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AN ECONOMIC EVALUATION OF COTTON PEST MANAGEMENT IN PINAL COUNTY, ARIZONA

by

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A Thesis Submitted to the Faculty of the

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For the Degree of

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ABSTRACT

Chemical pesticides are a major input to agricultural production in Arizona. The use of pesticides on cotton has been further magnified in the last few years due to heavy infestations of the pink bollworm. The uncertainty of crop losses resulting from pest outbreaks has caused many cotton growers to engage in inundative type control programs. However, increased applications and rising pesticide costs have made this form of risk aversion costly. An alternative to inundative control has been integrated pest control management where all suitable techniques--chemical, cultural, and biological--are used to maintain pest populations below some economic level.

It is the objective of this study to test the hypothesis that integrated pest control management will result in added net returns to the grower vis-à-vis that offered by an inundative control program. Pinal County is selected as the study area. The study considers a group of 14 growers who followed integrated pest management principals and 14 growers who did not for the 1972 growing season. Pesticide material and application costs were used in a budgeting framework to evaluate the two pest control alternatives, along with an examination of pest infestation levels for the two groups. In addition, statistical analysis and break-even analysis is used to provide more insight into the costs and returns associated with alternative pest control strategies.

CHAPTER 1

INTRODUCTION

Chemical pesticides are a major input to agricultural production in Arizona. Records for 1972 show that over two million technical pounds of organochlorine and over four million technical pounds of organophosphate pesticides were used in the production of Arizona crops (see Appendix A). The use of pesticides on cotton, a major user, has been further magnified in the last few years due to heavy infestations of the pink bollworm, *Pectinophora gossypiella*. This situation was further aggrevated in 1967 by large outbreaks of the cotton bollworm, *Heliothis spp*.

Inundative suppression with pesticides has been the main method of pest control for cotton. Although a ban on DDT has caused a shift in usage to substitutes such as methyl parathion and other organophosphates, inundative pest control is still the rule for much of Arizona cotton.

There have been several problems associated with inundative pest control practices in recent years. In a study conducted in the Safford Valley of Eastern Arizona, it was observed that heavy mortality of the honey bee, *Apis mellifera*, and heavier infestations of the cotton leaf perforator, *Bucclatrix thurberiella* developed after an automatic insecticide control program was started in 1969 (Carruth and Moore, 1973). Growers find it desirable to eliminate pest populations to lower the uncertainty in production. It is this risk and uncertainty that pushes farmers to make so-called "insurance" treatments. However, increased applications and rising pesticide costs have made this form of risk aversion costly. Not only may eradicative control measures eliminate natural enemies of many pests, which in turn may trigger serious outbreaks of secondary pests, but insect populations may develop resistance to pesticides resulting in the need for higher and often more frequent dosages, hence, more costly control measures. Previous research indicates that pest control is now an average of 10-15 percent of total production costs in Arizona cotton production (Hathorn and Wright, 1972).

An alternative to automatically scheduled chemical control has been the concept of integrated pest management. A frequent term associated with this approach is integrated control. In an integrated pest management program, all suitable techniques--chemical, cultural, and biological--are used in the best combination to reduce pest populations and maintain them below some economic injury level. A constant evaluation of the insect-crop relationship in the fields is needed so that insecticides may be applied at the proper time. Insecticides are only applied when the pest population in question reaches an economic injury level sometimes referred to as the "economic threshold."

"Cotton scouting" programs initiated in the states of Arkansas and Arizona, among others, (Boyer, Warren and Lincoln, 1962; Carruth and Moore, 1973) have served as the basis for developing integrated pest management systems in cotton. Basically, scouting is the "systematic collection of field information on the occurrence and activity of injurious and beneficial insects on an area-wide basis" (Carruth and Moore, 1973, p. 188). Activities included in a program of this nature are the assessment of pest infestations and their economic impact on a crop (see

Appendix B). This information permits more selective use of pesticides when actually needed. For example, it was observed in the Safford Scouting Program that the average number of spray applications declined significantly from previous levels after the program was started. Other objectives of the program include eliminating needless cost and minimizing objectionable side effects to the "agroecosystem" such as toxic hazards to humans, animals, and beneficial insects.

In general, a grower utilizing scouting information and recommendations will attempt to use chemical pesticides on a selective or restrictive basis to maintain the pest population below some level. Inundative control, on the other hand, is an attempt to suppress the pest completely.

Objectives

This project will test the hypothesis that integrated pest management, utilizing scouting information, will result in added net returns to the cotton grower vis-a-vis that offered by a total suppression program. This project will be limited to Pinal County and the 1972 cotton growing season.

The more specific objectives will be to determine:

1. The extent of infestation levels for three cotton insects: pink bollworm, bollworm, and lygus, between the two pest control alternatives.

2. Pesticide material and application costs for the two pest control alternatives.

Review of Relevant Research

Research in the area of pesticide economics has been both diverse and voluminous in the last few years. This research can be roughly divided into four major areas of investigation.

One area of study has been concerned with a restriction or a ban on certain pesticides. One study focused on a restriction of organochlorine pesticides on four specific crops: cotton, corn, peanuts, and tobacco (Davis et al., 1970). Estimated substitution rates showed an average of about three-fourths of a pound of organophosphates are needed to replace a pound of organochlorine pesticide. It was concluded that a 75 percent reduction of organochlorine pesticides on these crops was possible at an additional cost of $26.7 million or $2.23 per acre treated. A similar study showed that restricting the use of organochlorines on Mississippi Delta cotton farms would increase production costs as well as increase insect resistance (Cooke, 1970).

Investigations dealing with the productivity of pesticides and the possibility of substituting other inputs, mainly land and labor, for pesticides has been another research area (Headly, 1968). Headly found that large elasticities of cropland for pesticides existed in the Southeast and Southern Plains regions. It was estimated that if land input increased one percent, total pesticide usage could be reduced by more than six percent. Headly also found that pesticides generally return more to farmers than they cost. It was estimated that for each dollar spent on pesticides, four dollars of additional sales were generated. This implies annual benefits of about $1.8 billion attributable to pesticides used on crops in the United States.

Another research area has been concerned with minimizing pest control through the use of improved managerial strategies. In order to make a sound decision as to when to initiate control measures, the manager must be able to (1) detect the presence of a pest, (2) estimate the size of the pest population, and (3) estimate the amount of damage that may be inflicted on the crop if the pest is not controlled (Adkisson, 1969). Some attempts have been made to identify the relative value and effectiveness of successive numbers of pesticide treatments (Hillebrandt, 1960; Edwards and Heath, 1964). From this work, "dosage response curves" indicating the relationship between yields and amount of pesticide applied have been empirically established. The curve for a particular infestation will determine what control measures are necessary and that rate of application at which profits no longer increase. The difficulty with this concept as Smith points out, is that it fails to recognize that a pest infestation is not static, but may vary with time, crop maturity, and climatic conditions (Smith, 1970).

Carlson employed pesticide use decision theory based on subjective expected utility maximization (Bayesian analysis) to determine optimum crop disease control procedures on California peaches (Carlson, 1970). He concluded that this type of decision theory is applicable when disease control costs are high relative to product price, when the intensity of damage is highly variable from year to year, and when the disease can be predicted with some certainty.

Important in any crop protection scheme has been the concept of economic injury levels, otherwise known as the "economic threshold." Edwards and Heath (1964) have stated that a pest population has reached the economic threshold when the population is large enough to cause damages valued at the cost of practical control. Headly (1971) further built on this definition by isolating three variables: damage, pest population, and time. These factors are related in that damage is a function of pest population, and population is a function of time. Headly's definition of the economic threshold is the population that produces incremental damage equal to the cost of preventing that damage.

Another research area has dealt with systems approaches that take into account benefits and costs of pesticide use accruing not only to the farm sector, but to external groups of people as well (Edwards, 1969). Utilizing a model which maximized a measure of welfare (defined as consumer's surplus plus producer's surplus) over the production of crops grown in Dade County, Florida, Edwards concluded that a 50 percent reduction in organochlorine type pesticides could be made with less than a one percent decrease in net social value of the crops studied.

CHAPTER 2

METHODOLOGY

Three sources of data were utilized in this study to determine the extent of pest infestations, pesticide material and application costs, selected cultural practices, and yields of the two pest control alternatives in Pinal County. These sources were: (1) computerized records of the Pinal County Cotton Pest Management Program, (2) a field survey, and (3) the findings of previous studies.

Sample Selection

Since detailed information concerning pest infestation and control measures were vital to this study, only those growers who were participants of the 1972 Pinal County Cotton Pest Management Program were selected as the initial group. In 1972, this group was comprised of 60 growers, all of whom grew cotton as the major source of income.

Entomologists at The University of Arizona were asked to classify the participating growers as to whether or not they had used pest management principles during the 1972 growing season. The main criterion utilized in dividing the sample was whether or not the growers had followed published University of Arizona insect control procedures and used the data of the cotton scouts working with the pest management program (see Appendix C). A final sample was comprised of 14 growers who had followed pest management principles (adopters) and 14 growers who did not (nonadopters). The location of the final sample is shown in Figure 1.

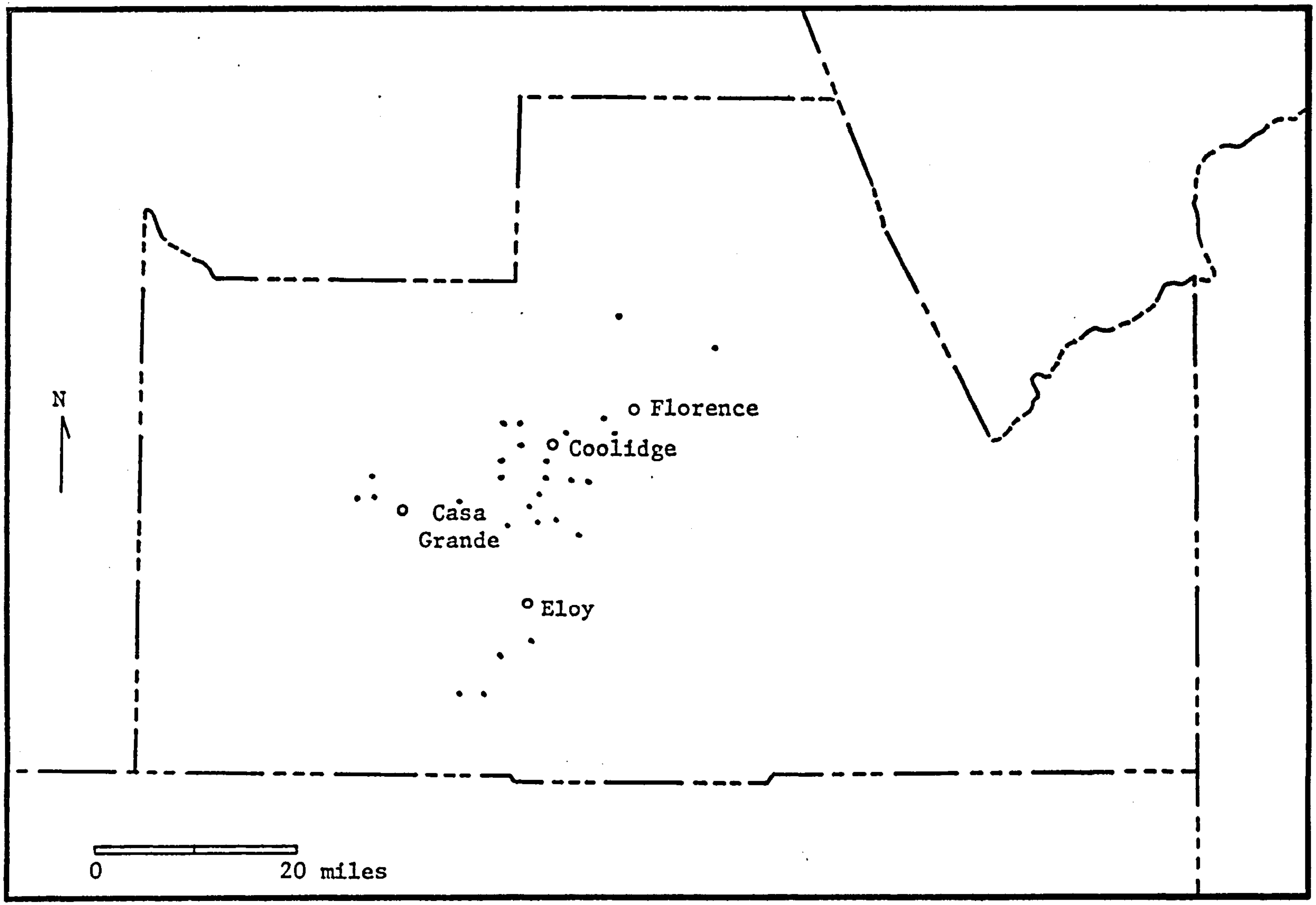

Figure 1. Map of Pinal County, Showing Location of Cotton Growers in Survey, 1972.

Data Collection

The field survey was conducted in the summer of 1973. Cotton growers were interviewed to obtain information on their 1972 cotton operations. Data obtained included planting rates, fertilizer, irrigation practices, harvest data, and cotton quality (see Appendix D).

Arizona Pest Management Program records were used to obtain data concerning daily insect counts and pesticide usage on a field by field basis.

Previous research concerned with economic injury levels for cotton pests were used in determining the relative effectiveness of the two alternative control programs (Watson and Fullerton, 1969; Moore and Watson, 1973).

Analytical Procedure

Cost budgeting was used as the main analytical tool. This technique was suited to this study because there were only two pest control alternatives to be considered, and the problem (as defined) was concerned with only one area of the business. As a supplement to cost budgeting, break-even analysis was used to provide some insight into the returns associated with the alternative pest control approaches. Comparisons of pest control costs and practices will provide a basis for drawing inferences between the two pest control alternatives.

Differences in means between pesticide materials, number of treatments, pest control costs, and yields for the two groups were tested for statistical significance (Steel and Torrie, 1960).

Limitations of the Study

This study has certain limitations which must be recognized when interpreting the results.

Only one year, 1972, was chosen for the study as data pertaining to insect infestations and pesticide usage for other years was not available. This may have the possibility of introducing bias into the study, because insect populations and thus pest control measures may vary from year to year. For example, the pink bollworm, normally considered the major pest problem in Pinal County, did not reach expected levels in 1972, while the bollworm, normally considered a secondary pest, became a serious problem in 1972.

This study was concerned with only 28 cotton growers who participated in the 1972 Pinal County Pest Management Program. Growers outside of the program were not considered because the extent of their pest problems and pesticide usage could not be accurately determined. Increasing the sample to include not only those growers not participating in the program, but also growers outside of Pinal County, would greatly expand the scope of inference.

Pesticide material costs were estimated using 1972 prices provided by a major chemical firm in central Arizona. It was assumed that these prices were representative of those paid by Arizona cotton growers in general, however, using additional sources to estimate pesticide costs could more clearly reflect pesticide expenditures because such factors as quantity discounts, "service," and "nonservice" prices could possibly be determined.

The attempt to fully evaluate the returns from alternative pest control approaches was limited by a lack of data. Detailed gin records of 1972 cotton yields could not be obtained and data pertaining to cotton lint quality was limited to grower responses on the field survey.

CHAPTER 3

CHARACTERISTICS OF FARMS SURVEYED

Area Studied

Pinal County was chosen for the study because it has an established cotton pest management program. The data generated by this program was vital to this study and could not be obtained from areas of the State without such a program.

Agriculture in Pinal County

Pinal County occupies a high agricultural position in Arizona. It accounts for 19 percent of Arizona's total cash crop receipts, and is surpassed only by Maricopa and Yuma Counties in total crops and livestock receipts. Of all crop production, cotton ranks as the leading activity with gross receipts totaling $35.7 million in 1972. Pinal County accounted for approximately 37 percent of Arizona's total upland cotton production in 1972. Arizona cotton production by County is shown in Table 1. Other field crops of major importance are wheat, barley, alfalfa, sorghum, and sugar beets. The major vegetable crop is lettuce with a value of $13.0 million in 1972. These data are shown in Table 2.

Because of potential outbreaks of economic pests, agriculture in Pinal County is dependent on the use of chemical pesticides.

Table 1. Arizona Cotton Acreage and Production by Counties, 1972.

County	Acreage		Yield Per Acre		Production
	Planted	Harvested	Planted	Harvested	480 lb. Net Weight Bales
	(acres)		(pounds)		(bales)
Upland					
Cochise	15,830	15,600	622	631	20,500
Gila	--	--	--	--	--
Graham	5,700	4,560	497	621	5,900
Greenlee	1,230	1,000	519	638	1,330
Maricopa	101,500	101,200	1,125	1,128	238,100
Mohave	830	830	1,116	1,116	1,930
Pima	12,700	12,700	903	903	23,900
Pinal	101,600	101,500	1,051	1,052	222,700
Santa Cruz	50	50	624	624	65
Yavapai	10	10	750	750	15
Yuma	33,550	33,550	1,266	1,266	88,560
ARIZONA	273,000	271,000	1,059	1,067	603,000
American Pima					
Cochise	5,350	5,350	474	474	5,280
Gila	--	--	--	--	--
Graham	11,150	9,750	362	414	8,420
Maricopa	8,800	8,800	688	688	12,620
Pima	3,450	3,450	537	537	3,860
Pinal	8,700	8,700	630	630	11,430
Yuma	3,850	3,850	897	897	7,190
ARIZONA	41,300	39,900	567	587	48,800

Source: Mayes, 1972.

Table 2. Production of Crops in Pinal County, 1972.

Crop	Acres	Yield per Harvested Acre	Production
Upland Cotton	101,600	1,052 lbs.	222,700 bales
American Pima	8,700	630 lbs.	11,430 bales
Alfalfa Hay	18,000	4.7 tons	84,600 tons
Other Hay	2,900	2.1 tons	6,100 tons
Safflower	6,100	2,160 lbs.	6,600 tons
Sugar Beets	1,490	19.6 tons	29,170 tons
Barley[a]	42,000	3,260 lbs.	58,760 tons
Sorghum[a]	14,400	3,300 lbs.	18,170 tons
Wheat[a]	14,000	3,900 lbs.	72,150 tons
Corn[a]	200	4,200 lbs.	210 tons

a. Planted for all purposes.

Source: Smith and Mayes, 1972.

Geography and Climate

Pinal County is located in south central Arizona and covers a land area of almost 5,400 square miles. The surface relief ranges from low desert valleys in the western areas to mountains in the eastern and southern areas. Soil types range from deep soils characteristic of alluvial floodplains in the agricultural areas to shallow soils of the steep upland areas.

Pinal County may be described as a low altitide desert plant climate zone. The growing season is fairly long, averaging about 257 days at Casa Grande and Florence. Climatic data is presented in Table 3.

Selected Grower Practices

Acreages for the 28 farms surveyed in Pinal County ranged from 75 to 849 acres in the adopter group and from 63 to 2,289 acres in the nonadopter group. Acreage for the 14 farms in the adopter group totaled 4,328 acres with a mean of 309 acres. The 14 farms which comprised the nonadopter group totaled 6,401 acres with a mean of 457 acres. All growers in the survey listed cotton as their major crop.

Planting

Grower planting practices are tabulated in Table 4. DPL-16 was the most common variety planted with 92.8 percent of the growers in both groups planting this variety. The majority of growers in both groups started planting between March 15-31. None of the growers surveyed indicated planting before this date. The most prevalent seeding rate for both groups was 10-14 pounds per acre, although 35.7 percent of the

Table 3. Climatic Data, Pinal County, 1972.

Town	Elevation	Average Summer Maximum-Minimum Temperature	Average Winter Maximum-Minimum Temperature	Average Annual Rainfall
Casa Grande	1,405 ft.	105-71°	68-35°	8.2 in.
Florence	1,500 ft.	104-70°	68-38°	9.8 in.

Town	Average Date of Last Killing Frost in Spring	Average Date of Last Killing Frost in Autumn	Average Length of Growing Seasons (Days)
Casa Grande	March 7	November 19	257
Florence	March 8	November 21	258

Source: Sacamano, Charles M., n.d.

Table 4. Grower Planting Practices, by Group, Pinal County, 1972.

Item	Percent of Growers	
	Adopter Group	Nonadopter Group
Variety		
DPL-16	92.8	92.8
DPL 61-37	0	7.2
Stoneville 213	7.2[a]	0[b]
TOTAL	100.0	100.0
Average Planting Date		
March 1-14	0	0
March 15-31	78.6	64.3
April 1-14	7.1	35.7
April 15-30	14.3	0
TOTAL	100.0	100.0
Planting Rate (lbs/ac)		
Less than 10	7.2	7.1
10-14	57.1	85.7
15-20	35.7	0
20 and greater	0	7.1
TOTAL	100.0	100.0

a. In addition to DPL-16, 28.6 percent of Stoneville 213 was planted.

b. In addition to DPL-16, 7.1 percent of Stoneville 213 was planted.

growers in the adopter group reported planting rates of 15-20 pounds per acre, while none of the nonadopters used these rates.

Fertilization

Fertilizer use practices are shown in Table 5. Approximately 43 percent of the growers in the adopter group applied nitrogen before planting as opposed to 50 percent of the growers in the nonadopter group. Pounds of nitrogen applied before planting averaged 27.5 pounds per acre for the adopter group and 17 pounds per acre for the nonadopter group. Thirty-six percent of the growers in the adopter group applied phosphate before planting compared to 50 percent of the growers in the nonadopter group. Pounds of phosphate applied before planting averaged 30 pounds per acre for the adopter group and 36 pounds per acre for the nonadopter group.

The percentage of growers applying nitrogen at planting time was lower than before planting application. Approximately 29 percent of the adopter group and 22 percent of the nonadopter applied nitrogen at planting time. On the average, growers in the adopter group applied 23 pounds of nitrogen per acre and the growers in the nonadopter group applied 14 pounds of nitrogen per acre. Application of phosphate at planting time was rare. Only one grower from each group indicated applying phosphate at planting time. Rates of phosphate application at planting averaged 4 pounds per acre for the adopter group and 7 pounds per acre for the nonadopter group.

Post plant application of nitrogen was common to both groups. Thirteen growers or 92.8 percent from each group applied nitrogen after

Table 5. Grower Fertilization Practices, by Group, Pinal County, 1972.

Fertilization Practices	Adopter Group		Nonadopter Group	
	N	P_2O_5	N	P_2O_5
Preplant Application				
Percent of Growers	42.8	35.7	50.0	50.0
Pounds per Acre	27.5	30.1	17.0	36.1
Planting				
Percent of Growers	28.6	7.1	21.5	7.1
Pounds per Acre	22.8	4.3	14.3	6.6
Post-Plant				
Percent of Growers	92.8	14.3	92.8	28.6
Pounds per Acre	75.0	3.6	86.9	17.4
Percent of Growers Applying Fertilizer	100.0	64.3	100.0	85.7
Total Pounds Applied Per Acre	125.3	38.0	118.2	60.1

planting. Growers in the adopter group applied an average of 75 pounds per acre compared to 87 pounds per acre in the nonadopter group. Post plant application of phosphate was higher in the nonadopter group with 29 percent of the growers applying, as compared to 14 percent of the adopter group. Rate of phosphate application after planting averaged 4 pounds per acre for the adopter group and 17 pounds per acre for the nonadopter group.

In summary, all of the growers in both groups applied nitrogen at some time during the 1972 growing season. Total amount of nitrogen applied averaged 125 pounds per acre for the adopter group and 118 pounds per acre for the nonadopter group. Sixty-four percent of the growers in the adopter group applied phosphate during the growing season as compared to 86 percent in the nonadopter group. Total amount of phosphate applied averaged 38 pounds per acre for the adopter group and 60 pounds per acre for the nonadopter group.

Irrigation

The average number of crop irrigations for the 1972 growing season by group is presented in Table 6. Fifty-seven percent of the growers in the adopter group and 71 percent of the growers in the nonadopter group applied between 6 and 10 crop irrigations. The number of crop irrigations averaged 8.5 for the adopter group and 8.2 for the nonadopter group. All growers indicated applying one preirrigation.

Table 7 shows the percentage of growers terminating irrigation by date. Seventy-one percent of the growers in both groups terminated crop irrigation between September 1 and 15.

Table 6. Average Number of Crop Irrigations, by Group, Pinal County, 1972.

Number of Irrigations	Percent of Growers	
	Adopter Group	Nonadopter Group
0 - 5	7.1	7.1
6 - 10	57.1	71.4
11 - 15	35.7	21.5
16 and greater	0	0

Table 7. Irrigation Termination Date, by Group, Pinal County, 1972.

Date	Percent of Growers	
	Adopter Group	Nonadopter Group
August 15-31	14.3	7.1
September 1-15	71.4	71.4
September 16-31	14.3	21.5
October 1 and later	0	0

Disease and Nematodes

Diseases and nematodes were not generally serious problems for the growers surveyed. The percentage of growers by group that indicated disease and nematode problems is presented in Table 8. Root rot appeared to be the only problem with two growers or 14 percent from each group reporting its occurrence. Approximate yield reduction resulting from root rot ranged from 1 to 5 percent for both groups. Other disease problems reported included verticillium wilt (7 percent of the adopter group and 14 percent of the nonadopter group) and nematodes (7 percent of both groups). One grower of the adopter group stated that salt problems caused an estimated reduction in his cotton yields by one-fourth bale per acre.

Harvesting Dates

Dates of harvest for the two groups are shown in Table 9. The occurrence of unusual rains beginning in early October and continuing throughout the fall made harvesting difficult and reduced cotton quality. Starting dates for harvest ranged from September 25 to December 15 for the adopter group and from September 21 to October 20 for the nonadopter group. Average starting date for harvest was October 15 for the adopter group and October 13 for the nonadopter group. Percentages of the total crop harvested during the first picking averaged 83 percent for the adopter group and 79 percent for the nonadopter group.

Dates of second harvest and rooding ranged from December to February for both groups. Growers from both groups indicated that 10 to 20

Table 8. Occurrence of Diseases, by Group, Pinal County, 1972.

Disease	Percent of Growers	
	Adopter Group	Nonadopter Group
Root Rot	14.3	14.3
Nematodes	7.1	7.1
Verticillium Wilt	7.1	14.3
Boll Rot	0	0
Salt, Hail	14.3	0

Table 9. Average Starting Dates of Harvest, by Group, Pinal County, 1972.

Date	Percent of Growers	
	Adopter Group	Nonadopter Group
September 1-15	0	0
September 16-30	21.5	21.5
October 1-15	28.6	57.1
October 16-30	35.7	21.5
November 1-15	7.1	0
November 16-30	0	0
December 1-15	7.1	0

percent of the remaining crop was harvested during second picking and rooding operations.

Yields and Cotton Quality

Table 10 shows the average per acre yields produced by both the adopter and nonadopter groups for the 1972 growing season. The adopter group averaged 1,058 pounds of lint per acre and the nonadopter group averaged 1,081 pounds per acre. This mean difference was statistically insignificant at the 5 percent level. Adopter growers in the Eloy area produced the highest average per acre yields with 1,117 pounds, while nonadopter growers in the Eloy area produced the lowest, averaging 953 pounds per acre.

The occurrence of early season rains beginning in October had the effect of reducing lint quality for all 28 growers surveyed. Over 70 percent of the grades reported by both groups were strict low middling and below. Table 11 shows the breakdown of cotton lint quality as reported by the growers.

Table 10. Average per Acre Cotton Yields, by Group and Area, Pinal County, 1972.

Area	Pounds of Lint	
	Adopter Group	Nonadopter Group
Coolidge-Florence	1,041	1,110
Casa Grande	1,070	1,125
Eloy	1,117	953
Group Average	1,058	1,081

Table 11. Cotton Lint Quality, by Group, Pinal County, 1972.

Cotton Grade	Average Percent of Crop	
	Adopter Group	Nonadopter Group
Good Middling	0	0
Strict Middling	0	0
Middling Plus	0	0
Middling	27	26
Strict Low Middling	53	41
Low Middling Plus	3	7
Low Middling	8	8
Strict Good Ordinary Plus	2	6
Strict Good Ordinary	3	6
Below Grade	4	6

CHAPTER 4

PEST INFESTATIONS IN PINAL COUNTY

Infestations of the cotton insects studied, namely pink bollworm, (Pectinophora gossypiella), bollworm, (Heliothis spp.) and lygus bugs (lygus spp.) were variable as indicated by the data. These insects constituted the major pest problems in the 1972 crop season, thus were picked for the analysis. The cotton leafperforator (Bucculatrix thurberiella) was not chosen as it is a secondary pest and only periodically causes significant crop damage in Pinal County.

Infestation and damage levels for the adopter group and the nonadopter group are shown in tabular and graphical form.

Pink Bollworm

The pink bollworm, considered the major cotton pest in Pinal County, did not reach expected infestation levels in the 1972 growing season. This was due in part to a week of extremely hot weather in late July plus measures taken to control outbreaks of the bollworm.

Trends in damaged bolls, and the percentage of infested fields are shown in Tables 12, 13, and 14 and Figures 2 and 3. The average percent of damaged bolls and infested fields conformed to the normal 30 day pink bollworm life cycle. Infestation levels for the adopter group were slightly higher than the nonadopter group, however, in no case did a mean percentage of boll damage approach the economic threshold level,

Table 12. Pink Bollworm Damage, by Group and Date, Pinal County, 1972.

Week Ending	Number of Fields	Mean Damage Per 100 Bolls	Percent of Fields Infested
July 16			
Adopters	103	.20	9.7
Nonadopters	102	.93	23.5
July 23			
Adopters	132	1.86	34.8
Nonadopters	107	1.39	31.8
July 30			
Adopters	128	3.07	53.1
Nonadopters	129	1.35	38.8
August 6			
Adopters	135	2.04	50.4
Nonadopters	138	1.04	31.2
August 13			
Adopters	136	1.13	33.8
Nonadopters	138	.66	23.2
August 20			
Adopters	103	1.68	33.0
Nonadopters	113	1.20	31.0
August 27			
Adopters	121	2.47	44.6
Nonadopters	111	1.16	35.1
September 3			
Adopters	100	3.22	46.0
Nonadopters	121	.98	30.6
September 10			
Adopters	98	1.51	35.7
Nonadopters	110	.79	25.5
September 17			
Adopters	102	1.66	33.3
Nonadopters	95	.75	26.3

Table 13. Pink Bollworm Damage, Magnitude of Damaged Bolls, Adopter Group, Pinal County, 1972.

Week Ending	Number of Fields	Percent Fields at the Indicated Level of Damaged Bolls						
		0	1-5	6-10	11-15	16-20	21-25	25 or more
July 16	103	90.3	8.7	1.0	0	0	0	0
July 23	132	65.2	18.9	11.4	3.8	0.8	0	0
July 30	128	46.9	38.3	8.6	3.9	0	0.8	1.6
August 6	135	49.6	43.0	5.2	.7	0	0	1.5
August 13	136	66.2	28.7	3.7	0	0.7	0.7	0
August 20	103	67.0	25.2	5.8	1.0	0	0	1.0
August 27	121	55.4	28.9	9.1	5.0	0	0.8	0.8
September 3	100	54.0	29.0	9.0	3.0	2.0	2.0	1.0
September 10	98	64.3	26.5	8.2	0	0	1.0	0
September 17	102	66.7	23.5	7.8	1.0	0	1.0	0

Table 14. Pink Bollworm Damage, Magnitude of Damaged Bolls, Nonadopter Group, Pinal County, 1972.

Week Ending	Number of Fields	Percent Fields at the Indicated Level of Damaged Bolls						
		0	1-5	6-10	11-15	16-20	21-25	25 or more
July 16	113	78.8	17.7	2.7	0.9	0	0	0
July 23	107	69.2	23.4	4.7	2.8	0	0.9	0
July 30	129	62.0	31.8	5.4	0.8	0	0	0
August 6	138	68.8	27.5	3.6	0	0	0	0
August 13	138	76.8	20.3	2.2	0.7	0	0	0
August 20	113	69.0	25.7	5.3	0	0	0	0
August 27	111	64.9	31.5	3.6	0	0	0	0
September 3	121	69.4	28.9	0.8	0	0	0	0
September 10	110	74.5	24.5	0.9	0	0	0	0
September 17	95	73.7	25.3	1.1	0	0	0	0

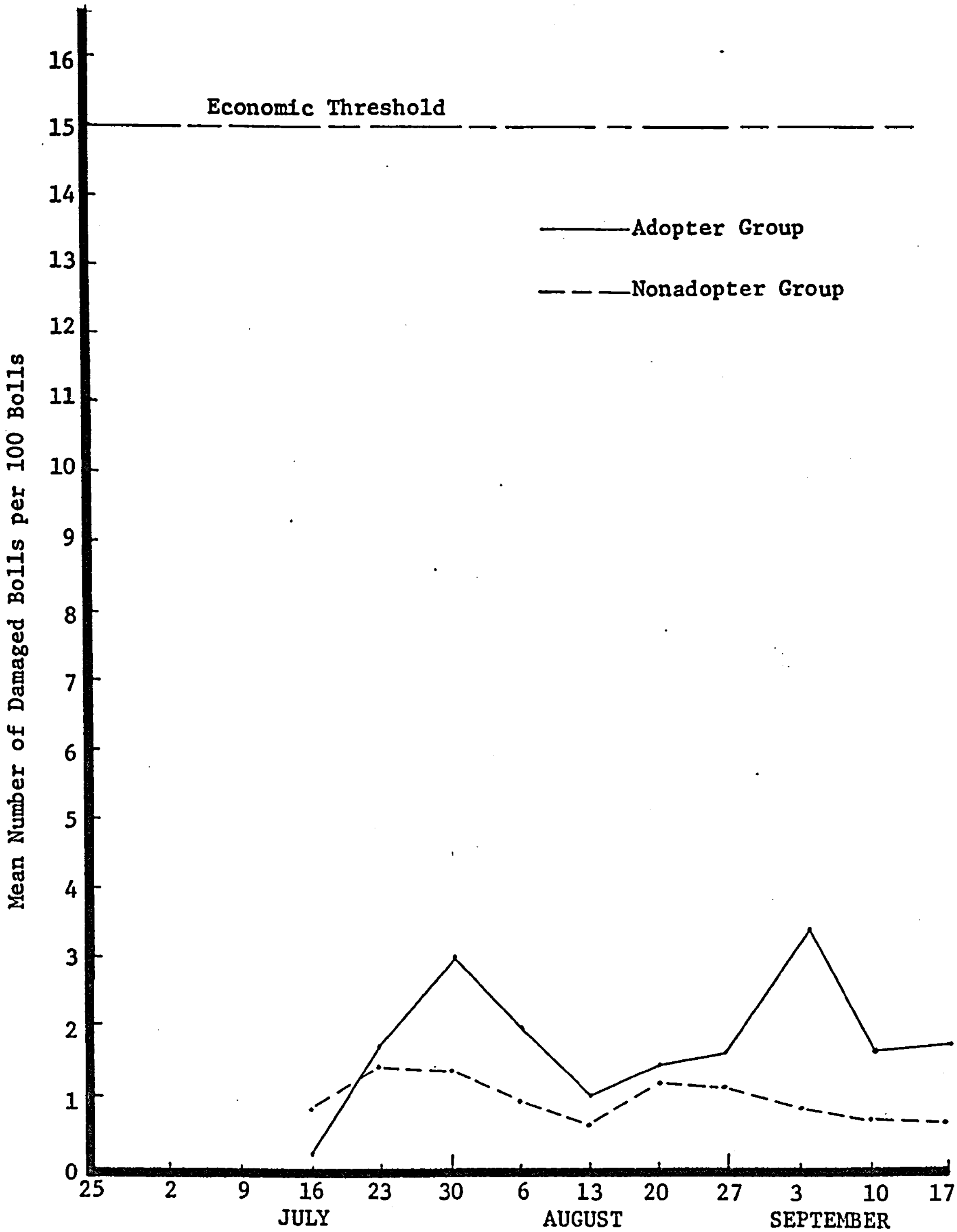

Figure 2. Pink Bollworm Damage Levels, Pinal County, 1972.

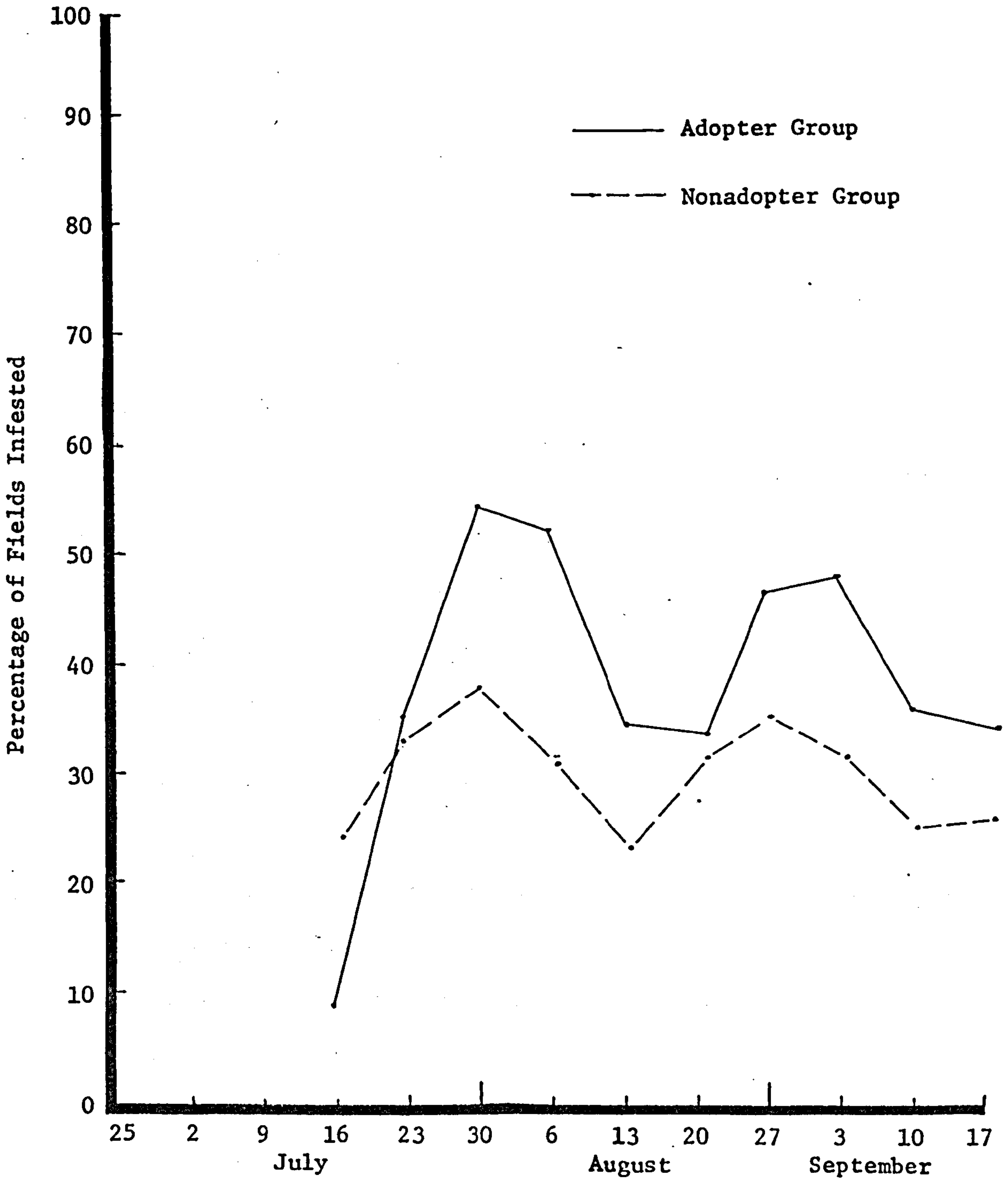

Figure 3. Pink Bollworm Infested Fields, Pinal County, 1972.

which has experimentally been found to be 15-20 percent damaged bolls (Watson and Fullerton, 1969). Lower infestation levels for the nonadopter group were partially a result of the inundative nature of their control programs.

In comparing percentage of fields infested, it can be seen that a higher percentage of infested fields existed with the adopter group. The highest level for the adopter group occurred during the week of July 30, when 53.1 percent of the fields were infested. Close examination of the magnitude of this level (Table 13) shows that only 2.4 percent of adopter group fields had infestation levels which exceeded the economic injury level for that week. For the entire growing season, the distribution of percent of fields infested for both groups shows that a very small percentage of fields ever exceeded economic levels. Nearly all infested fields ranged in the 0-10 percent level.

Bollworm

The bollworm is normally considered a periodic cotton pest in Arizona, however, in 1971 and 1972, infestation levels were to become serious. Large outbreaks of bollworm and tobacco budworm (H. Virescens) in Pinal County were partially attributed to the intensive treatment of lygus bugs in the early portion of the growing season.

Table 15 and Figure 4 show that mean percentage of bollworm larvae for the adopter and nonadopter groups were very similar. Average larval counts were very low for most of the growing season, reaching a peak the first week of September when infestation levels averaged 3.6 larvae for the adopter group and 2.9 for the nonadopter group.

Table 15. Bollworm Infestation Levels, by Group and Date, Pinal County, 1972.

Week Ending	Number of Fields Checked	Mean Number of Larvae per 100 Plants	Percent of Fields Infested
June 18			
Adopters	118	.16	11.0
Nonadopters	126	.72	24.6
June 25			
Adopters	114	.65	27.2
Nonadopters	131	1.28	33.6
July 2			
Adopters	128	.37	16.4
Nonadopters	121	.50	19.0
July 9			
Adopters	119	.13	10.9
Nonadopters	137	.29	10.2
July 16			
Adopters	111	.12	5.5
Nonadopters	130	.16	7.7
July 23			
Adopters	107	1.37	32.7
Nonadopters	106	1.05	18.9
July 30			
Adopters	126	2.19	54.0
Nonadopters	125	.97	30.4
August 6			
Adopters	165	1.16	33.9
Nonadopters	128	1.34	37.5
August 13			
Adopters	136	1.15	36.8
Nonadopters	138	.87	29.3
August 20			
Adopters	103	2.63	61.2
Nonadopters	125	2.49	52.8
August 27			
Adopters	121	2.03	53.7
Nonadopters	111	3.01	55.9

Table 15. (continued)

Week Ending	Number of Fields Checked	Mean Number of Larvae per 100 Plants	Percent of Fields Infested
September 3			
Adopters	100	3.63	62.0
Nonadopters	119	2.88	68.9
September 10			
Adopters	101	2.59	56.4
Nonadopters	114	2.21	52.6
September 17			
Adopters	107	2.38	43.0
Nonadopters	99	3.47	48.5

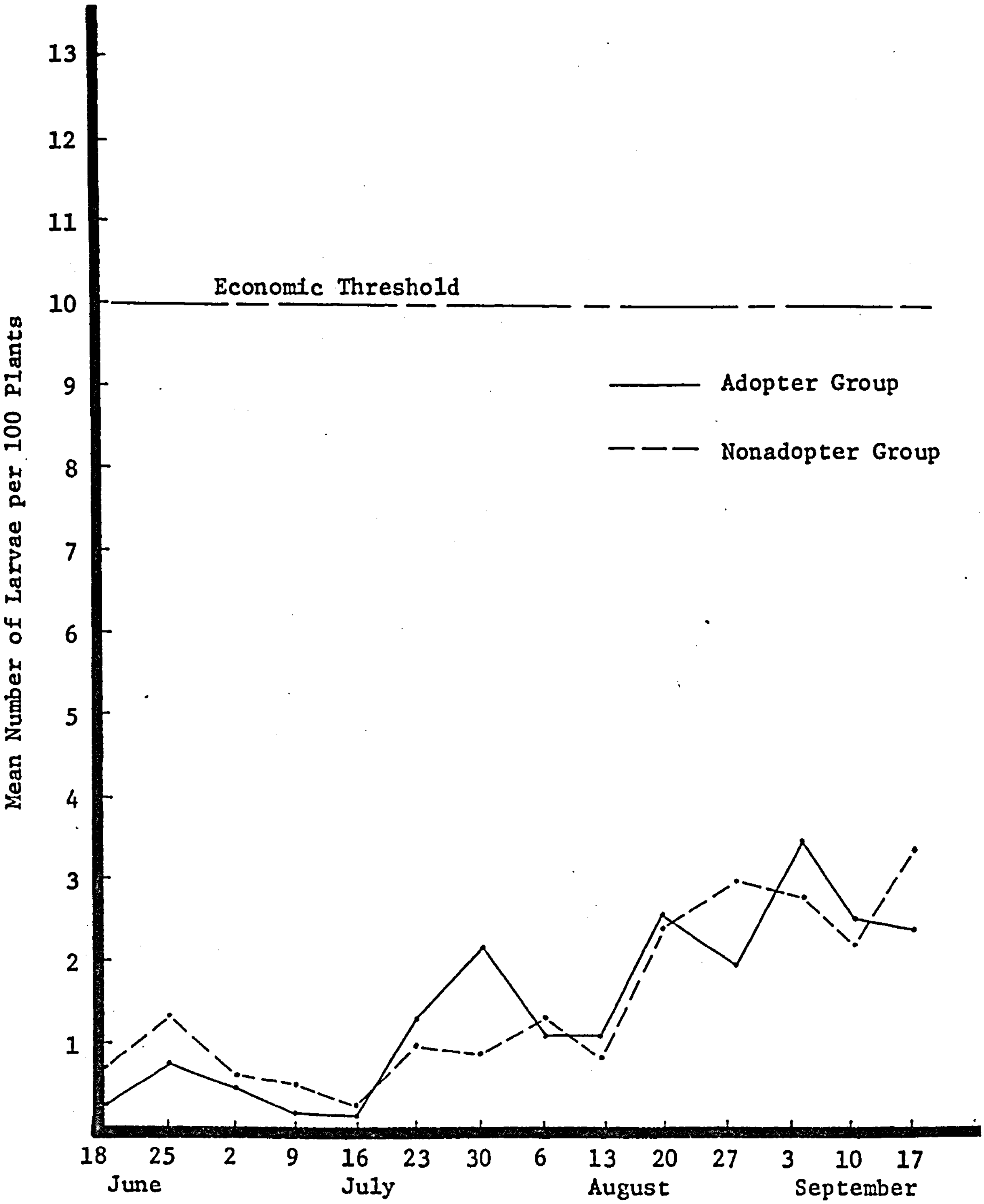

Figure 4. Bollworm Infestation Levels, Pinal County, 1972.

The similarity of the two groups with respect to bollworm infestations can be further illustrated. Figure 5 shows that the percentage of bollworm infested fields climbed rapidly for both groups after July 16, reaching a peak during the first week of September when over 60 percent of the fields were infested. Tables 16 and 17 show, however, that the magnitude or distribution of infestations were very low. Less than 10 percent of adopter and nonadopter fields had infestation levels that exceeded the 10-12 percent economic level.

Lygus Bugs

Lygus infestations became serious enough in some fields to warrant some early season control measures. Table 18 and Figure 6 show mean levels of lygus damage for the adopter and nonadopter groups. Damage levels were slightly higher for the adopter group; however, the mean percentage of lygus damaged squares was far below the economic level of 25 percent damaged squares.

In comparing percentage of fields with lygus damage (Figure 7) it can again be noted that the adopter group was slightly higher than the nonadopter group. The highest level of infested fields occurred during the first week of July when 90.8 percent of adopter fields and 87 percent of nonadopter fields were infested. These infestations were for the most part of very low magnitude (Tables 19 and 20). Very few fields had infestations which approached or exceeded economic injury levels.

Summary

Infestation levels of pink bollworm, bollworm, and lygus bugs were very similar for the adopter and nonadopter groups for the 1972

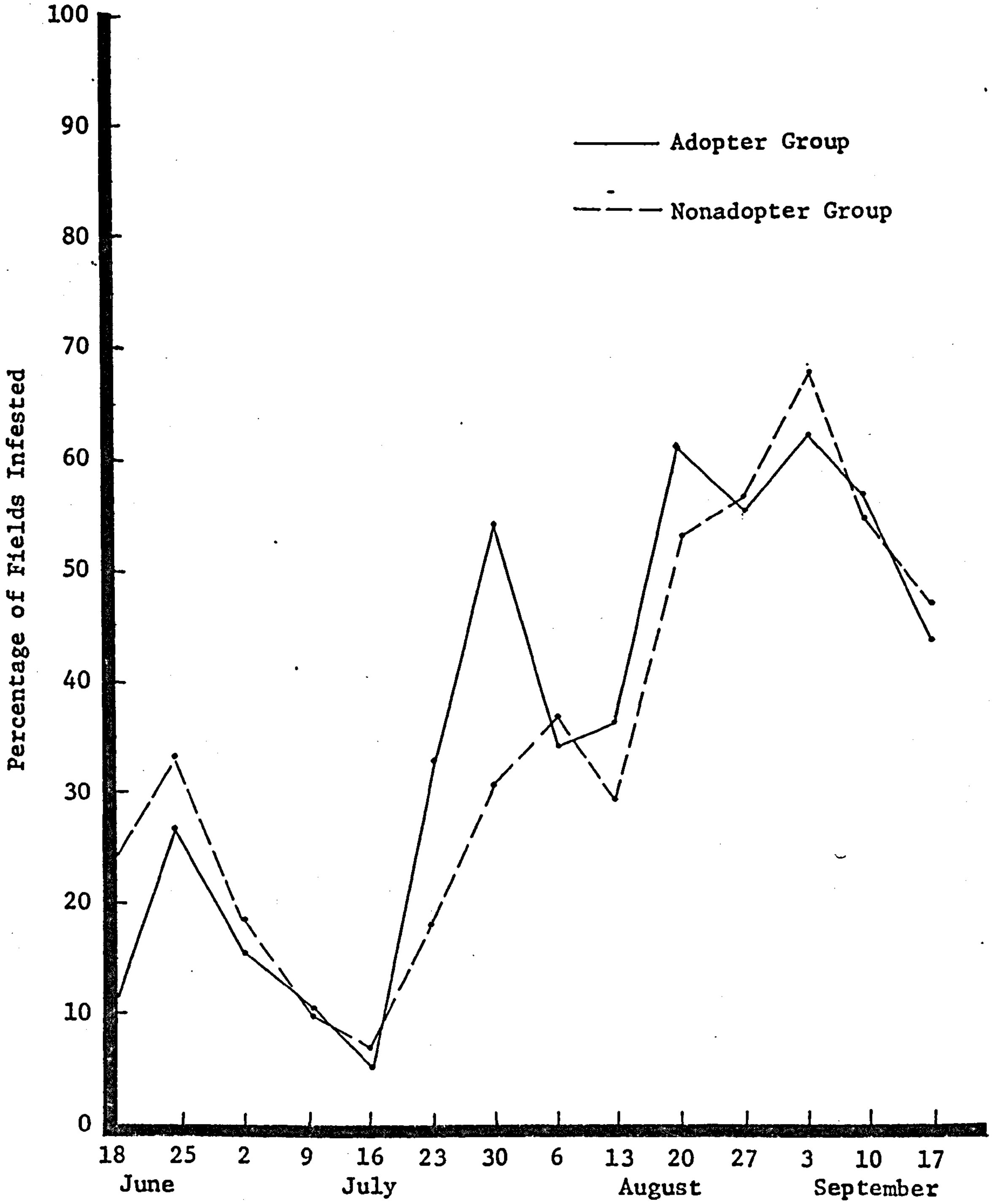

Figure 5. Bollworm Infested Fields, Pinal County, 1972.

Table 16. Bollworm Infestations, Magnitude of Infestations, Adopter Group, Pinal County, 1972.

Week Ending	Number of Fields	Percent Fields at the Indicated Level of Infestation						
		0	1-5	6-10	11-15	16-20	21-25	25 or more
June 18	118	89.0	11.0	0	0	0	0	0
June 25	114	72.8	23.6	2.6	0	0	0	0
July 2	128	83.6	11.7	2.3	2.3	0	0	0
July 9	119	89.1	10.9	0	0	0	0	0
July 16	111	95.5	3.6	0.9	0	0	0	0
July 23	107	67.3	29.0	3.7	0	0	0	0
July 30	126	46.0	43.7	5.6	1.6	3.1	0	0
August 6	165	66.1	27.9	3.6	1.8	0.6	0	0
August 13	136	63.2	32.4	3.7	0.7	0	0	0
August 20	103	38.8	47.6	7.8	2.9	1.9	0	1.0
August 27	121	46.3	42.1	10.7	0.8	0	0	0
September 3	100	38.0	41.0	13.0	2.0	4.0	1.0	1.0
September 10	101	43.6	39.6	13.9	1.0	1.0	0	1.0
September 17	107	57.0	28.0	9.3	2.8	1.9	0.9	0

Table 17. Bollworm Infestations, Magnitude of Infestations, Nonadopter Group, Pinal County, 1972.

Week Ending	Number of Fields	Percent Fields at the Indicated Level of Infestation						
		0	1-5	6-10	11-15	16-20	21-25	25 or more
June 18	126	75.4	22.2	2.4	0	0	0	0
June 25	131	66.4	26.0	4.6	3.0	0	0	0
July 2	121	81.0	18.2	0.8	0	0	0	0
July 9	137	89.8	8.8	1.4	0	0	0	0
July 16	130	92.3	7.7	0	0	0	0	0
July 23	106	81.1	13.2	2.8	0.9	0	1.9	0
July 30	125	69.6	25.6	4.0	0.8	0	0	0
August 6	128	62.5	30.4	5.5	0.8	0.8	0	0
August 13	138	71.7	23.2	5.1	0	0	0	0
August 20	125	47.2	39.2	8.0	5.6	0	0	0
August 27	111	44.1	38.7	10.0	4.5	1.8	0	0.9
September 3	119	31.1	55.5	10.1	0.8	1.7	0	0.8
September 10	114	47.4	36.8	14.0	1.8	0	0	0
September 17	99	51.5	33.3	8.1	1.0	2.0	0	4.0

Table 18. Lygus Infestation Levels, by Group and Date, Pinal County, 1972.

Week Ending	Number of Fields Checked	Mean Number of Damaged Squares per 100 Plants	Percent of Fields Infested
June 18			
Adopters	99	4.86	64.7
Nonadopters	103	5.65	71.8
June 25			
Adopters	113	7.35	69.0
Nonadopters	130	5.73	71.5
July 2			
Adopters	128	7.65	86.7
Nonadopters	121	5.26	79.3
July 9			
Adopters	119	7.91	90.8
Nonadopters	138	7.54	87.0
July 16			
Adopters	111	7.28	82.9
Nonadopters	120	4.13	65.0
July 23			
Adopters	107	6.36	72.9
Nonadopters	102	2.61	52.9
July 30			
Adopters	103	7.52	79.6
Nonadopters	64	5.81	82.8
August 6			
Adopters	79	3.44	67.1
Nonadopters	45	3.18	71.1

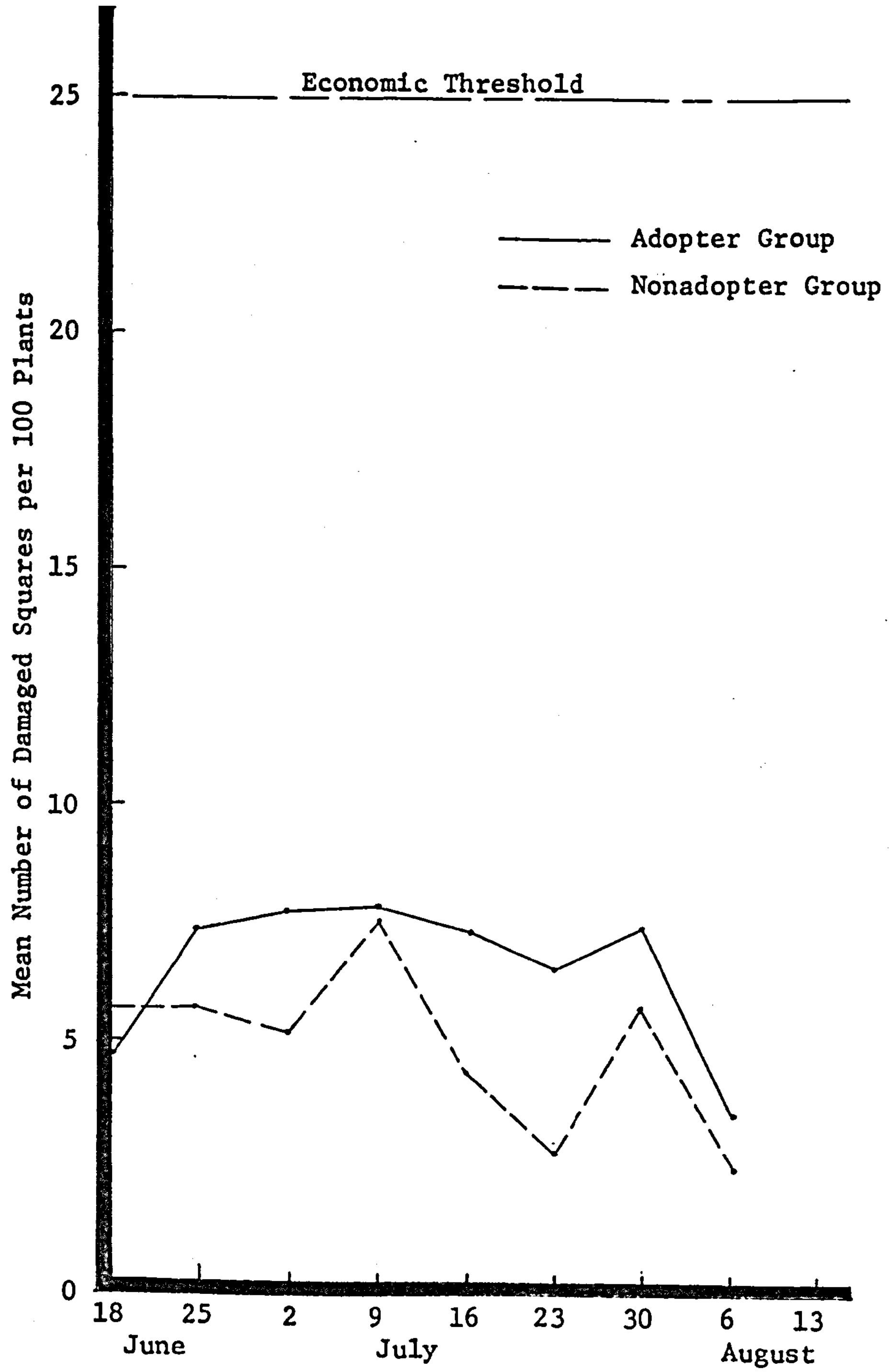

Figure 6. Lygus Infestation Levels, Pinal County, 1972.

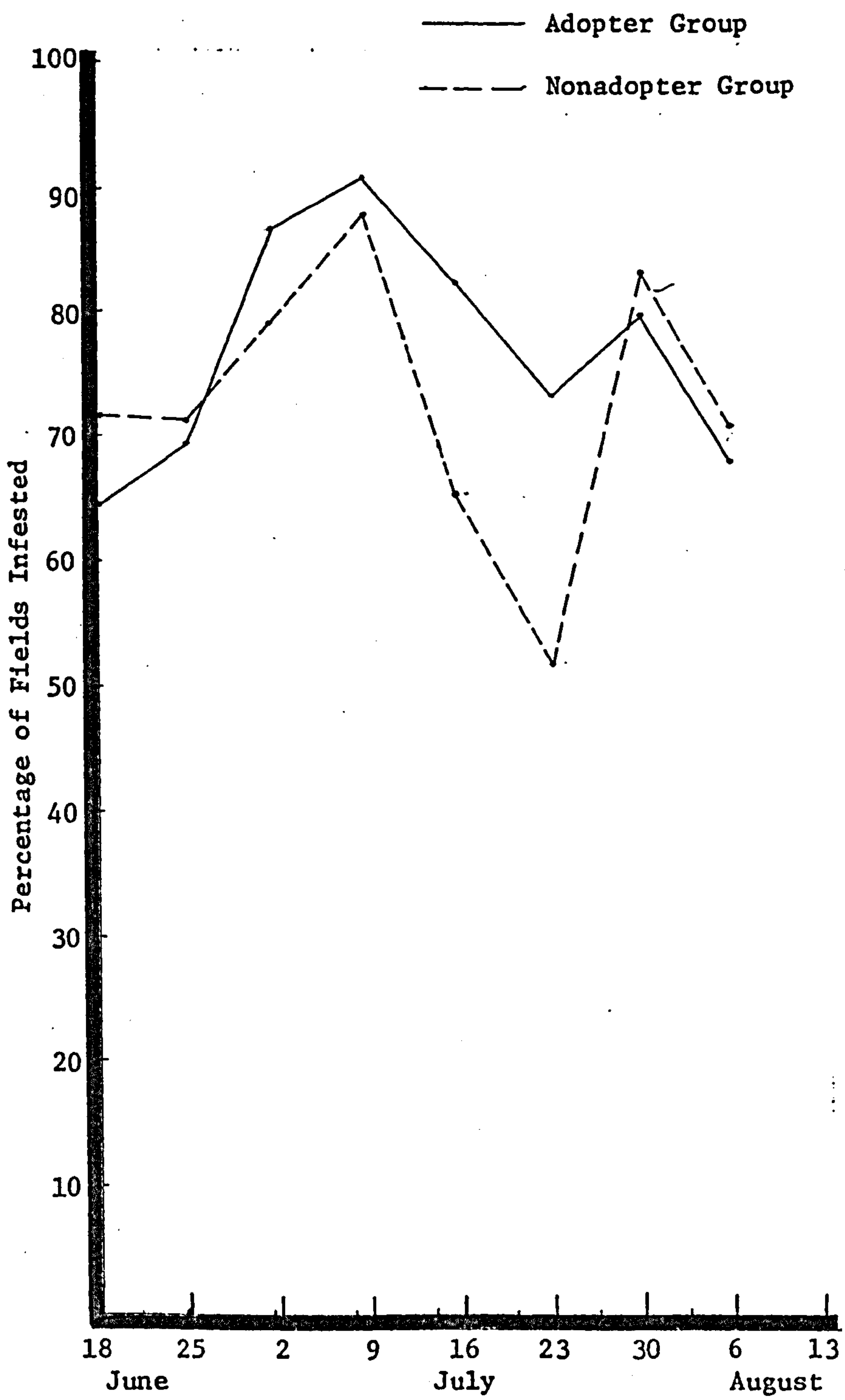

Figure 7. Lygus Infested Fields, Pinal County, 1972.

Table 19. Lygus Infestation, Magnitude of Damaged Squares, Adopter Group, Pinal County, 1972.

Week Ending	Number of Scouted Fields	Percent Fields at the Indicated Level of Square Damage						
		0	1-5	6-10	11-15	16-20	21-25	25 or more
June 18	99	35.3	34.3	15.1	6.1	8.1	1.1	0
June 25	113	31.0	15.9	21.2	15.9	11.5	3.5	0.9
July 2	128	13.3	25.0	36.7	11.7	12.5	0	0.8
July 9	119	9.2	25.2	37.0	19.3	7.6	1.7	0
July 16	111	17.1	24.3	33.3	17.1	6.3	0.9	0.9
July 23	107	27.1	23.4	29.0	11.2	6.5	0.9	1.9
July 30	103	20.4	18.4	33.0	20.4	5.8	0	1.9
August 6	79	32.9	43.0	21.5	1.3	1.3	0	0

Table 20. Lygus Infestation, Magnitude of Damaged Squares, Nonadopter Group, Pinal County, 1972.

Week Ending	Number of Scouted Fields	Percent Fields at the Indicated Level of Square Damage						
		0	1-5	6-10	11-15	16-20	21-25	25 or more
June 18	103	28.2	33.0	18.4	11.7	4.9	2.9	1.0
June 25	130	28.5	30.0	20.0	12.3	6.9	1.5	0.8
July 2	121	20.7	38.8	28.1	8.3	3.3	0	0.8
July 9	138	13.0	31.9	34.1	8.7	6.5	2.2	3.6
July 16	120	35.0	35.0	16.7	10.8	1.7	0.8	0
July 23	102	47.1	33.3	18.6	1.0	0	0	0
July 30	64	17.2	40.6	28.1	4.7	6.3	1.6	1.6
August 6	45	28.9	51.1	17.8	2.2	0	0	0

growing season. Although infestations of these insects varied greatly from field to field and from area to area, both groups maintained infestations well below economic injury levels.

CHAPTER 5

PESTICIDE USAGE AND COSTS

Pesticide Materials and Application Methods

Types of pesticide materials used by the growers in Pinal County to control cotton pests are shown in Table 21. These chemicals can be broken into three general categories: (1) organochlorines, (2) organophosphates, and (3) carbamates. The growers surveyed used a variety of formulations in their insect control programs, among them (1) wettable powder, (2) dusts, and (3) emulsibiable concentrates.

Aerial application is the most common method of applying pesticides in Pinal County as well as for most of Arizona. Ground application of pesticides does not appear to be a common practice among Arizona cotton growers. Generally, from 1 to 3 gallons of water are mixed with the chemical to give the required dosage per acre.

Assumptions Underlying Pesticide Material and Application Costs

Pesticide material costs were estimated using a 1972 price list from a major chemical firm in central Arizona. It was assumed that the chemical firms in Arizona are competitive in prices of materials. Normally, there are two prices associated with pesticides and other agricultural chemicals: "service" and "nonservice." "Service" price refers to the price of the chemical plus an additional charge for services rendered by the chemical firm. The price is generally on a per gallon

Table 21. Pesticides Used by Pinal County Cotton Growers in Survey, 1972.

Common Name	Pounds of Technical Chemical per Gallon of Material	Common Formulations	Chemical Name
<u>Organochlorines</u>			
Clordane	8 lbs/gal	Emulsifiable concentrate	1, 2, 3, 4, 5, 6, 7, 8, 8- Octachloro - 2, 3, 32, 4, 7, 72 - hexahydro - 4, 7 - methanoindence
Endrin	1.6 lbs/gal	Emulsifiable concentrate	1, 2, 3, 4, 10, 10-hexachloro - 6, 7, - epoxy - 1, 4, 42, 5, 6, 7, 8, 82 - octahydro - 1, 4 - endo-endo - 5, 8 - dimethanonapthalene
Thiodan (Endosulfan)	2 lbs/gal	50% wettable powder Emulsifiable concentrate	6, 7, 8, 9, 10, 10 - hexachloro - 1, 5, 52, 6, 9, 9a - hexahydro - 6, 9 - methano 2, 4, 3 - benzodioxathiepin - 3 - oxide
Toxaphene	4 lbs/gal	40% wettable powder Emulsifiable concentrate	Chlorinated camphene containing 67-69% chlorine
<u>Organophosphates</u>			
Azodrin	5 lbs/gal	Water miscible formulation	Dimethyl phosphate of 3 hydroxy - N - Methyl cis-crotonamide
Bidrin	8 lbs/gal	Emulsifiable concentrate	3 - (Dimethoxy - phosphinyloxy) - N - dimethylcis - crotonamide

Table 21. (continued)

Common Name	Pounds of Technical Chemical per Gallon of Material	Common Formulations	Chemical Name
Cygon	2.67 lbs/gal	Emulsifiable concentrate Wettable powder	0,0. dimethyl s-N methylcarbamoyl-methyl phosphorodithioate
Diazinon	4 lbs/gal	Emulsifiable concentrate Wettable powder, Dust, Granules	0, 0 - Diethyl 0-(2-isopropyl - 4 -mothyl-6-pyrimidinyl) phosphorothioate
Dylox	80% soluble powder/lb	Wettable powder	Dimethyl (2, 2, 2-trichloro-1-hydroxyethyl phosphorate
Guthion	2 lbs/gal	Emulsifiable concentrate 50% wettable powder	0, 0-dimethyl S-4-oxo-1, 2, 3-benzotriazin- 3(4H) 41 methyl phorphororoditioate
Malathion	5 lbs/gal	Emulsifiable concentrate Wettable powder, Dust	0,0-dimethyl dithiophosphate of diethyl mercaptosuccinate
Parathion (Ethyl)	4 lbs/gal		0, 0-diethyl o-nitrophenyl phosphorothioate
Parathion (Methyl)	4 lbs/gal	Emulsifiable concentrate Wettable powder Dust, Granules	0, 0-dimethyl o-P-nitrophenyl phosphorothioate
Carbonates			
Lannate (Methomyl)	1.8 lbs/gal or 90% soluble powder 1 lb.	Water-dispersible powder	S-Methyl-N-(Methyl-carbamoyl) (oxy) thioacetimidate

Table 21. (continued)

Common Name	Pounds of Technical Chemical per Gallon of Material	Common Formulations	Chemical Name
Sevin	80% soluble powder 1 lb	Wettable powder	N-napthyl N-methyl carbonate
<u>Other</u>			
Fundal (Galecron)	4 lbs/gal	Emulsifiable concentrate	N - (4-chloro-o-toyl)-N, N-dimethyl-formamindine.

Source: <u>Farm Chemicals Handbook</u>, 1973.

basis. These services may consist of checking the fields for insect counts (done by a representative of the chemical firm) and making insect control recommendations. The "nonservice" price refers only to the price of the chemical. Prices for pesticides are generally given in 1, 5, or 30 gallon lots. A quantity discount is generally given for bulk purchases. Most cotton growers prefer to purchase a large quantity of pesticide before the growing season and then purchase 1 or 5 gallon lots as needed. For purposes of establishing pesticide material costs, only "nonservice" prices were used, as it was unknown how the growers made their purchases. Assumed pesticide material costs are shown in Table 22.

Cost of aerial application was estimated at $1.25 per acre per treatment, based on interviews with entomologists familiar with the area.

The cost of participating in the Pest Management Program was $1.00 per acre; however, this cost was common to both groups and thus it was deleted from the analysis.

Grower Use and Cost of Pesticide Materials

The breakdown of pesticide materials and costs for both the adopter and nonadopter groups is shown in Tables 23 and 24.

Organochlorines

The application of organochlorine type pesticides was greater for the nonadopter group than the adopter group. The nonadopter group applied an average of 6.20 technical pounds of organochlorines per acre at an average cost of $5.15 per acre. The adopter group applied on the average, 2.13 technical pounds per acre at an average cost of $2.46 per acre. Toxaphene was the most common organochlorine material used for

Table 22. Assumed Prices for Pesticide Materials, 1972.

Pesticide	Price ($)
Organochlorines	
Clordane	10.97/gal
Endrin	8.02/gal
Thiodan	9.27/gal
Toxaphene	4.37/gal
Organophosphates	
Azodrin	20.45/gal
Bidrin	38.65/gal
Cygon	16.55/gal
Diazinon	19.58/gal
Dylox	2.03/lb
Guthion	9.05/gal
Malathion	9.77/gal
Parathion (ethyl)	5.60/gal
Parathion (methyl)	6.62/gal
Carbamates	
Lannate	10.50/lb
Sevin	1.10/lb
Other	
Fundal (Galecton)	30.70/gal
Combinations	
Toxaphene-methyl Parathion (6-3)	7.39/gal
Toxaphene-ethyl Parathion (6-3)	6.39/gal
Ethyl-methyl Parathion (6-3)	10.41/gal

Table 23. Pesticide Materials and Costs, Adopter Group, Pinal County, 1972.

Chemical	Total Amount Applied		Average Amount per Acre		Total Cost of Materials ($)	Average Cost of Materials per Acre
	Tech. lbs.	Gallons	Tech. lbs.	Gallons		
Organochlorines						
Clordane	88	11	.02	<.01	120.67	.03
Endrin	558	348.8	.12	.08	2,797.38	.65
Thiodan	288	144.0	.06	.03	1,334.88	.31
Toxaphene	8782.5	1463.8	1.93	.34	6,352.68	1.47
TOTAL	9716.5	1967.6	2.13	.45	10,605.82	2.46
Organophosphates						
Azodrin	755	151	.17	.04	3,087.95	.71
Bidrin	0	0	0	0	0	0
Cygon	128	47.9	.03	.01	793.41	.18
Diazinon	0	0	0	0	0	0
Dylox	0	0	0	0	0	0
Guthion	0	0	0	0	0	0
Malathion	319	63.8	.07	.01	623.33	.14
Parathion (Ethyl)	438	109.5	.10	.03	613.20	.14
Parathion (Methyl)	470	117.5	.11	.03	777.85	.18
TOTAL	2,100	489.7	.49	.11	5,895.73	1.36
Carbamates						
Lannate	743	412.8	.17	.10	7,801.50	1.80
Sevin	0	0	0	0	0	0
TOTAL	743	412.8	.17	.10	7,801.50	1.80

Table 23. (continued)

Chemical	Total Amount Applied		Average Amount per Acre		Total Cost of Materials ($)	Average Cost of Materials per Acre
	Tech. lbs.	Gallons	Tech. lbs.	Gallons		
Other						
Fundal	798	199.5	.18	.05	6,124.65	1.42
TOTAL	798	199.5	.18	.05	6,124.65	1.42
Combinations						
Toxaphene-Meth. Par. 6-3	38,141	4,366.4	8.81	1.01	32,267.62	7.46
Toxaphene-Eth. Par. 6-3	14,754.9	1,756.8	3.41	.41	11,225.95	2.59
Ethyl-Meth Para. 6-3	16,691.7	1,877.5	3.86	.43	19,545.09	4.52
TOTAL	69,578.6	8,000.7	16.08	1.85	69,163.31	14.57
TOTAL ALL MATERIALS	82,936.1	11,070.3	10.16	2.56	93,466.36	21.60

Table 24. Pesticide Materials and Costs, Nonadopter Group, Pinal County, 1972.

Chemical	Total Amount Applied		Average Amount per Acre		Total Cost of Materials ($)	Average Cost of Materials per Acre
	Tech. lbs.	Gallons	Tech. lbs.	Gallons		
Organochlorines						
Clordane	3,614	451.8	.57	.07	4,955.70	.77
Endrin	465	290.6	.07	.05	2,330.85	.36
Thiodan	0	0	0	0	0	0
Toxaphene	35,612.5	5,935.4	5.56	.93	25,759.72	4.02
TOTAL	39,691.5	6,677.8	6.20	1.04	33,046.27	5.15
Organophosphates						
Azodrin	8,124	1,624.8	1.27	.25	33,227.16	5.19
Bidrin	434	54.3	.07	.01	2,096.76	.33
Cygon	535	200.4	.08	.03	3,316.21	.52
Diazinon	170	42.5	.03	.01	832.15	.13
Dylox	120	0	.02	0	243.60	.04
Guthion	6	3.0	.01	.01	27.15	.01
Malathion	118	23.6	.02	.01	230.57	.04
Parathion (Ethyl)	2,975	743.75	.47	.12	4,165.00	.65
Parathion (Methyl)	1,032.5	258.1	.17	.04	1,708.82	.27
TOTAL	13,514.5	2,950.5	2.11	.46	45,847.42	7.16
Carbamates						
Lannate	559	310.6	.09	.05	5,869.50	.92
Sevin	281	224.8	.04	.03	309.10	.05
TOTAL	840	535.4	.13	.08	6,178.60	.97

Table 24. (continued)

Chemical	Total Amount Applied		Average Amount per Acre		Total Cost of Materials ($)	Average Cost of Materials per Acre
	Tech. lbs.	Gallons	Tech. lbs.	Gallons		
Other						
Fundal	1,291	322.8	.21	.05	9,908.43	1.55
TOTAL	1,291	322.8	.21	.05	9,908.43	1.55
Combinations						
Toxaphene-Meth. Par. 6-3	40,501.8	4,561.4	6.33	.74	33,708.97	5.27
Toxaphene-Eth. Par. 6-3	6,955.5	772.7	1.09	.12	4,937.36	.77
Ethyl-Meth Para. 6-3	38,850.7	4,340.0	6.07	.68	45,179.82	7.06
TOTAL	86,308.0	9,996.9	13.48	1.54	83,826.15	13.10
TOTAL ALL MATERIALS	141,654	20,483.4	22.13	3.20	178,806.87	27.93

both groups. The totals for toxaphene do not include amounts of this material used in combination with parathion.

Organophosphates

Nine different organophosphate chemicals were used by both groups with ethyl parathion and azodrin being the most commonly used. On the average, the adopter group applied .49 pounds of technical chemical per acre at an average cost of $1.36. The nonadopter group applied an average of 2.11 pounds of technical chemical per acre at an average cost of $7.16. These figures reflect the general movement away from organochlorine chemicals to the use of organophosphates.

Carbamates

The adopter group utilized carbamate pesticides to a greater extent than the nonadopter group, applying .17 technical pounds per acre as compared to .13 technical pounds for the nonadopter group. Average cost per acre of carbamate pesticides was $1.80 for the adopter group and $.97 for the nonadopter group. Methomyl (lannate) was the most common carbamate chemical used.

Other Pesticides

Various combinations of pesticides such as toxaphene-methyl parathion 6-3, toxaphene-ethyl parathion 6-3, and ethyl-methyl parathion were the most commonly used of all pesticides for the 1972 growing season. Application of these three combinations averaged 16.08 technical pounds per acre for the adopter group, and 13.48 technical pounds per acre for the nonadopter group. Average cost per acre for these pesticides was

$14.57 for the adopter group and $13.10 for the nonadopter group. Toxaphene-methyl parathion was the most widely used pesticide material for both groups. This combination is the generally recommended control for pink bollworm.

Total Pesticide Application and Costs

Total amount of pesticide material applied averaged 19.16 technical pounds per acre for the adopter group and 22.13 pounds per acre for the nonadopter group. This difference was not statistically significant at the 5 percent level.

Pesticide material costs averaged $21.60 per acre for the adopter group and $27.93 per acre for the nonadopter group. The difference between these two means was also statistically insignificant.

Pesticide Application

Data pertaining to date of initial treatment, number of treatments, application costs, and total pest control costs is presented in Table 25. The adopter and nonadopter groups were divided into three geographical areas: Coolidge-Florence, Casa Grande, and Eloy to further reflect differences in pest control practices.

Treatment Starting Date

Treatment starting dates ranged from June 10 to August 12 for the adopter group with a mean starting date of June 29. Initial treatment dates for the nonadopter group ranged from June 3 to July 14 with a mean date of June 26. The difference between these two means was insignificant at the 5 percent level.

Table 25. Pesticide Application and Costs, by Group and Area, Pinal County, 1972.

Area	Number of Fields	Acres	Average Treatment Starting Date	Total Number of Treatments	Average Number of Treatments	Acre Treatments	Total Application Costs[a]	Average Application Cost per Acre	Average Material Cost per Acre	Average Total Pest Control Costs per Acre	Average Cost per Treatment
Adopters											
Coolidge	93	2,708	June 23	657	7.1	20,173	$25,216.25	$ 8.88	$19.25	$28.13	$3.96
Eloy	13	1,127	June 25	116	8.9	10,327	12,908.75	11.13	27.68	38.81	4.36
Casa Grande	13	493	August 1	109	8.4	3,963	4,953.75	10.50	20.58	31.08	3.70
TOTAL	119	4,328	June 29	882	7.4	34,463	43,078.75	9.25	21.60	30.85	4.17
Nonadopters											
Coolidge	93	3,135	June 27	1,009	10.9	32,108	40,135.00	13.63	26.06	39.69	3.64
Eloy	42	2,999	June 28	475	11.3	34,314	42,892.50	14.13	30.60	44.73	3.96
Casa Grande	10	267	July 2	76	7.6	1,195	1,493.75	9.50	20.01	29.51	3.88
TOTAL	145	6,401	June 26	1,560	10.8	67,617	84,521.25	13.50	27.93	41.43	3.80

a. Total Application Costs = Acre Treatments x $1.25.

b. Average Application Cost per Acre = Average Number of Treatments per Acre x $1.25.

Number of Treatments

Number of pesticide treatments averaged 7.4 for the adopter group and 10.8 for the nonadopter group. The difference between these means was significant at the 1 percent level. The growers who comprised the adopter group in the Coolidge-Florence area showed the lowest number of treatments, averaging 7.1, while nonadopter growers in the Eloy area showed the highest, averaging 11.3 treatments per acre.

Application Costs

As was stated earlier, the cost of aerial application of pesticide was estimated at $1.25 per acre per treatment. Total application costs (acre treatments x $1.25) for the adopter group were $43,078.75 and for the nonadopter group totaled $84,521.25.

Average application costs per acre (average number of treatments per acre x $1.25) were $9.25 for the adopter group and $13.50 for the nonadopter group. Adopter growers in the Coolidge-Florence area showed the lowest application costs with an average expenditure of $8.88 per acre. Nonadopter growers in the Eloy area had the highest application costs, averaging $14.13 per acre.

Total Pest Control Costs

Total pest control costs per acre (application cost per acre + pesticide material costs per acre) averaged $30.85 for the adopter group and $41.43 for the nonadopter group. This mean difference of $10.58 was significant at the 5 percent level. Adopter growers in the Coolidge-Florence area showed the lowest total pest control costs, averaging

$28.13 per acre. Highest pest control costs were observed in the non-adopter group in the Eloy area, averaging $44.73 per acre.

Break-even Yield Loss Analysis

A break-even analysis was used to identify the yield loss which, for the given pest control cost difference between the two alternatives considered and various lint prices, will result in the two pest control alternatives becoming equivalent in terms of added net returns. By isolating this critical yield loss, an individual cotton grower could estimate whether his expected yield losses arising from insect damage would be greater or less than this level. Greater losses imply that the inundative strategy becomes most favorable; lower losses suggest that the integrated pest management strategy becomes most favorable.

Break-even yield losses were calculated for the cost difference between the two pest control alternatives which was found earlier, and various assumed lint prices.[1] Included in the calculation was the 1972 cottonseed price and cottonseed conversion factor. These losses, expressed in pounds of lint per acre, are reported in Table 26. With lint prices at the 50¢ level, for example, break-even losses are 20.2 pounds of lint per acre. The break-even losses decline as lint prices increase, since the value of yield losses becomes more important.

The effect of varying cost differences between the two pest control alternatives with given lint prices on break-even yield losses is shown in Table 27 and Figure 8.

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[1]Break-even yield loss = $\frac{\text{Cost difference per acre - 1.6 (cottonseed price)}}{\text{Lint price}}$

Table 26. Per Acre Break-even Yield Losses which Result in the Two Pest Control Alternatives Becoming Equivalent at Selected Lint Prices.

Cost Difference per Acre	Base Lint Price					
	30¢	40¢	50¢	60¢	70¢	80¢
$10.58	33.7	25.3	20.2	16.8	14.4	12.6

Table 27. Change in Table 26 per Acre Break-even Yield Losses which Result from Varying the Cost Difference Between the Two Pest Control Alternatives at Selected Lint Prices.

Cost Difference per Acre	Base Lint Price					
	30¢	40¢	50¢	60¢	70¢	80¢
$ 5.00	15.1	11.3	9.0	7.5	6.5	5.7
$15.00	48.4	36.3	29.0	24.2	20.7	18.2
$20.00	65.1	48.8	39.0	32.5	27.9	24.4

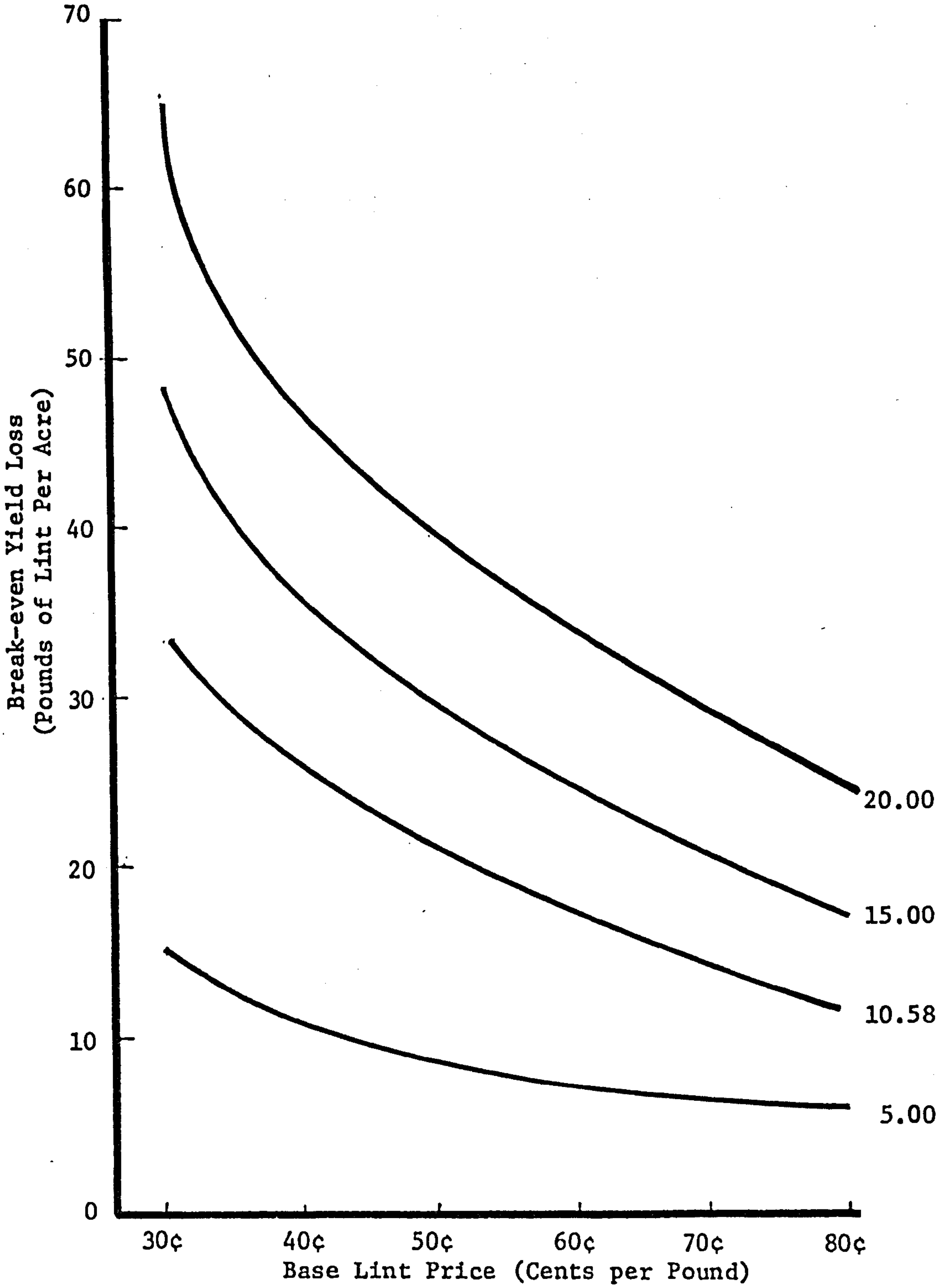

Figure 8. Break-even Yield Losses at Various Pest Control Cost Differences and Selected Lint Prices.

The figures in Table 27 indicate that as the cost difference between the inundative strategy and the integrated pest management strategy becomes greater at a given lint price, the break-even yield loss also becomes greater. With a cost difference in control programs of $20.00 per acre and a lint price of 50¢, break-even yield losses become 39 pounds of lint per acre.

CHAPTER 6

SUMMARY AND IMPLICATIONS

Summary

Chemical insect control is a major factor in the production of Arizona cotton. The importance of pest control in cotton production has been further magnified in the last few years due to heavy infestations of the pink bollworm and outbreaks of the cotton bollworm.

Pest control now accounts for an average of 10-15 percent of total production costs in Arizona cotton production. Rising pesticide costs and the tendency for some insect populations to develop resistance to chemicals have made the elimination of pest populations costly. An alternative to inundative type control programs has been the concept of integrated pest management. A grower utilizing this approach will attempt to maintain the pest population below some economic level as opposed to attempting complete elimination of the pest.

The primary objective of this study was to evaluate two insect control alternatives: integrated pest management versus an inundative suppression program on the basis of pest population maintenance and control costs.

Grower Production Practices

Grower production practices were compared on the basis of the field survey. The two groups were very similar in production practices.

DPL-16 was the most common variety planted by both groups, 10-14 pounds of seed per acre was the most common planting rate, and the majority of growers planted between March 15-31.

All growers surveyed applied nitrogen at some time during the growing season. Total amount of nitrogen applied per acre averaged 125 pounds for the adopter group and 118 pounds for the nonadopter group. Both groups applied most of their nitrogen after planting.

Application of phosphate was somewhat higher for the nonadopter group. Growers in this group applied an average of 60 pounds of phosphate per acre as compared to 38 pounds per acre for the adopter group. The bulk of phosphate utilized by both groups was applied before planting.

The number of crop irrigations averaged 8.5 for the adopter group and 8.2 for the nonadopter group. All growers indicated applying one preirrigation. The majority of growers in both groups terminated crop irrigation between September 1 and 15.

Diseases and nematodes were not serious problems for either group. Root rot, verticillium wilt, and nematodes were the most common problem reported.

Starting dates for harvested averaged October 15 for the adopter group and October 13 for the nonadopter group. Despite the presence of early season rains, both groups were able to harvesy approximately 80 percent of the total crop on the first pick.

Differences in average per acre yields were insignificant. Yields averaged 1,058 pounds of lint per acre for the adopter group and 1,081 pounds per acre for the nonadopter group. Cotton grades were very low due to early season rains beginning in October. The majority of harvested cotton by both groups was strict low middling and below.

Pest Infestations

Weekly infestation levels for three cotton insects, pink bollworm, bollworm, and lygus bugs, were identified for the adopter and nonadopter groups for the 1972 growing season. Pink bollworm infestation levels were slightly higher for the adopter group reaching a peak at the end of July when over 50 percent of the fields were infested. However, the great majority of pink bollworm infestations in both groups were of very low intensity. Although both groups maintained pink bollworm populations well below economic threshold levels, the adopter group allowed infestations to approach the economic level before treating. Bollworm and lygus bug infestation levels were very similar for the two groups as both maintained pest infestations below economic levels.

Pest Control Practices and Costs

Pest control costs were calculated to cover the major components of pesticide material and application. "Nonservice" pesticide prices for 1972 were used in determining chemical costs. Since aerial application is the most prevalent method of applying pesticides, a value of $1.25 per acre per treatment was used in determining application costs. The cost of participating in the Pest Management Program ($1.00 per acre) was left out, as this cost was common to both groups.

Total pesticide material costs averaged $21.60 per acre for the adopter group and $27.93 for the nonadopter group. This difference in material costs was statistically insignificant. The nonadopter group tended to utilize more organochlorine and organophosphate type chemicals than the adopter group. The adopter group utilized more carbamate chemicals and combinations of various pesticides. The most commonly used pesticides utilized by both groups were toxaphene-methyl parathion and ethyl-methyl parathion.

Number of pesticide applications averaged 7.4 per acre for the adopter group and 10.8 per acre for the nonadopter group. This difference was statistically significant at the 1 percent level. Cost of application averaged $9.25 for the adopter group and $13.50 for the nonadopter group. Treatment starting date averaged June 29 for the adopter group and June 26 for the nonadopter group.

Total pest control costs (material cost + application cost) averaged $30.85 for the adopter group and $41.43 for the nonadopter group. The $10.58 difference in pest control costs was significant at the 5 percent level.

At the $10.58 cost difference, per acre break-even yield losses ranged from 33.7 to 12.6 pounds of lint. This range became wider when the cost difference between the two pest control alternatives was allowed to vary.

Implications

Defining an optimum insect control program for cotton is an extremely difficult task. Insect infestations are dynamic in nature and may vary with weather, stage of the crop, populations of natural enemies, and a host of other abiotic and biotic factors. Thus, each farmer faces unique pest control problems. However, the identification of pest infestation levels and costs associated with pest control carry implications to farmers who wish to reduce the cost of insect control.

Timing and frequency of insecticidal applications appear to be crucial in reducing pest control costs. The grower who initiates early season control for lygus may eliminate populations of beneficial insects which serve as natural enemies of other cotton pests. This may lead to a build-up of other economic pests such as the bollworm which will result in the need for more frequent and heavier dosages of pesticides. If the grower is engaged in a heavy treatment schedule, the natural predators have no opportunity to recover. Thus, the grower may find himself on a costly pesticide treadmill.

Constant monitoring of insect populations on a field-by-field basis is very important in determining when to apply pesticides. Control procedures should be undertaken when the pest population in question approaches or reaches an economic injury level. Frequently, pesticide application is made to control an insect population which will cause no economic damage to the crop. Such a treatment will not result in yield or lint quality gains, however, it is still added to the cost of growing the crop. As the data indicated, growers in the adopter group were able to apply 3.4 fewer applications, at a savings of $4.25 per acre in application costs, by allowing insect populations to approach economic levels.

Choice of pesticide material offers an opportunity to further reduce pest control costs. The growers should attempt to evaluate alternative pesticides as to their cost and control efficiency. It was seen from the data that adopter growers were able to spend approximately $6.00

less per acre for pesticides than the nonadopter group, while essentially maintaining the same degree of pest control.

In total pest control costs, the adopter group spent on the average $10.58 less per acre than their nonadopter counterparts.

Researchable Areas

The opportunity for expanding research efforts in the area of pest control economics is substantial. Continuing research might include activities that focus on improving managerial strategies for pest control decisions, reducing the rising costs of pest control, and considering the ecological consequences that arise from alternative pest control actions.

Additional work could place emphasis on the area of predicting serious pest outbreaks. If enough information is known on the biology of economic pests, predictive ability on possible crop damage would be greatly improved. This would remove much of the risk and uncertainty associated with crop losses and tend to reduce pesticide usage.

An extension of the Arizona Pest Management Program might include, for example, providing additional information on the computer printout, particularly the annual summary. Aside from data on weekly pest infestations and pesticide usage, the computer would combine information pertaining to agronomic practices, production costs and yields in a partial budget format on a field-by-field basis in the printout. Such information would provide the grower with a basis for making cost comparisons in the light of his own insect problems and would be helpful in evaluating the relative success of a given pest control program.

An interdisciplinary approach may provide the most suitable answer to pest control problems. In utilizing this approach, new methods and technologies of controlling pests could be found, with all relevant economic variables as well as ecological consequences of alternative control strategies given consideration in a simultaneous context. Given the additional biologic and economic data, computer analysis might make it possible to optimize pest control decisions. A pest management program for alfalfa in Indiana which has not yet been fully activitated is an example of such an approach (Alfalfa Pest Management in Indiana, 1973). The Indiana program utilizes computer analysis to combine information pertaining to insect populations, crop conditions, agronomic and biotic data together with all available control methods. These factors are analyzed with consideration given to economic variables and environmental implications to arrive at pest control procedures for a variety of conditions. A systems approach of this type would provide a valuable input to a grower faced with a pest control decision.

APPENDIX A

PESTICIDE USAGE IN ARIZONA

Appendix A. Pesticide Usage in Arizona.[a]

Insecticides	1966	1967	1968	1969	1970	1971	1972
Chlorinated <u>Hydrocarbons</u>							
Aldrin[b]	24.0	7.7	29.9	24.0	50.6	51.0	27.8
BHC	8.2	18.9	9.0	8.5	.3	0.0	9.2
Chlordane	25.7	34.3	16.9	11.1	26.1	34.3	135.5
Chlorbenzilate	1.3	1.6	5.4	2.5	9.4	2.6	1.0
DDT	1,072.3	2,519.9	528.0	0.0	.7	0.0	0.0
Dieldrin	14.5	9.3	66.4	15.7	28.6	2.0	29.4
Dilan[c]	32.2	24.6	15.8	81.5	38.7	0.0	0.0
Endrin	19.2	21.6	49.0	53.8	18.0	24.0	23.7
Heptachlor	4.1	4.6	4.9	0.0	0.0	2.0	12.0[d]
Kelthane	4.6	5.6	14.7	9.2	10.2	5.1	5.2
Perthane	2.9	9.8	97.4	333.3	126.8	62.6	50.6
Rhothane	12.6	.9	2.4	0.0	0.0	0.0	0.0
Strobane	126.0	214.9	1,226.0	292.9	397.4	897.9	509.2
Thiodane	98.2	75.2	106.9	370.7	128.2	56.4	77.0
Toxaphene	1,028.5	2,450.6	2,028.2	2,510.0	1,932.6	1,203.9	1,468.3
Other		.6	1.0	8.0	0.0	.6	1.1
TOTALS	2,474.3	5,400.1	4,201.9	3,721.2	2,767.6	2,342.4	2,350.0
<u>Organophosphates</u>							
Azodrin	21.7	528.7	264.0	195.8	128.9	114.2	197.1

Appendix A. (continued)

Insecticides	1966	1967	1968	1969	1970	1971	1972
Bidrin	2.8	16.5	65.5	58.6	38.9	11.2	12.7
Cygon	8.5	24.6	13.4	28.3	33.5	38.0	47.2
Delnav	1.4	6.3	8.4	6.4	12.0	1.8	14.6
Diazinon	16.7	17.6	30.8	28.2	62.4	36.9	75.6
Dibrom	30.2	6.3	13.3	33.1	32.6	8.6	13.7
Disyston	5.5	31.7	56.4	91.2	73.0	96.7	81.1
Dylox	98.6	65.5	173.4	99.8	40.9	7.0	16.1
Ethion	0.0	0.0	0.0	0.0	0.0	.2	11.9
Guthion	32.2	22.4	64.6	59.3	49.0	21.9	18.5
Malathion	100.1	199.5	118.3	94.0	59.0	56.6	79.0
Meta Systox R	0.0	0.0	0.0	0.0	.1	1.3	5.0
Monitor (1st year)	0.0	0.0	0.0	0.0	0.0	0.0	48.9
Parathion	292.7	680.5	158.2	882.0	852.0	2,606.7	1,231.5
Parathion	0.0	0.0	1,167.2	985.1	1,121.2	1,780.3	2,052.4
Phosdrin	147.0	63.1	128.0	194.6	155.9	224.9	116.9
Phosphamidon	4.5	8.8	8.0	7.2	20.4	10.6	21.0
Systox	2.1	3.0	5.0	4.5	2.2	2.2	.7
Thimet	39.4	54.7	63.6	244.5	110.0	106.1	102.6
TOTALS	803.4	1,649.2	2,838.1	3,012.6	2,792.0	5,125.2	4,146.5

Appendix A. (continued)

Insecticides	1966	1967	1968	1969	1970	1971	1972
Carbamates Insecticides							
Baygon	0.0	.3	1.5	1.1	1.9	2.7	.5
Lannate	0.0	0.0	0.0	2.2	73.0	125.4	122.9
Sevin	22.2	54.8	151.9	185.0	279.0	243.6	232.2
Temic	0.0	0.0	0.0	0.0	4.1	21.4	41.5
TOTALS	22.2	55.1	153.4	188.3	358.0	393.1	398.1
Miscellaneous Insecticides							
Crylite	114.5	144.7	224.0	248.7	445.0	572.7	120.9
Thuricide	21.3	15.5 gal.	30.0 gal.	27.0 gal.	49.0 gal.	49.0 gal.	77.0 gal.
Sabadilla	0.0	13.5 gal.	9.6 gal.	14.7 gal.	72.0 gal.	1.8 gal.	24.3 gal.
Ryania	0.0	0.0	0.0	0.0	0.0	23.5	11.0
Sulfur	0.0	0.0	0.0	0.0	325.0	641.6	1,148.6
Galecron (Fundal) (1st year)	0.0	0.0	0.0	0.0	0.0	0.0	160.9

a. All in 1,000 lbs. of tech material unless marked in gallons.

b. Most if not all Aldrin is used by PCO's.

c. Dilan has been phased out.

d. Increase in Heptachlor due to increased PCO use.

Source: Arizona Community Pesticide Studies (1973).

APPENDIX B

DESCRIPTION OF ACTIVITIES IN PINAL COUNTY PEST MANAGEMENT PROGRAM

Training

All scouts and supervisors attended a three day training session at The University of Arizona. Training activities included insect identification, insect behavior and life history, sampling techniques, field situations (surrounding crops, stress, plant density), public relations, insecticidal names and uses and safety measures.

Additional training pertaining to problem solving and potential problem forecasting (insect outbreaks due to spraying, life cycles, moisture, etc.) was given at mandatory weekly meetings.

Scouting Procedures

Fields are scouted at least once a week. Early in the season (before pink bollworm counts) fields are checked every four to five days. After pink bollworm counts begin, fields are checked once a week with the exceptions of rechecks on bollworm and budworm build-up and kill checks.

Procedures for Scouting an Average Field

A. Insects of most importance

1. Pests - pink bollworm, lygus, bollworm, tobacco budworm, cotton leafperforator.

2. Beneficials - orius, lacewings, big-eyed bugs, nabibs, etc.

B. Making the counts

1. Check at least 4 areas in the average sized field (30-80 acres) and adjust for smaller or larger fields.

2. Areas in the field are checked in a rotating pattern that is dependent on:

a. Initial infestation level.

(1) Population evenly distributed - normal rotation.

(2) Population unevenly distributed - adjusted rotation.

b. Physical condition of field

(1) Stage of plant growth (maturity, etc.)

(2) Soil type (sandy, clay)

(3) Stress (dry, heat, cold, etc.)

c. Physical location of field

(1) Adjacent fields

(a) Type (alfalfa, safflower, sugar beets, etc.)

(b) Physical condition (stress, harvest, etc.)

(c) Chemical treatment (insecticide, defoliant, etc.)

(2) Power and telephone lines

(3) Trees

(4) Dwellings

3. In each area

a. Lygus and other plant bugs

(1) 25 sweeps

(2) 25 half grown squares

(3) look for signs of damage

b. Pink bollworm

(1) 25 bolls 15-20 days old

(2) break them open

(a) warts

(b) mines

(c) larvae (large and small)

c. Cotton bollworm and tobacco budworm

(1) 25 terminals (top and side)

(2) Part the terminal leaves

(3) Search for the live worm

(4) Open at least 1 square in each terminal area

(5) Note the worm size and position on plant

d. Cotton leafperforator

(1) 25 leaves

(2) Look at underside of leaf for mines, horseshoe stage or exposed larvae

e. Record minor pests and beneficials

4. Time required

a. Depends on time of season

b. Probably 45 minutes for average sized field in pink bollworm part of season.

Reporting Procedures

Insect Counts

After field record forms are filled out with insect counts and comments, the grower's copy is left with him or placed on a clipboard in a place designated by the grower, the sampler's copy is retained for his files and the office copy is taken to a bus depote and placed in a manila envelope for shipment to Tucson, that day.

Computer Augmentation

Daily Danger Level

The Daily Danger Level is a computer printout listing all fields checked the previous day. The fields are reported in three categories or ranges of infestation for the major pest insect species. If a field is in no immediate danger of economic infestation, there is no level of infestation listed by the field number. The next infestation level reported is intermediate. The actual insect count is listed beside the field number. This indicates an impending infestation and the situation is checked by a supervisor and discussed with the grower. The last range is the established economic threshold and above. The grower is to be contacted immediately if contact has not already been made.

Weekly Data Summary

A weekly insect summary computer printout is compiled each Saturday morning from the data recorded Monday through Friday each week.

The County is divided into nine areas of similar insect pest problems. The number of fields in each range of infestation level for each pest was listed for each county area. The resulting printout showed which area or areas had insect problems and the species that were increasing or decreasing when compared with the previous week.

The beneficial insects were also shown in a weekly printout. The format was the same, having the nine county areas and a range for each insect and the number of fields in that range that week.

Annual Summary

Another way in which the computer has been put to use is in the Annual Summary sent to each grower in the program. The printout shows the data for the entire season for each field by date scouted including treatment data by date of treatments.

Source: Arizona Cotton Pest Management Program 1972 Annual Report.

APPENDIX C

RECOMMENDED UNIVERSITY OF ARIZONA COTTON INSECT CONTROL PROCEDURES

Appendix C. Recommended University of Arizona Cotton Insect Control Procedures.

Pest	Insecticide	Dosage Per Acre Lbs. Active Ingredient	Min. Days from Last Treatment to Harvest	Safety Restrictions and Remarks
Aphids	Demeton[a] (Systox)	0.25	21	Do not graze dairy or meat animals on treated fields or feed gin waste to livestock.
	Dimethoate	0.25	14	Do not feed treated forage or graze livestock on treated fields. Do not repeat applications within 14 days.
	Malathion	0.5-1.0	No Limitation	
	Phosphamidon	0.5	14	
Beet Armyworm	Methomyl[a] (Lannate)	0.33	40	Do not feed treated plants to livestock.
	Toxaphene + Trichlorfon (Dylox)	2.0 + 1.0	See Remarks	Do not graze dairy animals or animals being finished for slaughter in treated fields. Do not feed gin waste to livestock.
Bollworm and Tobacco Budworm	Azodrin[a]	1.0	21	Do not graze livestock on treated fields or feed gin waste.
	Methomyl[a] (Lannate)	0.45	40	Do not feed treated plants to livestock.
	Methyl Parathion	1.0	7	Workers entering fields within 24 hours after application should wear protective clothing.
	Methyl Parathion + Endosulfan (Thiodan)	0.75+1.5	See Remarks	Do not apply after bolls open. Workers entering fields within 24 hours after application should wear protective clothing. Do not graze dairy or meat animals in treated fields.
Cabbage Looper	Bacillus thuringiensis	2-3 qts. or 2-3 lbs.	No Limitation	
	Endosulfan (Thiodan)	1.0	See Remarks	Do not apply after bolls open. Do not graze dairy or meat animals in treated fields.
	Methomyl[a] (Lannate)	0.33	40	Do not feed treated plants to livestock.

Pest	Insecticide	Dosage Per Acre Lbs. Active Ingredient	Min. Days from Last Treatment to Harvest	Safety Restrictions and Remarks
Pink Bollworm	Azinphos-methyl (Guthion)	0.5	1	If late season applications are made, do not graze livestock on treated areas or feed gin waste. Apply on a 6 day schedule.
	Azodrin[a]	1.0	21	Do not graze livestock on treated fields or feed gin waste. Apply on a 6 day schedule.
	Carbaryl (Sevin)	2.0	No Limitation	Apply on a 6 day schedule.
	Toxaphene + Methyl Parathion	2.0+1.0	7	Apply on a 6 day schedule. Workers entering fields within 24 hours after application should wear protective clothing.
Salt-Marsh Caterpillar	Carbaryl (Sevin)	2.0	No Limitation	
	Methyl Parathion	1.0	7	Workers entering fields within 24 hours of application should wear protective clothing.
	Trichlorfon (Dylox)	1.5	7	Do not graze livestock in treated fields within 14 days after application.
Seed Corn Maggot	Chlordane Dieldrin Lindane	3.5 oz. 1.5 oz. 3.0 oz.	See Remarks	Seed treatment only. Apply the dosage listed of the 75 per cent WP formulation per 100 pounds of seed.
Spider Mites[a]	Azodrin	0.5	21	Do not graze livestock on treated fields or feed gin waste.
	Dicofol (Kelthane)	1.0	14	Do not graze treated fields by meat or dairy animals.
	Fundal-Galecron	0.75	21	Do not feed foliage from treated cotton plants or gin trash to livestock.

Appendix C. (continued)

Pest	Insecticide	Dosage Per Acre Lbs. Active Ingredient	Min. Days from Last Treatment to Harvest	Safety Restrictions and Remarks
Stink Bugs	Endosulfan (Thiodan)	1.0	See Remarks	Do not apply after bolls open. Do not graze meat or dairy animals on treated fields.
	Methyl Parathion	1.0	7	Workers entering fields within 24 hours of application should wear protective clothing.
	Trichlorfon (Dylox)	1.5	7	Do not graze livestock in treated fields within 14 days after application.
Cotton Leaf-perforator	Fundal-Galecron	0.75	21	Do not feed foliage from treated cotton plants or gin trash to livestock.
	Methomyl[a] (Lannate)	0.22 - 0.45	40	Do not feed treated plants to livestock.
	Aldicarb (Temik)	2.0	90	Do not make more than one at planting time application and one sidedress application per crop. Do not allow livestock to graze in treated areas before harvest.
Cutworms	Toxaphene	2.0	See Remarks	Seedling pests. Use ground application equipment and apply in a 12 inch band over row.
Darkling Ground Beetles	Carbaryl (Sevin)	1.5	See Remarks	Seedling pests. Use ground application equipment and apply in a 12 inch band over row.
Lygus Bugs, Cotton Flea-hoppers	Azodrin[a]	0.5	21	Do not graze livestock on treated fields or feed gin waste.
	Bidrin[a]	0.3	10	
	Dimethoate	0.3	14	Do not feed treated forage or graze livestock on treated fields. Do not repeat applications within 14 days.
	Malathion	1.0	No Limitation	Apply as EC or ULV.
	Phosphamidon	0.5	14	

Appendix C. (continued)

Pest	Insecticide	Dosage Per Acre Lbs. Active Ingredient	Min. Days from Last Treatment to Harvest	Safety Restrictions and Remarks
	Toxaphene	4.0	See Remarks	Do not graze dairy animals or animals being finished for slaughter in treated fields. Do not feed gin waste to livestock. Parasite and predator populations are not severely affected by applications of Strobane or Toxaphene.
Leaf Roller	Carbaryl (Sevin)	2.0	No Limitation	
	Trichlorfon (Dylox)	1.0	7	Do not graze livestock in treated fields within 14 days after application.
Thrips				No control is suggested since plants recover from thrips injury without loss in yield or earliness.

a. Highly toxic and require strict attention to precautions for safe use. Dust, water dispersable powder or granular formulations are especially likely to cause posioning when handled in such a way that material is inhaled.

Source: Moore and Watson, 1973.

APPENDIX D

GROWER QUESTIONNAIRE FORM

CONFIDENTIAL

Grower Name ______________________________

Address ______________________________

1. Planting data (1972)

   (a) Variety ____________________

   (b) Date ____________________

   (c) Rate ____________________

2. What crop did the cotton follow? ____________________

3. Is cotton the major crop? ____________________

4. Fertilization date (1972 cotton)

When	Material	Rate
Preplant		
Planting		
Post plant		

5. (a) Number of irrigations ____________________

   (b) Cut-off date ____________________

   (c) Water cost ____________________

   (d) Cost of applying one acre-foot of water ____________________

6. (a) Major problems associated with disease and nematodes __________

   ____

   ____

   ____

   ____

(b) Approximate yield reduction resulting from above problems ______

____

7. Methods used to determine when to apply insecticides ____________

____

____

____

8. Herbicides applied ____

____

____

9. Harvest data

	Date	Percent of Total Crop
First Pick	_____	_________
Second Pick	_____	_________
Ground Cotton	_____	_________

10. Cotton quality (approximate percent of crop)

(a) Good middling_____

(b) Strict middling_____

(c) Middling plus_____

(d) Middling_____

(e) Strict low middling_____

(f) Low middling plus_____

(g) Low middling_____

(h) Strict good ordinary plus___

(i) Strict good ordinary_____

(j) Good ordinary_____

(k) Below grade_____

11. Highest historical average yield attained ______________________

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