the others a plant may finally approach a normal condition, with the original injury apparent only in a slight curve near the base of the stalk.

Severely damaged seedlings may be retarded in growth for two to three weeks as compared with nearby uninjured plants (Eddy and Clark, 1930). Bailey (1938) observed that thrips-injured plants in California may show temporary stunting, although recovery is rapid after the onset of hot weather. Eyer and Medler (1941) reported thrips caused retarded growth and malformed cotton seedlings in New Mexico.

Newsom et al (1953) reported that thrips-injured plants produced significantly more dry matter per unit area of leaf surface than comparable uninjured plants, although during the first 10 weeks of growth the latter developed a much greater amount of new leaf area.

To emphasize the suddenness and short duration of thrips attacks in South Carolina Watts (1937) reported in his field notes as follows: "May 4: scattered adult thrips on young seedlings. May 13: larvae abundant and doing serious damage. May 20: populations beginning to diminish. After this date, very little damage." He observed that thrips injury is negligible after the cotton has reached the age of about six weeks, with injury never observed after the beginning of squaring. Newsom et al (1953) observed in Louisiana that seedling cotton is usually attacked by adult tobacco thrips as soon as it breaks through the soil and that one or two generations develop during the following 4 to 6 weeks before the thrips leave the cotton. Maximum thrips populations usually developed approximately one month after the seedling plants emerged from the soil. Injury was most noticeable at this time, although recovery was rapid.

Gaines (1934) studied effects of thrips injury in Texas by tagging injured plants in May for later observation. Such plants usually had two or more main branches, often with excessive vegetative branching. When such plants were compared with normal plants in the same rows the injured plants set bolls at least two weeks later than the normal plants and produced 56 per cent fewer bolls.

Watts (1937) states that the boll weevil becomes of more importance in South Carolina when cotton is severly injured by thrips and fruiting is delayed for 10 days or more. In average and severe boll weevil years a delay in fruiting caused by thrips injury causes much of the late fruit, that would otherwise mature, to be destroyed by the boll weevil. Parencia and Ewing (1950) state that early-season insect control becomes more important in Texas when the value of early production and harvesting is considered. Gaines et al (1952) reported that plants delayed in fruiting by thrips injury in Texas required additional applications of insecticides for control of late season pests.

Gaines et al (1947) have shown that the number of early-set fruits is not indicative of the final yield. Protection of squares early in the season helped to set early bolls but failed to produce an increase in total yield. A loss of about 50 per cent of the squares during the first 30-day period of fruiting apparently did not affect yields where adequate protection against the boll weevil and bollworm was provided later in the season.

Dunnam et al (1943) reported no loss in yield when all squares were removed during the first four weeks of the fruiting period in Mississippi. At State College, Mississippi, Hamner (1941) found that the removal of all squares at weekly intervals for a period of six weeks caused no significant reduction in yield of upland cotton. Newsom et al

(1953) reported that thrips infestations produced an initial reduction of squares, although injured plants outgrew the damage and by August 16 had produced more squares and bolls than treated plants.

Smith (1942), working in California, reported that flowers appeared later on thrips-damaged plants, resulting in a shorter period of blossoming and smaller and fewer bolls. Watts (1937) found injured plants were 10 days later than normal plants in developing the first blooms, that the blooming period of injured plants was eight days less than normal plants, and that both stopped blooming at approximately the same time. The delay in fruiting resulted in injured plants producing only 65 per cent as many open blossoms as uninjured plants.

Parencia and Ewing (1950), working in Texas, reported an average of slightly more than twice as many blooms on treated plants as on those receiving no treatments. Eaton (1931) reported an increase in the number of bolls when all the flowers were removed during the first 25 days of the flowering period in Arizona. Newsom et al (1953) found that untreated plants produced a greater total number of blossoms, although treated plants produced significantly more blossoms during the first three weeks. The rate of blossoming tended to equalize after the third week.

Watts (1937) found that untreated plants produced only 60 per cent as many mature bolls as treated plants. Gaines (1934) reported 56 per cent more bolls on treated plants. Fletcher and Gaines (1939) observed two striking differences between thrips-injured plants and normal plants: first, that the bolls matured earlier on normal plants and, secondly, that such plants produced one pound of seed cotton per 118 bolls, although 134 bolls were required from thrips-injured plants. Smith (1942) reported that cotton plants injured by thrips in the San Joaquin Valley of California produced bolls that were lighter, smaller and later in occurrence. Four-lock bolls were more frequent.

Dunnam and Clark (1937), in testing varietal susceptibility to thrips injury in Mississippi, found the average boll crop for all varieties was reduced approximately 8 per cent and delayed two weeks on thrips-damaged plants. They also reported an average loss of 13 per cent seed cotton and a decrease in boll size on damaged plants. Commercial classification of the lint showed a loss in staple length on damaged plants of seven varieties. They concluded that destruction of the terminal buds caused a loss in seed cotton production in most varieties tested.

Fletcher et al (1947) reported that insecticide sprays and dusts reduced thrips populations in Texas, although percentages of "thrips-injured"plants or yields were not materially affected. Applications to prevent reinfestations were made at weekly intervals, but none were profitable. In Texas, Gaines and Wipprecht (1948) found that yields were reduced slightly on plots which received dust treatments for thrips control when cotton was in the 4 to 8-leaf stage of growth. They found that when cotton is forced to set fruit early, vegetative growth is retarded, and yields are apparently reduced.

Watts (1937) studied the effect of thrips injury on yields in South Carolina by comparing plants injured so severely by thrips that the terminal buds were killed (resulting in the development of two or more main stems instead of one) with adjacent plants showing little or no injury. He concluded that the infested plants would have produced approximately 40 per cent more cotton in the absence of thrips injury.

Kauffman and Stevenson (1953) reported an increase of an average of 311 pounds of seed cotton per acre during a three-year period in Arizona when early-season applications of insecticide were made to seedling cotton. Plots receiving two or three late insecticide applications produced only 273 pounds, while those receiving one early application, followed by two or three late insecticide applications (for the control of other insects), had an average increase of 584 pounds of seed cotton per acre over untreated plots.

Parencia and Ewing (1950) reported that plots receiving an average of 3.5 early-season thrips-control applications produced 317 pounds more seed cotton per acre than untreated plots in Central Texas.

Newsom et al (1953) found that control of the tobacco thrips resulted in a slightly higher percentage of the total crop being harvested in the first picking, but total yields were not affected. Gaines et al (1947, 1948, 1951, 1952) and Fletcher et al (1947) in Texas reported failure to increase total yields by early-season thrips control.

Gaines (1934) observed in Texas that thrips migrated in large numbers from nearby weeds while cotton was in the two-leaf stage. Fletcher and Gaines (1939) found that thrips injury was greatest near edges of fields adjacent to weeds and grasses having high thrips populations. Prevailing winds caused thrips migration into the cotton fields.

Studies in Louisiana by Newsom et al (1953) showed that thrips dispersion reached its peak during May. Tremendous numbers of tobacco thrips moved into seedling cotton at a time when it was most susceptible to attack. Here, as in Texas, it was found that prevailing winds from the south were the major factor affecting the direction of flight.

In California, Bryan (1952) found Frankliniella occidentalis to be widespread on members of nearly every order of Spermatophyte plants. He reported young cotton plants were often stunted and deformed by feeding of nymphs and adults, which delayed cotton maturity by as much as three weeks. He observed that forage crops grown for seed, such as alfalfa and clover, suffered to some extent from flower blasting caused by thrips feeding. Newsom et al (1953) found that tobacco thrips were capable of reproducing and establishing heavy populations on a wide range of important crop plants in Louisiana. Among the more important were the clovers and alfalfa. The latter was the only crop plant observed to furnish a satisfactory food supply for the development of tobacco thrips throughout the year.

REPORT OF ORIGINAL EXPERIMENTS

Similar experiments were conducted in three different fields where the principal variable was the date of planting. In each field were four series of plots, each replicated six times. Individual plots were 110 feet long and 80 feet (24 rows) wide. One series of plots received no insecticide treatments. The three remaining series of plots in each field received insecticides as follows:

(1) A single application during the late cotyledon stage.

(2) A single application during the 2 to 4-leaf stage.

(3) Three applications, made during the late cotyledon stage, the 2 to 4-leaf stage, and the 4 to 8-leaf stage, respectively.

Slight variations in plant development were encountered between fields at the scheduled times of treatment, although, basically, the above schedule was followed. Data concerning the experimental fields and treatment periods are summarized in Table 1.

A 15 per cent emulsifiable concentrate of dieldrin was applied to all plots scheduled for treatment at the rate of three-fourths pint, or two ounces of actual toxicant, per eight gallons of water, per acre. Dieldrin is 1, 2, 3, 4, 10, 10-hexacholoro-6, 7-epoxy-1:4, 5:8-diendomethano-1, 4, 4a, 5, 6, 7, 8, 8a-octohydronaphthalene, has a melting point of 175 to 176° C and, in purified form, is a white, nearly odorless, crystalline compound stable to the action of strong alkali. This insecticide is recommended for the control of thrips on cotton and has a prolonged residual action.

Applications were made with a "Yellow Devil" sprayer, Model 27, mounted on a Model M. Farmall tractor. This sprayer was operated from a power take-off and had a boom twenty-four and one-half feet long which covered eight rows in one swath. Eight 3X "Pen-e-Cone" nozzles were mounted on the spray boom which was located directly above the cotton seedlings. The tractor was driven at approximately four miles per hour with a spray pump pressure of sixty pounds per square inch.

Thrips populations were first counted in the field by examining seedling plants with a 10X head band magnifier. High winds prevailed at this time, and this method was shortly substituted for a laboratory counting method. The precount and the first, second, and third counts of Field I were taken in this manner. The precount was based on an examination of ten plants from each plot in the first four replicates of each plot series in this field. Further counts in this and other fields were made by collecting ten plants, selected at random from each plot in all six replicates of each plot series. These plants were placed in quart-size ice cream cartons and brought to the laboratory, where each was shaken against a blackened glass plate. Thrips dislodged from the plants in this manner were separated into nymphal and adult forms for counting and tabulation. Tables 3a and 3b summarize total numbers of thrips found in the respective fields during the period of examination.

Samples of thrips populations were taken at various intervals for determination. These samples were collected from cotton seedlings,

Table 1. DATA CONCERNING EXPERIMENTAL FIELDS AND TREATMENT PERIODS

	Field I	Field II	Field III
Cooperators:	Shawn and Orteg	Moody	Moody
Location:	All fields were located on the Colorado River Valley floor, south of Yuma, Arizona		
Cotton Variety:	Acala 44	Acala 44	Acala 44
Planting Dates: (1953)	April 2, 3	April 8-10	May 15
Late Cotyledon Stage Treatment: (Plot series 1 and 3 treated)			
Date (1953):	April 19	May 1	May 30
Time:	8:00-11:00 A.M.	8:00-11:00 A.M.	8:00-11:00 A.M.
Wind velocity:	1-3 MPH	6-8 MPH	Calm
Temperature (°F):	80	75	85
2 to 4 Leaf Stage Treatments: (Plot series 2 and 3 treated)			
Date (1953):	April 27	May 11	June 4
Time:	8:00-11:00 A.M.	8:00-11:00 A.M.	1:00-3:00 P.M.
Wind velocity:	4-6 MPH	Calm	4-6 MPH
Temperature (°F):	90	85	95
4 to 8 Leaf Stage Treatment: (Plot series 3 treated)			
Date (1953):	May 8	May 21	June 23
Time:	8:00-11:00 A.M.	8:00-11:00 A.M.	8:00-11:00 A.M.
Wind velocity:	Calm	Calm	1-3 MPH
Temperature (°F):	90	95	100

Each plot series was replicated six times. Plot series number 4 was left untreated.

weeds, and from adjacent fields of alfalfa and cantaloups.

Species determinations were made by Dr. Lewis J. Stannard, of the University of Illinois. An examination of 17 lots of thrips, comprising about 250 specimens, showed that about 90 per cent were Frankliniella occidentalis (Perg.), 5 per cent were Scolothrips 6-maculatus (Perg.) (which were collected on nearby cantaloups), and 5 per cent were Anaphothrips spp., collected from cotton seedlings. These records are summarized in Table 2.

Weed hosts of the western flower thrips adjacent to cotton fields were collected and determined by Dr. Donald M. Tuttle, Assistant Entomologist, University of Arizona Agricultural Experiment Station, Yuma, Arizona. Five common weeds that were hosts of thrips during April, 1953, were: Malva spp. (mallow or cheese weed), Aster spinosus Benth (spring aster or Mexican Devilweed), Phalaris minor Retz (canary grass), Polygonum aviculare L. (knotweed or smart weed), and Sonchus aleraceus L. (sow-thistle).

Data on plant height and fruiting were taken from the three center rows of the 24-row plots. Four plants were tagged on the center row with three plants each on the two adjacent rows. Plants were selected at random. The same individual plants were used throughout the period of observation and were marked with 1½ by 2½-inch white tags. Plots were inspected during the season for injurious insects, such as lygus bugs,[1/] stink bugs,[2/] and bollworms.[3/] With the exception of Field I, which

1/ Lygus bugs reported attacking cotton in Arizona are Lygus hesperus Knight, Lygus elisus Van D., and Lygus oblineatus (Say).

2/ Common stink bugs in Arizona are: Chlorochroa sayi Stal. (Sayi stink bug), Euschistus impictiventris Stal. (brown stink bug), and Thyanta custator (F.) (red-shouldered stink bug).

3/ Heliothis armigera (Hubner).

Table 2. IDENTIFICATION RECORDS OF THRIPS COLLECTED FROM COTTON IN TEST FIELDS AND FROM OTHER NEARBY PLANT HOSTS, YUMA, ARIZONA, 1953. ALL DETERMINATIONS WERE MADE BY DR. LEWIS J. STANNARD, UNIVERSITY OF ILLINOIS

Date of Collection	Host Plant	Collector	Thrips Species Found
April 16	*Malva* spp.	Tuttle	*Frankliniella occidentalis* (Perg.)
April 19	cotton	Tuttle	*F. occidentalis*
April 20	*Phalaris minor*	Tuttle	*F. occidentalis*
April 20	*Sonchus oleraceus*	Tuttle	*F. occidentalis*
April 20	*Aster spinosus*	Tuttle	*F. occidentalis*
April 20	*Polygonum aviculare*	Tuttle	*F. occidentalis*
April 26	alfalfa	Tuttle	*F. occidentalis*
April 29	cotton	Tuttle	*F. occidentalis*
May 1	cotton	Tuttle	*F. occidentalis* and *Anaphothrips* species
May 4	cotton	Tuttle	*F. occidentalis*
May 6	cantaloups	Tuttle	*F. occidentalis* and *Scolothrips 6-maculatus* (Perg.)
May 10	alfalfa	Tuttle	*F. occidentalis*
May 12	cotton	Tuttle	*F. occidentalis*
July 8	alfalfa	Tuttle	*F. occidentalis*
July 30	cotton	Haga	*F. occidentalis*

was dusted with 10 per cent DDT for lygus bugs on the morning of August 10th, no damaging populations of mid and late season insects were found in the fields at any time. No serious mite populations were found.

Plant heights were measured from the soil line to the tip of the terminal bud and were recorded to the nearest inch. The same marked plants were measured throughout the observation period, beginning approximately one month after the planting date and continuing until the middle of August.

Measurements of possible effects of thrips upon fruiting were based on counts of squares, flowers, closed bolls, and opened bolls. Yield records were taken at the end of the season. Counts of all recognizable squares were made on each of the ten tagged plants in each plot and were continued until the plants had begun to produce bolls.

Counts were taken of all flowers that were open on each inspection date. These counts were made throughout the season and no attempt was made to tag individual flowers for later observation. Counts were made of all recognizable bolls on each plant at each time of observation. These were continued until the first bolls had started to open. Open bolls were then counted separately and, in Fields I and III, a differentiation was made between bolls occurring above and below the fifth node.

Yield data from Field I were calculated from a series of three subsamples per plot for each of the six replicates. Each subsample was 20 feet wide (6 rows) and 10 feet long. The 18 subsamples for each plot series totaled 3600 square feet, or 0.08 acre. Yield data from Fields II and III are based on plots picked in their entirety, each plot series comprising 1.2 acres. Yield records, as shown in the following tables, are expressed on the basis of pounds per acre.

Table 3a. THRIPS POPULATIONS IN RELATION TO INSECTICIDE APPLICATION AND PLANTING DATES, YUMA, ARIZONA, 1953.

No. of Appls.:	1			1			3			None		
Period:	Late Cotyledon			2 to 4 leaf			Late Cotyledon 2 to 4 leaf 4 to 8 leaf					
Dates:	N 1/	A 1/	T 1/	N	A	T	N	A	T	N	A	T
Field I, Planted April 2, 3, 1953												
April												
17 2/	9	1	10 3/	8	2	10 3/	3	3	6 3/	15	2	17
21	4	0	4	18	2	20 3/	14	0	14	18	3	21
23	0	2	2	20	6	26 3/	3	5	8	7	16	23
27	6	3	9	61	5	66 3/	5	1	6	33	6	39
May 4/ 1	12	5	17	15	2	17	7	0	7	66	13	79
5	7	3	10	7	1	8	6	2	8	17	5	22
14	7	5	12	6	4	10	6	3	9	8	0	8
20	3	0	3	7	2	9	8	3	11	3	1	4
Totals:	48	19	67	142	24	166	52	17	69	167	45	212

1/ N: Number of nymphs; A: no of adults; T: combined totals.

2/ Population counts based on an examination of 40 plants only.

3/ Counts made before insecticides were applied.

4/ Only the observations on this date were significant at the 5% level.

Table 3b. THRIPS POPULATIONS IN RELATION TO INSECTICIDE APPLICATION AND PLANTING DATES, YUMA, ARIZONA, 1953.

No. of Appls.:	1			1			3			None		
Period:	Late Cotyledon			2 to 4 leaf			Late Cotyledon 2 to 4 leaf 4 to 8 leaf					
Dates:	N[1]	A[1]	T[1]	N	A	T	N	A	T	N	A	T
Field II, Planted April 8-10, 1953												
April												
25	8	10	18[3]	3	3	6[3]	5	6	11[3]	4	5	9
May												
1	46	18	64	57	5	62[3]	50	4	54	56	22	78
4	13	3	16	34	3	37[3]	7	1	8	42	3	45
7	5	1	6	10	5	15[3]	10	2	12	29	1	30
15	3	1	4	0	0	0	3	2	5	1	0	1
Totals:	75	33	108	104	16	120	75	15	90	132	31	163
Field III, Planted May 15, 1953												
June												
1	13	0	13	9	0	9[3]	1	0	1	4	1	5
5	1	0	1	5	2	7	3	0	3	7	0	7
15	7	2	9	6	6	12	13	3	16	12	3	15
25	10	2	12	6	2	8	6	3	9	8	2	10
Totals:	31	4	35	26	10	36	23	6	29	31	6	37

For explanation of footnotes see Table 3a.

In Fields I and II thrips populations increased until May 1, at which time maximum populations were found to have infested these fields. After this period, as summarized in Tables 3a and 3b, populations declined on all plot series. Field III counts were taken after the period when large numbers of thrips were found in Fields I and II and show approximately the same degree of infestation as was found in these fields on the same dates in their final counts. Table 3b indicates that the numbers of thrips infesting Field III at any one observation period never reached the peak numbers found in Fields I and II. No significant differences in thrips populations were found between any plot series on any date, with the exception of counts made on May 1 in Field I, when a statistical significance was found between the treated and untreated plots. In all cases untreated plots had fewer thrips on the final count than had a number of the treated plots.

Newsom et al (1953) reported that maximum populations in Louisiana were found infesting the fields on May 18, or about one month after the seedling plants had emerged from the soil. Their investigations showed the necessity for making the first insecticidal application as soon as cotton had emerged to a stand, since in cases of heavy infestations seedlings were otherwise unable to develop to the 4-leaf stage without severe damage. They indicated that waiting until the 4-leaf stage of growth before making the first insecticidal application for thrips control, as recommended in some areas, was definitely unsatisfactory. Gaines and Wipprecht (1948) in Texas reported a loss in yield when seedlings were first treated in the 4 to 8-leaf stage of growth.

On the basis of information gained in these experiments it appears that thrips control may be of more importance on early-planted cotton than on late-planted cotton. When cool nights persist, even though the days may be hot, cotton seedlings do not grow to any extent, and it is on these plants that thrips and plant diseases cause extensive damage. These observations should be repeated before final conclusions are drawn on the importance of thrips under Arizona conditions.

Table 4: HEIGHT OF COTTON PLANTS AS AFFECTED BY INSECTICIDE APPLICATIONS FOR THRIPS CONTROL, YUMA, ARIZONA, 1953.

No. of Insecticide Applications:	1	1	3	None
Period of Insecticide Applications:	Late Cotyledon	2 to 4 leaf	Late Cotyledon 2 to 4 leaf 4 to 8 leaf	
Dates:	Average Plant Height in Inches 1/			
	Field I, Planted April 2, 3, 1953			
June				
3	8.9	8.8	9.1	8.7
12	14.2	13.9	15.2	13.8
25 2/	25.5	25.2	26.0	23.5
July 2/				
6	30.8	30.0	30.6	27.8
16	37.2	38.4	36.8	36.7
30	48.1	47.0	47.2	45.9
August				
10	52.4	51.1	50.3	51.2
	Field II, Planted April 3-10, 1953			
June 2/				
8	11.6	11.0	11.4	10.0
22 2/	26.8	25.3	26.0	23.0
July 2/				
7	35.2	33.0	35.3	30.5
21 2/	54.3	54.9	56.0	51.0
August				
11	68.6	69.0	71.0	67.7
	Field III, Planted May 15, 1953			
July 2/				
8	18.1	16.3	18.5	16.0
15 2/	24.7	21.8	25.4	21.3
28 2/	34.9	30.7	34.9	30.6
August				
5	38.5	35.5	39.1	36.3
14	44.2	39.8	43.2	41.8

1/ Based on 60 measurements, representing 10 tagged plants in each of six replicates.

2/ Only the observations on these dates were significant at the 5% level.

Growth, as expressed by plant height increase, was not materially reduced during early observations of the untreated plot series in Field I. No significant height differences were found at any time except on June 25 and July 6. Plant heights were reduced in the untreated plots in Fields II and III, apparently due to thrips infestations. This reduction in height was gradually overcome, and at the final measurements the differences were no longer significant. These observations are summarized in Table 4.

Gaines (1934) reported that thrips injury to the terminal buds of seedling cotton results in their death and that apical dominance of the stem is lost. Such plants are later characterized by the occurrence of two or more main branches and sometimes by excessive vegetative branching. This would account for the lower plant heights in untreated plots during early measurements in present tests.

Newsom et al (1953) observed in Louisiana that plants stunted as a result of thrips injury could not compete on an equal basis with adjacent uninjured plants and were unable later to compensate for early stunting. This situation was not observed in the present experiment.

Table 5. RATE OF SQUARE FORMATION AS AFFECTED BY INSECTICIDE APPLICATIONS FOR THRIPS CONTROL, YUMA, ARIZONA, 1953.

No. of Insecticide Applications:	1	1	3	None
Period of Insecticide Applications:	Late Cotyledon	2 to 4 leaf	Late Cotyledon 2 to 4 leaf 4 to 8 leaf	
Dates:	Average number of squares 1/			
June	Field I, Planted April 2, 3, 1953			
3	3.1	3.1	3.4	3.1
11	11.4	10.9	12.1	11.4
25 2/	29.7	28.0	29.6	25.5
June	Field II, Planted April 8-10, 1953			
8	6.4	6.0	6.6	5.6
22	30.5	28.4	30.1	26.8
July	Field III, Planted May 15, 1953			
8 2/	8.8	7.1	9.9	5.3
15 2/	14.0	11.0	16.3	10.2
28 2/	18.0	17.9	20.7	14.6

1/ Based on 60 plants, representing 10 tagged plants in each of six replicates.

2/ Observations on these dates were significant at the 5% level.

In the three test fields, variations in the square, flower, and boll counts make interpretation difficult. In all cases, at the time of final observation, more squares and bolls were found on the treated plots than on the untreated. Total number of flowers was higher in the treated plots, while in the untreated areas, blooming was delayed.

Square production in all fields was delayed to some extent by the thrips damage, and at the time of final observations, the untreated plants in all cases had fewer squares than the treated plants. These differences were statistically significant in Fields I and III, as summarized in Table 5. Newsom et al (1953) reported initial reductions in squares in the untreated plants, although these plants finally produced more squares than treated plants. Gaines et al (1952) observed that, if the first fruit is destroyed, the plants grow vegetatively, requiring a considerable period of time before normal fruiting is resumed. This condition would be reflected in the later appearance of squares, flowers, and bolls on injured plants. It would indicate that such plants would have as much as a week or two less time to mature their crop. Injury to a square may ultimately cause it to drop, although some time may elapse before actual abscission takes place. This may account for the smaller number of squares found on the thrips-injured plants.

Table 6. RATE OF BLOSSOM OCCURRENCE AS AFFECTED BY INSECTICIDE APPLICATIONS FOR THRIPS CONTROL, YUMA, ARIZONA, 1953.

No. of Insecticide Applications:	1	1	3	None
Period of Insecticide Applications:	Late Cotyledon	2 to 4 leaf	Late Cotyledon 2 to 4 leaf 4 to 8 leaf	
Dates:	Average number of blossoms per plant 1/			
	Field I, Planted April 2, 3, 1953			
June 25	.5	.5	.5	.4
July 6 2/	.8	1.0	1.3	.6
16 2/	1.4	1.1	1.5	.8
30	.9	.9	1.1	.8
August 10	.7	.4	.5	.8
	Field II, Planted April 8-10, 1953			
June 22 2/	.9	.8	1.0	.3
July 7 2/	1.0	1.0	1.2	.8
21 2/	1.3	1.0	1.6	.9
August 11 2/	1.0	.9	1.2	.8
	Field III, Planted May 15, 1953			
July 28	.6	.6	.7	.5
August 5 2/	.9	.8	1.1	.6
14	.7	.4	.7	.4

1/ Based on 60 plants, representing 10 tagged plants in each of six replicates for each plot series.

2/ Observations on these dates were significant at the 5% level.

Flower counts show that in all fields there was a delay in blooming period for the untreated plants and that these plants never produced as many flowers in the period of observation as did the treated plants. In Field I, as shown in Table 6, there was a statistical significance in the numbers of blooms produced between the treated and untreated plots only on the July 6 and 16 observations, while in Field II, all counts were significant on all dates. Field III had significantly more flowers on the treated plants only on August 5.

Parencia and Ewing (1950) reported that effective early-season thrips control in Texas was reflected in the numbers of blooms, which averaged more than twice as many on treated plants as on those that were not treated. Newsom et al (1953) observed that blossoming began earlier on treated plants, although in Louisiana plants receiving no insecticides exceeded the treated plots in total numbers of blossoms produced.

Table 7. RATE OF BOLL FORMATION AS AFFECTED BY INSECTICIDE APPLICATIONS FOR THRIPS CONTROL, YUMA, ARIZONA, 1953.

No. of Insecticide Applications:	1	1	3	None	
Period of Insecticide Applications:	Late Cotyledon	2 to 4 leaf	Late Cotyledon 2 to 4 leaf 4 to 8 leaf		
Dates:	Average number of closed bolls 1/				Significance 5% level
	Field I, Planted April 2, 3, 1953				
June 25	1.9	1.8	2.2	1.1	Sign.
July 6	4.1	3.8	4.7	3.0	Sign.
16	10.2	9.6	11.0	7.6	Sign.
30	12.2	11.2	13.7	9.7	Sign.
August 10	13.0	11.4	14.1	11.3	Sign.
	Field II, Planted April 8-10, 1953				
June 22	.8	.7	1.1	.2	Sign.
July 7	5.4	4.5	5.9	3.1	Sign.
21	9.6	8.8	10.9	7.9	Sign.
August 11	13.9	12.1	13.3	12.0	N. S.
	Field III, Planted May 15, 1953				
July 28	1.2	.7	1.9	.7	Sign.
August 5	4.1	3.7	5.0	3.5	Sign.
14	8.3	6.8	8.4	6.4	Sign.

1/ Based on 60 plants, representing 10 tagged plants in each of six replicates.

As summarized in Table 7, Fields I and III had significantly more closed bolls on the treated plants on all observation dates. Field II had significantly more closed bolls on all dates, with the exception of the final observation, at which time the numbers of closed bolls on treated and untreated plants tended to equalize. In all cases more bolls were produced by the treated plants.

Fletcher and Gaines (1939) reported that treated plants produced an average of 5.7 bolls per plant, while the untreated areas produced an average of 4.5 bolls. This was calculated to be a loss of 358 pounds of seed cotton per acre. Eaton (1931) secured an increase in the total number of bolls when all flowers were removed during the first 25 days of the flowering period. Gaines et al (1947) observed that during the latter part of July a high percentage of the additional squares and bolls that had been produced as a result of insecticidal control were later shed because they proved to be more than the soil could support. Newsom et al (1953) observed initial reductions in bolls and squares on thrips-injured plants, although these later produced more bolls than treated plants. This was not observed in the present experiments.

Table 8. OCCURRENCE OF OPEN BOLLS AS AFFECTED BY INSECTICIDE APPLICATIONS FOR THRIPS CONTROL, YUMA, ARIZONA, 1953

No. of Insecticide Applications:	1	1	3	None	
Period of Insecticide Applications:	Late Cotyledon	2 to 4 leaf	Late Cotyledon 2 to 4 leaf 4 to 8 leaf		
Dates:	Average number of open bolls				Significance 5% level
August	Field I, Planted April 2, 3, 1953				
10	1.1	1.0	1.6	.8	Sign.
22 1/	3.8	3.3	4.1	2.8	Sign.
22 2/	2.9	2.4	3.2	2.0	Sign.
August	Field II, Planted April 8-10, 1953				
11	1.5	1.0	1.9	.9	N. S.
October	Field III, Planted May 15, 1953				
6 1/	7.4	7.0	7.8	6.7	Sign.
6 2/	1.4	.8	1.2	.6	Sign.

1/ Total number of open bolls.

2/ Number of open bolls below the fifth node.

As shown in Table 8, rate of maturity, as measured by counts of open bolls, was delayed in the untreated plots of Fields I and III. There were significantly more open bolls on the treated plants in these fields on all observation dates. Similar differences apparently occurred in Field II, although the data were not quite statistically significant. The early suppression of squares, flowers, and closed bolls in the untreated plants was still apparent in the open-boll counts.

To determine where the early bolls were set on the plant, counts were made in Fields I and III of the numbers of bolls occurring above and below the fifth node. There were significantly more bolls below the fifth node of the treated plants.

Newsom et al (1953) doubted the value of the lower bolls, since, where mechanical pickers are employed, such bolls are often missed. Low bolls often rotted, and the lint frequently became stained. They concluded that such effects, resulting from setting early fruit, may tend to offset any advantages gained. Damage to low bolls was not observed in these experiments, possibly because of more favorable climatic conditions in Arizona.

Table 9. YIELDS OF SEED COTTON AS AFFECTED BY INSECTICIDE APPLICATIONS FOR THRIPS CONTROL, YUMA, ARIZONA, 1953

No. of Insecticide Applications:	1	1	3	None
Period of Insecticide Applications:	Late Cotyledon	2 to 4 leaf	Late Cotyledon 2 to 4 leaf 4 to 8 leaf	
Dates of Picking:	Yields of Seed Cotton in Pounds Per Acre 1/			
	Field I, Planted April 2, 3, 1953			
August 26	1047	1073	1160	935
January, 1954 1, 2	1397	1442	1356	1149
Total	2444	2515	2516	2084
	Field II, Planted April 8-10, 1953			
September 6 2/	469	497	756	416
October 28	1810	1699	1992	1556
December 31	387	505	458	423
Total	2666	2701	3206	2395
	Field III, Planted May 15, 1953			
October 7	1917	1819	2014	1904
December 16	931	859	950	883
Total	2848	2678	2964	2787

1/ Based on harvest samples but expressed on the basis of pounds per acre.

2/ Yields on this date were significant at the 5% level. Other yield records summarized on this page were not quite significant at the 5% level when subjected to the analysis of variance.

Although there were apparent yield increases in all fields in the treated plots, with the exception of plot series 2 in Field III, none was significant as regards total yields when the data were subjected to the analysis of variance. On the September 6 picking in Field II, there was a significant increase in the yield of the plots receiving three treatments over the untreated plots. This would indicate an early maturity for a portion of the crop in this field. Other yields, when subjected to statistical analysis, were not quite significant at the 5% level.

Plot series 3 in all fields yielded the highest poundages of seed cotton per acre, while plot series 2 in Fields I and II had higher yields than plot series 1, but were lower than the untreated plot series 4 in Field III. This is summarized in Table 9.

A trend is noted to follow through from the number of thrips found infesting the plot series 3 to the number of squares, flowers, closed bolls, open bolls, and total yields for these series of plots. In most cases plot series 3 had the least number of thrips, and the highest number of fruiting structures than the other treated or untreated plots.

Similar trends have also been observed by Kauffman and Stevenson (1953) in their experiments in Arizona. Perhaps under irrigated conditions in the Southwest environmental conditions are altered from those found in other areas where similar experiments have been conducted, but where no increases in yields have been reported. Other factors to consider are the species of thrips present, the variety of cotton grown, and whether moisture is derived from irrigation or natural rainfall.

The results of this study show that more work should be conducted before early-season thrips control can be unqualifiedly recommended.

SUMMARY

This study is concerned with the effects of thrips injury to cotton seedlings and subsequent effects on fruiting and yields. Previously published work is summarized, and original experiments conducted in the Yuma valley area of Arizona are reported.

The Western Flower thrips, Frankliniella occidentalis (Perg.) was the only species of importance found attacking cotton seedlings. Highest populations were found on May 1, with decreasing numbers after this date. Early spring weed hosts, harboring thrips near cotton fields, were Malva spp., Phalaris minor Retz, Sonchus oleraceus L., Aster spinosus Benth, and Polygonum aviculare L.

Feeding of thrips adults and nymphs destroyed leaf tissue in the bud stage, resulted in ragged, crinkled leaves, and reduced the height of injured plants. Effects of such injury on vegetative growth were usually outgrown, although uninjured plants usually bloomed earlier and more abundantly than injured plants.

Plants sprayed with from one to three applications of an insecticide (dieldrin) consistently showed a trend toward earlier maturity and higher yields, although the gains over untreated plants were not quite significant when analyzed statistically. Further experimental work is needed before the insecticidal control of thrips on seedling cotton can be generally recommended in the Yuma area.

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