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Economic threshold studies of the boll weevil (Anthonomus grandis) in West Tennessee

William Bailey Wyatt

To the Graduate Council:

I am submitting herewith a thesis written by William Bailey Wyatt entitled "Economic threshold studies of the boll weevil (Anthonomus grandis) in West Tennessee." I have examined the final electronic copy of this thesis for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science, with a major in Agricultural Biology.

Charles D. Pless, Major Professor

We have read this thesis and recommend its acceptance:

Gary Lentz, Laurence Skold

Accepted for the Council:
Carolyn R. Hodges

Vice Provost and Dean of the Graduate School

(Original signatures are on file with official student records.)

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and recommend its acceptance:

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ECONOMIC THRESHOLD STUDIES OF THE BOLL WEEVIL (*ANTHONOMUS GRANDIS*) IN WEST TENNESSEE

A Thesis

Presented for the

Master of Science

Degree

The University of Tennessee, Knoxville

William Bailey Wyatt

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ABSTRACT

Experiments were carried out at Ames Plantation, Grand Junction, Tennessee, and Milan Field Station, Milan, Tennessee, during the cotton growing seasons of 1975 and 1976 to better define the economic threshold level of the boll weevil, *Anthonomus grandis* (Boheman). Chemical control efforts were begun at levels of 10, 20, and 30 percent fruit infestation.

Boll weevil activity was monitored and recorded throughout the growing seasons. Experiments were set up in a randomized complete block design with varying replications depending upon the location of the test. The Milan test in 1975 showed a high negative correlation between levels of boll weevil infestation at initiation of chemical treatment and yield of seed cotton. The test indicated that, with a base yield of 20.595 cwt. per acre, every unit (percent) increase in boll weevil damage there was a decrease in production of .2151 cwt. per acre. Three tests showed no significance between the yield of seed cotton per acre and percent boll weevil damage at the initial chemical application in plots sprayed at lower damage levels as compared to plots sprayed at higher damage levels.

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CHAPTER I

INTRODUCTION

Cotton ranks second among major cash crops in West Tennessee. Optimum yields and profits realized are highly dependent on the proper control of the boll weevil, *Anthonomus grandis* (Boheman).

Chemical control is the major practice employed in boll weevil management programs. Proper timing of chemical applications is important for a successful control program to be carried out at a minimum cost to the grower.

The present experiments were carried out to better define the economic threshold level of the boll weevil under Tennessee conditions. Mid-season spray programs were initiated at various boll weevil damage levels. The results were evaluated by comparing yield data among treatments.

CHAPTER II

REVIEW OF LITERATURE

Use of chemicals to combat the boll weevil, *Anthonomus grandis* (Boheman), in cotton dates back to 1920 when calcium arsenate was widely used. There is some controversy concerning the proper time to initiate applications of chemicals in order to gain the maximum benefit for yield and profit.

An early paper by Coad and Cassidy (1920) discussed the purpose of chemical treatment as well as the proper timing of applications. They stated that insecticides were not aimed at the extermination of the boll weevil but at reduction of populations to the point at which a cotton crop could continue to form a full crop. The shedding of fruit due to boll weevil attack takes the place of normal shedding by the plant caused by plant genetic, soil moisture, and nutritional factors. Cotton produces a great deal more fruit than the plant is able to nurture and approximately 60 percent of the squares fail to mature. This habit allows some degree of weevil infestation to occur without requiring chemical application.

At this early stage of chemical control efforts, these researchers recommended that 15 to 20 percent of the squares be punctured before applications begin and that treatments be repeated often enough to prevent damage levels from rising above 25 percent until the crop was set and the bolls were safe from attack.

As research continued, conflicting recommendations were soon made regarding the time of initiation of control measures. Ames (1923) and McGehee suggested that chemical applications begin as soon as the squares start to form with a second application after 10 days. He also recommended a third treatment in rank cotton with a damage level of 10 percent. Barre (1923), working in South Carolina, reported little increase in cotton yield as a result of early season applications. He stated that early season dusting would, however, delay mid-season and later applications and these later treatments resulted in increased yield. Hunter and Coad (1923) agreed with Barre (1923) that applications should be initiated when 10 to 15 percent of the squares were punctured. Early work in Arkansas by Isely and Baerg (1924) indicated that treatment should begin at the 10 to 15 percent damage level and be continued for 3 to 4 applications at four- or five-day intervals. Results from North Carolina indicated one early application followed by four to seven later treatments beginning when 10 percent of squares were punctured resulted in best yields (Leiby and Harris, 1924).

In 1925, two studies, Armstrong et al. (1925) and Nichols (1925), reaffirmed the findings of Barre (1923) in South Carolina suggesting that initial applications at the 10 percent level of damage were superior to other schedules. Tests in Alabama by Robinson (1926) revealed no advantage to dusting with damage below 10 percent. Oklahoma tests by Sanborn (1926) led to similar results and recommendations in that state were to initiate controls beginning at 10 to 15 percent damage. Robinson and Arant (1929) expanded recommendations in Alabama to stipulate that treatments, in order to be profitable, should begin at 10 percent only when potential yield was one-half bale or more per acre. Results from Louisiana (Young, 1935) followed the developing trend of beginning dusting at the 10 percent damage level followed by applications at four- to five-day intervals. A report from Mississippi indicated that growers should wait until plants are fruiting heavily and 10 to 25 percent punctured squares are found (Anon., 1939). Bandy and Rainwater (1940) reported that experiments conducted from 1928 to 1940 showed that dusting on a five-day schedule beginning at a 10 percent damage level was more effective and more profitable than any other treatment schedule yet attempted.

The early 1940's brought little change to recommended dusting schedules. Hamner (1941), Ferton and Chester (1942), and Young et al. (1942) all had results which were in accord with the generally accepted schedules of initiating treatment at the 10 percent damage level. Thomas et al. (1942), in a committee report on boll weevil control, suggested that the most practical method of protecting cotton from weevil attack was dusting only when injury was being incurred by the crop while the plants were fruiting freely and then only at a predetermined damage level as indicated by state entomologists based upon local conditions.

Hamner (1943), in further tests under Mississippi conditions, stated the cotton plant sets a higher percentage of young bolls and produces heavier bolls as a reaction to the loss of squares. He felt that there should be an average of one bloom per 5 feet of row for control measures to result in appreciable gains. Hamner also suggested that during the first and last weeks of production weevil damage of 25 percent was necessary to justify control measures. This 25 percent level could be lowered on very fertile soils where yield potential is greater and economic gain might result. Sherbakoff and Stanley in Tennessee (1943) disagreed with Hamner's idea about dusting cotton growing in fertile soil at lower levels of damage. They agreed with the general concept of treatments beginning at the 10 to 15 percent level but felt that, since cotton on rich land would grow until very late season, dusting should be delayed until the 25 percent level is reached rather than beginning at a lower level.

Research efforts up until the mid- to latter-1940's were conducted during the era in which calcium arsenate was extensively used. The year 1946 saw the advent of the chlorinated hydrocarbon era in boll weevil control. The late 1940's also brought on consideration of the role of beneficial insects in cotton pest management and its economics. Gaines et al. (1947), stated that the 10 percent standard recommended in most states helped the early bolls to set but was not the most economical schedule in all areas. Dusting at the 10 percent level depleted parasites and predators of aphids and bollworms, giving rise to further problems. Early protection of squares also failed to produce an increase in total yield. Gaines and Wipprecht in 1948, working in Texas, further substantiated their findings of 1947 and revealed that the loss of 50 percent of the squares due to boll weevil attack during the first 30 days of the fruiting period resulted in no significant yield reduction. Findings of Bandy et al. (1950), in South Carolina differed from those of Gaines and Wipprecht (1948).

They proposed the best schedule to be three applications at seven-day intervals beginning at squaring, followed by further applications at the 10 percent infestation level.

Gaines and Wipprecht (1950), completing another year of research, concluded that under prevailing Texas conditions it was not profitable to attempt early season control even when followed by later season applications. The apparent economic gains resulted only from controlling injurious populations of weevils. Isely (1950) reported that in Arkansas dusting should begin at 25 percent punctured squares and should continue until the percentage is reduced below that level with applications at four- or five-day intervals. He also noted, however, that when a good crop of cotton was fruiting heavily, a higher percentage of squares could be shed without a loss in yield. This was the case in 1949 when he observed cotton which never had less than 50 percent damage yet yielded "a good crop."

Walker et al. (1950) worked with toxaphene in an attempt to determine the best dusting schedule. They determined that beginning applications at the 10 percent damage level was equally as effective as beginning at squaring as well as an initial application one week after squaring. Isely and Barnes (1951) found that the greatest return from dusting resulted from concentrating spray efforts when cotton was fruiting most rapidly.

From 1947 to 1956, Lincoln and Leigh (1957) tested boll weevil infestations in cotton growing on bottomland soils in Arkansas. Their results showed that chemical applications would not result in a significant increase in yield unless infestations were heavy and conditions were favorable for fruiting. The experimental results revealed there was little advantage to holding damage below the 40 percent mark and damage levels considerably higher than 40 percent for short periods did not decrease yields. These tests indicated that, under practical farm conditions, satisfactory control could be obtained by beginning applications only after the 25 percent punctured square level had been reached. It would be advisable to begin at a lower level during wet weather when a brood was emerging or when migration was underway because under these circumstances, infestations may increase rapidly. In addition to testing in bottomland, cotton growing on upland soil was tested from 1951 to 1956. Boll weevil control on hill land sites proved to be a different problem than control on bottomland soils due to a combination of factors. The upland cotton growing areas were characterized by an abundance of well-drained hibernation quarters which insured maximum winter survival resulting quite often in heavy early-season populations. The lower fertility and lower moisture-holding capacity of the upland soils also limits the length of the fruiting period thereby lowering the yield potential. This combination of factors makes timing of insecticide applications more critical and difficult. Careful scouting of the upland areas is essential and insecticides should be applied in a manner which prevents infestations from remaining above 25 percent punctured squares for over one to two weeks. The protection of the first squares is justifiable, if an extremely high population of boll weevils is present, especially on heavy or sandy soils on an upland site.

In 1960, the USDA (Farmers' Bulletin No. 2147) described two schedules of boll weevil control. The first program was the early-season schedule, the purpose of which was to kill the boll weevils which were returning to cotton from hibernation quarters. This should be accomplished before the females lay the eggs of the first generation. The second program consisted of mid- or late-season applications determined by damage counts. On soils in which cotton sets an early crop and cuts out, applications should begin when 10 percent of the squares are punctured. On heavier soils in which cotton fruits over a longer period and potential yield is high, applications can begin after the 10 percent level is surpassed, but before 25 percent of the squares are punctured. These applications should be repeated on a five-day schedule until the damage level drops below the starting level or until the crop is mature.

Fye et al. (1961) reported from South Carolina that insecticide applications before July 1 for boll weevil control were almost as effective as the same program followed by later spraying when infestations reached 10 percent. However, there was a tendency for bollworms to build up when the early-season applications were made.

Lloyd et al. (1961) characterized boll weevil feeding patterns as follows.—The squares on the upper half of the plant are the most preferred for feeding and egg laying so long as the weevil population remains low; and with an increasing population, small bolls are damaged in addition to the squares, and damage is intensified in the upper half of the plant and reaches into the lower fruiting branches. Bolls up to 19 days old are subject to weevil damage. This study also noted that insect exposure of up to four weeks would result in no yield reduction if control efforts were exercised after that period. Some basic relationships between boll weevil damage levels and cotton yield and quality have also been described (Lloyd et al., 1962). Seasonal square damage levels of 0, 25, 50, and 75 percent were used to reach the following conclusions. Plant fruiting is delayed as damage levels increase, resulting in a delay in harvest. The earliest cotton was harvested from the 0 percent plots while those plots held at the highest levels produced the latest harvestable cotton. Yield data indicated an inverse relationship between total yield and percent of squares damaged. The weevil-free plots yielded significantly more seed cotton than the plots at the 25 percent damage level. There was no significant difference between the 25 percent and the 50 percent plots when yields were compared. Grade indices and lint values indicated no significant loss in lint quality at any damage level.

Watson and Sconyers (1965) working in Alabama published results from a three-year study, 1962 through 1964. The most satisfactory schedule proved to be beginning spray applications at the 10 percent level and continuing until square damage dropped below 10 percent or until the crop was mature. There was one exception to this finding which occurred in 1963. Bollworms and tobacco budworms were the major cotton pests in 1963 and cotton which was sprayed for weevils at the 25 percent level had the highest yields.

Mistric and Covington (1968) concluded that square removal and boll weevil damage up to 45 percent during early- to mid-season resulted in no loss in yield when insecticides were applied in late season to protect the bolls. Maturity was delayed, however, which is a critical factor in many growing and harvesting seasons. Mistric and Mitchell (1968) compared a "preventive control" program to a program where cotton spraying was initiated at the 10 percent square damage level. The preventive control applications were initiated when cotton reached the eight-leaf stage with three or four applications at five- or seven-day intervals. Late season applications were started during the last week of July and continued until the end of squaring. Late season applications were on a three- to five-day interval. This study was conducted in a county in which 90 percent of the non-experimental cotton crop was treated by the growers. The preventive schedule resulted in no significant increase in yield as compared to cotton sprayed on the count system. However, for the year the study was conducted, only one-half as many applications were required by the preventive schedule and it was easier to follow because no scouting was required.

Newsom and Brazzel (1968), in a discussion resulting from a symposium in Dallas, Texas, explored the question of whether to spray on an automatic schedule or to spray on a schedule based upon an insect population level which had increased to the point at which a reduction in yield or quality of the cotton crop was imminent. Insecticides are applied under the latter schedule only as needed as determined by population assessment. The proponents of this schedule believe the cotton plant to be capable of producing a crop limited only by cultural practices, climatic factors, and edaphic factors even when a considerable amount of insect damage is being incurred. There are several advantages to using insecticides only as dictated by the presence of boll weevils at or near the economic injury level. These advantages include:

1. Less insecticide is required thereby reducing production costs.
2. The schedule is less detrimental to biological control agents and provides for the maximum use of those agents in controlling other pest species.
3. Contamination of the environment is reduced and a longer period of time exists between seasons for pesticide residues to undergo chemical and biological degradation.
4. Less selective pressure is exerted on pest populations thus prolonging the time required for the resistant boll weevil populations to develop.

Disadvantages include:

1. Frequent and thorough field inspections are necessary in order to monitor the status of a population.
2. Timing of applications is more critical and injury thresholds may be exceeded as a result of applications being delayed by inclement weather, equipment breakdowns, and the interference of other necessary farm operations.
3. There is a lack of sufficiently precise data on the economic injury threshold of the boll weevil.
4. This system contributes to instability in the supply and marketing of insecticides.

The basic difference between the two concepts is the question of what levels of pest infestations can the cotton plant tolerate without reduction in yield. The physiology of the cotton plant allows only 40 to 60 percent of the fruit produced to be set and the indeterminate growth pattern of cotton allows for the compensation of large amounts of damage to the crop. Due to these factors, yield should not be affected below certain thresholds and any chemical control attempted before the economic injury threshold is reached will have no effect on yield. The economic injury threshold as defined by Newsom and Brazzel (1968) is that level "of infestation or population density at which the loss caused by a pest just equals in value the cost of control measures available." This definition should take into account any known side effects resulting from using an insecticide which results in any adverse circumstances whereby the values gained by control of the pest are outweighed by those values lost by its usage. The primary example of this is the reduction of beneficial populations to the point where they are no longer effective biotic control agents.

This discussion further concludes that the lack of reliable information on economic thresholds is the major drawback to the intelligent use of insecticides. Most control programs using population assessment as a criterion for spraying for the boll weevil assume the economic injury threshold to be relatively high--usually 25 percent injury to the squares. The need for research on this problem as of the late 1960's was "one of the most urgent in entomology" (Newsom and Brazzel, 1968).

Mistric and Covington (1969) conducted a study in an attempt to better define the proper time to cease chemical applications. Their findings substantiated previous beliefs that the end of squaring was the best time, from an economic standpoint, to end late season insecticide treatments for boll weevil control. The end of squaring is defined as the presence of less than one square per linear foot of row.

Stern (1973) defined some terms and made qualifications which should be understood when considering threshold levels. He described the economic injury level as "the lowest population density that will cause economic damage." Stern stated that control efforts should be initiated at the economic threshold level which is "the density at which control measures should be determined to prevent an increasing pest population from reaching the economic injury level." The basic principle in an attempt to determine an economic threshold is to properly distinguish between the mere presence of a pest species in a crop, as opposed to a higher population density which will cause a "reasonable" loss to the crop in terms of yield and/or quality. Stern (1973) used the term "reasonable" in describing a loss because he feels that pest control is not as simple as comparing the cost of the chemical and application against an equal dollar return, although he agrees that, ideally, a cost/potential benefit ratio is the best avenue to arrive at a decision involving the proper timing of pesticide application. There are many factors which complicate such an analysis including market conditions, local grower economics, and investment in the crop. A valid economic threshold needs to be qualified in several terms which should include:

(1) local climatic conditions

(2) time of year

(3) stage of plant development

(4) the crop involved

(5) plant variety

(6) cropping practices

(7) the purpose for which the crop is to be used

(8) the desire of men and economic variables.

Metcalf and Luckman (1975) described the economic injury level of the boll weevil in relation to average population density. They used the term "equilibrium position" and defined it as "the average population density of an insect population over a long period of time, unaffected by the temporary interventions of pest control." The boll weevil reaches an economic injury level at a point only slightly above the equilibrium position. This requires intervention by man at nearly every upward movement of the population in order to produce a modified average population density well below the economic injury level.

Two studies have been conducted under West Tennessee conditions which relate directly to this thesis study. The first, Overton et al. (1969), describes the fruiting pattern of cotton in the area of the study. The West Tennessee cotton crop is normally set in a four-week or less period, from mid-July to mid-August. This is a very critical period and, due to the time period in which the crop is set, Overton et al. (1969) feel that early season insect control should possibly be given more consideration.

During the summer of 1973, Cherry et al. (1974), conducted field experiments at the Ames Plantation and the Milan Field Station in order to explore the feasibility of initiating boll weevil control at higher than the presently recommended damage level of 10 percent. Cherry reported that 10 of the 12 cotton growing states recommend maintaining a 10 percent damage rating while Texas and Louisiana have a 25 percent level. This West Tennessee study involved weekly square sampling beginning at first fruiting. Data collected included: squares per acre, boll weevil oviposition and feeding damage, bollworm eggs, and bollworm square damage. Results at both test sites revealed no significant yield differences between plots sprayed at the recommended 10 percent level and plots sprayed at the 20, 30, and 35+ percent levels. Those results indicate that boll weevil control initiated at the 10 percent level may not result in yield increases under West Tennessee conditions; however, additional data taken under different insect and environmental conditions for at least two years are needed before conclusive results are obtained. Cherry felt that, if additional study confirmed his conclusions, the standard of 10 percent might be raised.

CHAPTER III

MATERIALS AND METHODS

Field experiments were conducted during the 1975 and 1976 growing seasons with chemical applications beginning at different boll weevil damage levels. Early season applications were utilized in the study because large numbers of overwintering weevils emerged each spring. Early season applications were made over the entire test area with one exception. Boll weevil damage to the squares was monitored and recorded throughout the growing season in each experiment (Tables I, II, III, and IV). Damage levels were ascertained by pulling one hundred squares from each plot and counting those which had feeding or oviposition punctures. The tests were carried out both years at the Ames Plantation, Grand Junction, Tennessee, and the Milan Field Station, Milan, Tennessee. Table V presents cultural information common to all locations. Linear correlation and regression statistics were used to analyze the data from all locations.

I. 1975 EXPERIMENT--AMES PLANTATION

The test area consisted of a 28-acre field of Memphis silt loam (B slope) planted with the Hancock variety of cotton. Approximately 75 percent of the field was planted on May 20 and the remainder on May 23.

TABLE I. Boll weevil damage levels--Ames 1975.

Date	Plot:	Percentage of Damaged Squares 1	2	3	4	5	6
July 10*		32	16	18	16	24	34
17		26	47	33	25	50	60
24		10	11	7	6	14	10
28		22	18	13	5	18	19
31			42	22	18	16	
August 4						31	
14		24					22
19		12	21	9	17	25	7

*Indicates square load was too light to consider mid-season spray application.

TABLE II. Boll weevil damage levels--Milan 1975.

Date		Plot:	1	2	3	4	5	6	7	8	9
			Percentage of Damaged Squares								
July	9*		0	5	0	10	30	15	10	10	15
	16*		14	20	8	6	12	16	4	4	16
	21		40	33	37	21	29	24	23	12	22
	29		25	26	26	34	37	30	16	15	11
August	5								16		22
	11								41		
	15		53	37	46	46	31	44		38	
	20		38	36	37	53	52	51	55	54	39

*Indicates square load was too light to consider mid-season application.

TABLE III. Boll weevil damage levels--Ames 1976.

Date	Plot:	Percentage of Damaged Squares					
		1	2	3	4	5	6
August 12		12	2	18	8	10	2
17			14		26		28
20			2				

TABLE IV. Boll weevil damage levels--Milan 1976.

Date		Plot:	Percentage of Damaged Squares 1	2	3	4	5	6
July	23*		28	26	20	14	24	22
August	3		0	14	4	8	2	2
	6		10	16	6	14	4	12
	9		28	26	12	20	28	42
	24			4			2	2

*Indicates square load was too light to consider mid-season spray application.

TABLE V. Cultural information for all test locations.

Location	Year	Soil Fertility Levels			Herbicide Rates		Fertilizer Rates	
		pH	P_2O_5	K_2O	Trifluralin	Fluometuron	Fertilizer	Rate
Ames	1975	5.9	High	High	1.5 lbs. ai/A	1.5 lbs. ai/A	Unknown	Unknown
Milan	1975	6.4	High	Medium		1.0 lbs. ai/A	10-20-20	200 lbs./A
Ames	1976	5.6	High	High	1.5 lbs. ai/A	1.5 lbs. ai/A	28-14-14	200 lbs./A
							Lime	1.5 tons/A
Milan	1976	7.1	Medium	Medium	1.5 lbs. ai/A	1.0 lbs. ai/A	10-20-20	300 lbs./A

The test area was divided into nine equal-sized plots. Boll weevil damage levels of 10, 20, and 30 percent were randomly assigned to the plots with three replications of each level. Malathion was applied to the entire field at the rate of .75 pint per acre as an early-season application on July 18. Mid-season spraying began July 28 on a plot basis by plan. Rain delayed further applications until August 6, at which time all the plots required chemical application. Chlordimeform was added to the spray program August 16 and by August 19, it became apparent that a severe *Heliothis virescens* (Fabricius) infestation of 10 or more larvae per one hundred squares had developed and subsequent chemical applications were aimed largely at the *H. virescens* population.

Insecticides were applied with an International 660 high clearance sprayer except for one aerial application on August 6. Table VI presents mid-season spray information. Data from the plots which were planted on May 23 are not included due to the difference in growth compared to the earlier planting.

Yield data were gathered on October 27-28 by recording the following information from three sub-samples of 1/1000 acre each per plot:

(1) Total number of plants

(2) Total number of bolls

(3) Bollworm damaged bolls

(4) Number of white open bolls

TABLE VI. Mid-season spray information--Ames 1975.

Application Date	Actual Percentage When Sprayed						Chemical Used
	10% Plots		20% Plots		30% Plots		
Plot:	1	4	3	6	2	5	
7/28	22			19			Malathion
8/6	x	18	22	x	42	31	*Methyl parathion--EPN
8/11	x	x	x	x	x	x	Malathion
8/16	24	x	x	x	x	x	Methyl parathion + Chlordimeform
8/19	12	17	9	7	21	25	Monocrotophos + Chlordimeform
8/25	x	x	x	x	x	x	Monocrotophos + Chlordimeform
8/31	x	x	x	x	x	x	Malathion + Chlordimeform
9/5	x	x	x	x	x	x	Monocrotophos + Chlordimeform
9/9	x	x	x	x	x	x	Monocrotophos + Chlordimeform
9/18	x	x	x	x	x	x	Monocrotophos

*Aerial application.

NOTE: Percentages and "x" marks indicate spray applications; and chemical rates were as recommended by the University.

II. 1975 EXPERIMENT--MILAN FIELD STATION

The test area at Milan consisted of a seven-acre field which was predominately Vicksburg silt loam and Iuka sandy loam on an A slope. The cropping history of the site was cotton for at least the previous three growing seasons. The Stoneville 603 variety of cotton was hilldropped May 13 at a rate of 12 pounds of acid delinted seed per acre. The field was replanted in part by hand on June 3 and 4 because of skips in the original planting.

The test field was divided into plots with insecticide applications to begin at boll weevil infestation levels of 10, 20, and 30 percent or as near these desired levels as possible. The plots were replicated three times. Field-wide treatments of toxaphene--methyl parathion (6-3) were applied on July 3 at the rate of .75 pint per acre and on July 24 at the rate of 1.33 pints per acre. Insecticide treatments were applied on a plot basis beginning July 30 and continued on a five to seven day schedule through September 3. Chlordimeform was added beginning August 7 because of a developing *Heliothis* problem and monocrotophos was substituted for toxaphenemethyl parathion (6-3) on August 21 when the worm population was identified as being primarily *Heliothis virescens* (Fabricius). Insecticide treatments were applied with an International 660 high clearance sprayer except for one aerial application on August 7. Table VII presents mid-season spray information.

Seed cotton yields were determined on November 14 by harvesting eight rows in each plot using a two-row spindle picker.

TABLE VII. Mid-season spray information--Milan 1975.

Application Date	Actual Percentage When Sprayed: 10% Plots			20% Plots			30% Plots			Chemical Used
Plot:	2	3	8	1	4	9	5	6	7	
7/30	26	26	15	25	34		37	30		Toxaphene-Methyl parathion (6-3)
8/7	x	x	x	x	x	22	x	x	*	Toxaphene-Methyl parathion
8/11	x	x	x	x	x	x	x	x	41	Toxaphene-Methyl parathion
8/16	37	46	38	53	46	x	31	44	x	Toxaphene-Methyl parathion
8/21	36	37	54	38	53	39	52	51	55	Monocrotophox - Chlordimeform
8/27	x	x	x	x	x	x	x	x	x	Toxaphene-Methyl parathion (6-3)
9/3	x	x	x	x	x	x	x	x	x	Monocrotophos + Chlordimeform

*Aerial application.

NOTE: Percentages and "x" marks indicate spray applications; and chemical rates were as recommended by the University.

III. 1976 EXPERIMENT--AMES PLANTATION

Deltapine 16 cotton variety was planted at a rate of 21 pounds of machine delinted seed per acre on May 13 in the 28-acre field used in 1975. Only six plots (two replicates) were used this year. The same desired levels of 10, 20, and 30 percent were used as criteria for beginning spray applications. On July 20, the entire field was treated with .50 pint of azinphosmethyl per acre as an early-season application. Mid-season applications on a plot basis began on August 12. Treatments were made with an International 660 high clearance sprayer. Table VIII presents mid-season spray information.

Seed cotton yields were determined on November 16 by harvesting eight rows in each plot using a two-row spindle picker.

IV. 1976 EXPERIMENT--MILAN FIELD STATION

An eight-acre field of predominately Collins silt loam soil with some Vicksburg silt loam was the test site in 1976. The field had been planted to wheat in 1975 and cotton in 1974. Stoneville 603 cotton variety was hilldropped April 20 at a rate of eight to nine seeds per hill.

Six plots were used in the 1976 experiment with two replications of each desired damage level. The 10, 20, and 30 percent levels were once again used. On July 23, a pin-head square application was applied only on those plots incurring weevil damage at or above the desired damage level. Malathion was used at the rate of .50 pint per acre. Mid-season applications began August 9 with the entire field

TABLE VIII. Mid-season spray information--Ames 1976.

Application		Actual Percentage When Sprayed						
		10% Plots		20% Plots		30% Plots		
Date	Plot:	1	5	3	4	2	6	Chemical Used
8/12		12	10	18				Azinphosmethyl
8/17		x	x	x	26	14*	28	Azinphosmethyl
8/23		x	x	x	x		x	Azinphosmethyl
8/30		x	x	x	x		x	Azinphosmethyl + Chlordimeform
9/4		No effect on weevil population						Chlordimeform by air
9/7		No effect on weevil population						Chlordimeform by air

*Did not require spray application. Did not reach desired level.

NOTE: Percentages and "x" marks indicate spray applications; and chemical rates were as recommended by the University.

being treated with 1.33 pints of toxaphene-methyl parathion (6-3) per acre. Chlordimeform was added to the next two applications.

By August 24, the weevil infestation had dropped well below the required levels in all the plots; however, a heavy infestation of Trialeurodes abutilonea (Haldeman) required treatment with 1.50 pints of monocrotophos per acre. Heliothis spp. eggs were found in sufficient numbers on August 31 to require an application of chlordimeform which was followed by an application of toxaphene-methyl parathion (6-3) + chlordimeform on September 13 in an attempt to prevent Heliothis spp. damage. Table IX presents complete mid-season spray information.

Seed cotton yields were determined on November 20 by harvesting eight rows in each plot using a two-row spindle picker.

TABLE IX. Mid-season spray information--Milan 1976.

Application Date	Actual Percentage When Sprayed: 10% Plots		20% Plots		30% Plots		Chemical Used
Plot:	3	5	2	4	1	6	
8/9	12	28	26	20	28	42	6-3 Toxaphene-Methyl parathion
8/13	x	x	x	x	x	x	6-3 + Chlordimeform
8/18	x	x	x	x	x	x	6-3 + Chlordimeform
8/24	x	2	4	x	x	2	Monocrotophos
8/31	No effect on weevil population						Chlordimeform
9/13	x	x	x	x	x	x	6-3 + Chlordimeform

NOTE: Percentages and "x" marks indicate spray applications; and chemical rates were as recommended by the University.

CHAPTER IV

RESULTS AND DISCUSSION

Yield data from two locations for the two years presented in Table X were analyzed and the significance of the results are presented in Table XI. No statistically significant correlations were found except for the Milan experiment in 1975.

I. DISCUSSION OF THE AMES (1975, 1976) AND MILAN (1976) TESTS

The statistical analyses of these experiments indicate that the results were much the same as those reported by Cherry et al. (1974). However, there are some important aspects of these tests which signify we should not conclude that all the experiments are indicative that boll weevil infestation levels of over 10 percent can be tolerated. Due to limitations in travel time between locations, we were not able to monitor weevil damage on a daily basis so as to avoid sudden rises in damage levels. This made it difficult to initiate treatments at the 10 percent infestation level at all locations. Attempts to initiate treatments at the 10 percent infestation level at Ames in 1975 and Milan in 1976 were further hindered because boll weevils were present in high numbers from the onset of fruiting as a result of the test plots being planted at a later date than cotton growing in nearby fields. Also, severe late-season Heliothis virescens damage occurred in the

TABLE X. Yield data for all test locations.

Location	Year	Percent Damage at First Spraying	Total Bolls Per .001 Acre (Mean of 3 Sub-Samples)
Ames	1975	22	143
		42	148
		22	173
		18	103
		31	130
		19	150
			Yield Lbs. Seed Cotton Per Acre
Ames	1976	12	810
		14*	586
		18	850
		26	982
		10	722
		28	658
Milan	1975	25	1291
		26	1459
		26	1502
		34	1309
		37	1372
		30	1324
		41	1188
		15	1741
		22	1842
Milan	1976	28	823
		26	618
		12	441
		20	650
		28	708
		42	464

*Did not require spray application. Fourteen percent is highest damage level reached.

TABLE XI. Correlation coefficients of the regressions of yield on percent damage at initiation of spraying. Total sum of analyses.

Location	Year	r	Significance
Ames	1975	.0036	N.S.
Ames	1976	.1445	N.S.
Milan	1975	.7913	**
Milan	1976	.0574	N.S.

**The coefficient of linear correlation of .7913 indicates a high level of correlation between the variables of the regression at the 1 percent level of probability.

test at Ames in 1975. Although unmeasured, it appeared to have a greater negative effect on final yield than did boll weevil damage.

Chemical applications were begun at low infestation levels of 10 to 12 percent at Ames in 1976. Two plots were sprayed at the low-damage level while a third plot reached a high infestation level of only 14 percent and was never sprayed with a mid-season application. It should be noted the Ames planting yield in 1976 was severely affected by an early frost that caused many bolls to rot which would have opened. Boll weevil infestations were slow to build up during the growing season. The results of this test seem to be in agreement with the findings of Cherry et al. (1974). The analysis indicated no significant difference in yield between plots sprayed at 10 to 12 percent and those incurring an infestation level of 25 to 30 percent before spray applications began.

II. DISCUSSION OF THE MILAN (1975) TEST

The results of the Milan test in 1975 indicate a high negative correlation between the variables of the regression at the 1 percent level of probability. Figure 1 illustrates the results of the analysis. The best fit equation which describes the relationship between yield and percent damage from these data is: $\hat{Y} = 20.595 - .2151$ (percent damage), indicating that, with a base yield of 20.595 cwt. per acre, every unit (percent) increase in boll weevil damage is associated with an average decrease in production of .2151 cwt. per acre.

The Milan plots in 1975 were under heavy boll weevil pressure throughout the growing season. A severe infestation of <u>Heliothis</u>

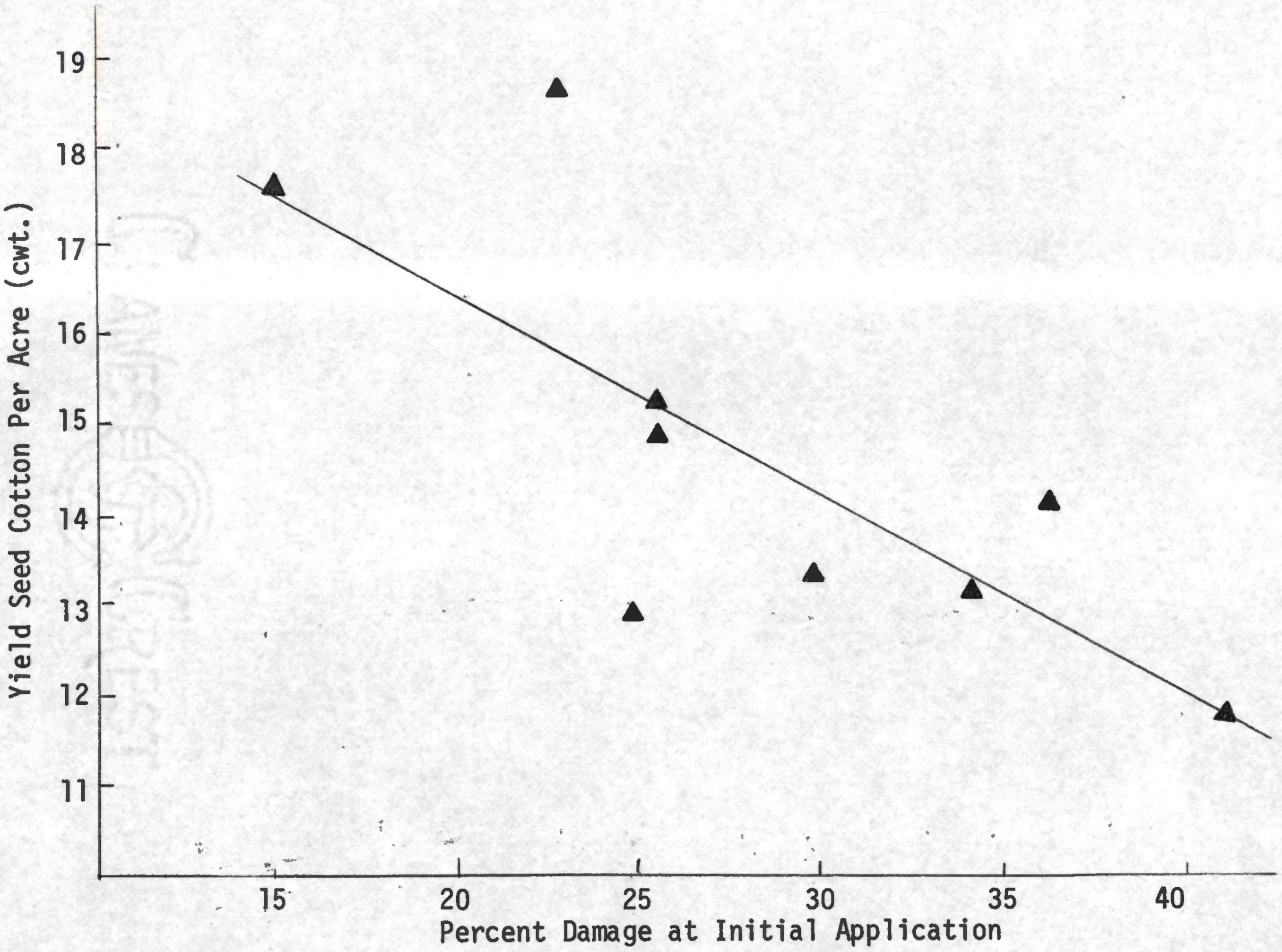

FIGURE 1. Regression of yield of cotton on percent damage at spray initiation.

virescens occurred in late season and had a considerable effect on final yield.

It is obvious from Table VII, page 25, that all the Milan (1975) plots, with one exception, received an initial spray application at a rather high boll weevil infestation level. Chemical treatments were not initiated in any plots with a low boll weevil infestation level of 10 percent. This is not to say the results should be ignored but more data are needed from which to draw conclusions.

CHAPTER V

SUMMARY

1. The following tests showed no significance between the independent variable of the regression, percent damage at the initial spray application, and the dependent variable, yield of seed cotton or total boll counts: Ames (1975), Ames (1976), Milan (1976). See Table XI, page 32.

2. The Ames (1976) data indicate boll weevil control measures initiated at the 10 to 12 percent level may not result in significant yield increases as compared to control measures initiated in plots with boll weevil infestation levels of 20 and 30 percent.

3. The Ames (1975) and Milan (1976) data cannot be interpreted in the same manner as those data from Ames (1976) because of adverse conditions of the tests which were high boll weevil infestations at the onset of fruiting, late fruiting due to late planting dates as compared to cotton growing nearby, and severe *Heliothis virescens* damage.

4. The Milan (1975) test showed there was a high negative correlation between the variables of the regression at the 1 percent level of probability. See Table XI, page 32, and Figure 1, page 34. The best fit regression equation for the data is: $\hat{Y} = 20.595 - .2151$ (percent damage). These data may not imply a cause and effect relationship between the two variables for the following reasons:

a. There was no yield information at the 10 percent infestation level.

b. The crop experienced severe <u>Heliothis virescens</u> damage, which probably overshadowed boll weevil damage.

c. Mid-season applications were begun late in the season due to a late planting date.

5. Due to the adverse conditions outlined in the above statements, further research should be conducted and compared with the data of Cherry et al. (1974) and the data presented in this thesis before recommendations are changed.

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VITA

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