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EPA

Alternatives for Reducing Insecticides on Cotton and Corn

Economic and Environmental Impact

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ALTERNATIVES FOR REDUCING INSECTICIDES ON COTTON AND CORN: ECONOMIC AND ENVIRONMENTAL IMPACT

by

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FOREWORD

Environmental protection efforts are increasingly directed towards preventing adverse health and ecological effects associated with specific compounds of natural or human origin. As part of this Laboratory's research on the occurrence, movement, transformation, impact, and control of environmental contaminants, the Technology Development and Applications Branch develops management and engineering tools for assessing or controlling toxic substances in the environment.

The toxicity and persistence of pesticides and their decomposition products are problems of major importance to those concerned with environmental quality. Because of widespread pesticide pollution and because of high economic costs of pesticide controls, alternate ways of controlling insect pests should be considered. This report analyzes various insect control strategies for two important agricultural crops and estimates the economic benefits and costs of each program as an aid to environmental decision-makers and research planners.

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ABSTRACT

To develop an analysis of alternative insect control technologies, data on current, potential, and future insect control techniques on cotton and corn were assembled using information provided by 31 leading entomological specialists in 29 states. Cotton and corn were selected for the analysis because 64% of all the insecticide in U.S. agriculture is applied to these two crops. The insecticide levels and application costs supplied by the entomological experts, plus estimates of the other costs involved with various insect control strategies, indicate that many insect control strategies that may significantly reduce insecticide use on cotton and corn may be more economical than strategies currently being used.

An analysis of alternative insect control technologies in corn revealed that few opportunities exist to employ alternative strategies because only about 1 lb of insecticide is applied per acre. The prime pest on corn is the rootworm complex and the practical alternative control is crop rotation. Employing rotations would reduce the quantity of insecticide used in corn by about 71%, but this would be accomplished at an increased annual cost of nearly $90 million.

Cotton is currently treated an average of about 4.4 times with about 13.3 lbs of insecticide per acre per season. Several alternative technologies are available for reducing the large quantity of insecticide applied to cotton. If the United States adopted various alternate insect control technologies for cotton in regions where feasible, the reduction in number of treatments and insecticide used per acre per season would be as follows: a scouting program reduced the number of treatments by 1.6 and insecticide by 4.8 lbs; a diapause/scouting program reduced treatments by 3.2 and insecticide by 10.2 lbs; trap crop/scouting program reduced treatments by 3.8 and insecticide by 10.9 lbs; a short season/scouting program reduced treatments by 3.9 and insecticide by 11.7 lbs; a resistant/scouting program reduced treatments by 4.8 and insecticide by 14.4 lbs; and a resistant/short season/scouting program reduced treatments by 5.4 and 16.2 lbs.

Detailed static and dynamic analyses of insect control strategies for cotton and corn were run and information was provided on economic costs, insecticide usage, acreage utilized, and regional changes in production. An important finding with cotton was that selecting the most economical control strategy in each region resulted based on a static analysis, in an annual reduction in insect control costs of $81 million and also reduced total insecticide usage by about 40%.

A significant finding was that if cotton production could be allowed to shift naturally in the nation, insecticide use and cotton production costs would be greatly reduced. Cotton production would shift from the

southeast and far west into Texas, Oklahoma, and the Delta states. This implied that insecticide use in cotton could be reduced more by allowing regional shifts in production than by adopting scouting or any other insect control strategy. The high level of insecticide use and associated environmental pollution appears to have been an externality of U.S. Government allotment programs.

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INTRODUCTION

Since 1945, production of synthetic pesticides has grown to over 1.4 billion pounds annually (Figure 1) and more than half this amount is applied to agricultural crops (Table I). Recent estimates of crop losses due to insect, pathogen, and weed pests are about $18.2 billion or 33% of our crops in spite of all pest controls (Table II). According to survey data collected during past decades, crop losses due to insects increased about 83% from 1942 to 1974 (Table II). Plant disease losses during the same period increased 14%, while weed losses declined 42%.

Another substantial loss of crops occurs post-harvest. Losses of stored foods to insects, rodents, and microorganisms are estimated to be about 9% (USDA, 1965). In the U.S. a total of 39% (33% + 9% of the remainder) of our food supply is lost to pests during the pre- and post-harvest periods.

Although the overall percentage of crop losses to insects has increased, as mentioned, despite the application of insecticides, important advances have been made in reducing insect losses in some crops. For example, losses in yield and quality from potato insects declined from 22% in 1910-35 (Hyslop, 1938), to 16% in 1942-51 (USDA, 1954), and to 14% in 1951-60 (USDA, 1965). This reduction is expected, considering the effectiveness of insecticides in controlling the major potato insect pests. In Minnesota, insecticides are reported from 1945 to 1975 to have contributed to doubling the yields (D.M. Noetzel, University of Minnesota, letter, 1976).

In contrast, losses in apples caused primarily by codling moth and apple maggot generally have not declined with increased use of organic insecticides. A 10.4% loss in yield and quality was reported for the period 1951-60 (USDA, 1965). This loss pattern reflects not only the higher quality standards for salable fruit but also a possible decline in sanitation and other cultural controls formerly practiced in orchards for control of these pests.

According to USDA estimates, insect losses also have been increasing in a major grain crop, corn. A 3.5% loss was reported for the period 1942-51 (USDA, 1954) and 12.0% loss for the period 1951-60 (USDA, 1965). Factors contributing to increased corn losses due to insects include the continuous culture of corn on the same land year after year (increasing rootworm populations and attack) in some cases planting of corn types susceptable to attack by insects (e.g., corn borer) rather that resistant corn types, and the use of herbicides such as 2,4-D which increases pest problems on corn (Oka and Pimentel, 1976).

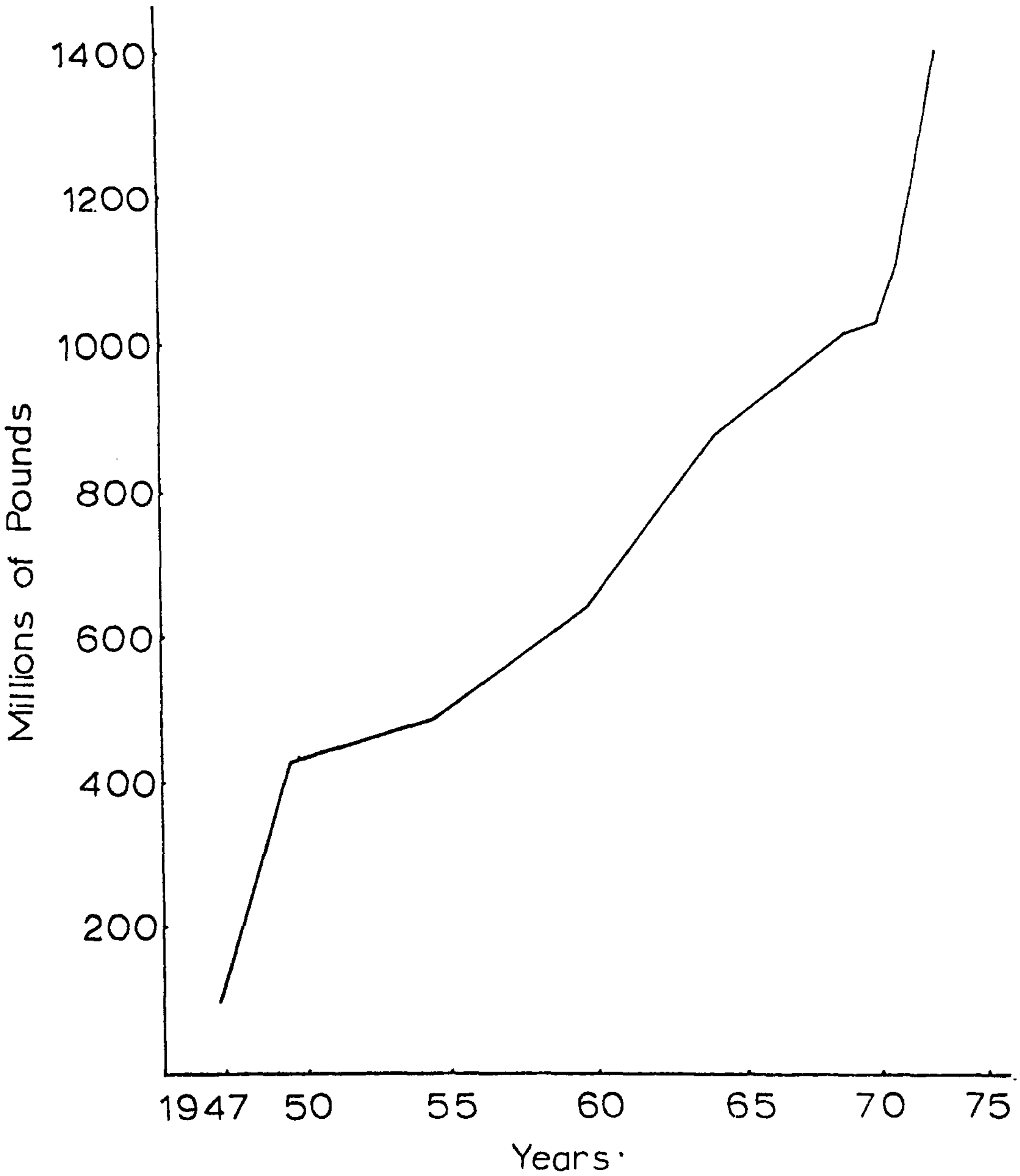

Figure 1. Estimated amount of pesticide produced in United States (USDA, 1971; Fowler and Mahan, 1975).

Table I. Some examples of percentages of crop acres treated, of pesticide amounts used on crops, and of acres planted to this crop (USDA, 1968; 1970; 1975a).

Crops	Insecticides % Acres	Insecticides % Amount	Herbicides % Acres	Herbicides % Amount	Fungicides % Acres	Fungicides % Amount	% of Total Crop Acres
Non-Food	NA	50	NA[a]	NA	<0.5	NA	1.26
Cotton	61	47	82	6	4	1	1.11
Tobacco	77	3	7	NA	7	NA	0.11
Food	NA	NA	NA	NA	<0.5	NA	98.74
Field Crops	NA	NA	NA	NA	NA	19	NA
Corn	35	17	79	41	1	NA	7.43
Peanuts	87	NA	92	3	85	4	0.16
Rice	35	NA	95	2	0	NA	0.22
Wheat	7	NA	41	7	0	NA	6.11
Soybeans	8	2	68	9	2	NA	4.19
Pasture Hay & Range	0.5	3	1	9	0	NA	68.40
Vegetables	NA	8	NA	5	NA	25	NA
Potatoes	77	NA	51	NA	49	12	0.16
Fruit	NA	13	NA	NA	NA	NA	NA
Apples	91	6	35	NA	67	28	0.07
Citrus	88	2	22	NA	58	13	0.08
All Crops	6	54	17	36	0.9	10	100

[a]not available

Table II. Comparison of annual pest losses in agriculture for the periods 1904, 1910-35, 1942-51, and 1951-60 and an estimate of losses for 1974.

	Insects		Diseases		Weeds		Total Loss		Potential Production
	$[a]	%[b]	$[a]	%[b]	$[a]	%[b]	$[a]	%[b]	$[a]
1974[c]	7.2	13	6.6	12	4.4	8	18.2	33	55[d]
1951-60[e]	3.8	12.9	3.6	12.2	2.5	8.5	9.9	33.6	29.5[f]
1942-51[g]	1.9	7.1	2.8	10.5	3.7	13.8	8.4	31.4	26.7
1910-35[h]	0.6	10.5	NA[i]	NA	NA	NA	NA	NA	5.7[j]
1904[k]	0.4	9.8	NA	NA	NA	NA	NA	NA	4.1

[a]Billion dollars

[b]Percentage of estimated dollar crop losses on a crop-by-crop basis.

[c]Estimated based upon discussions with various pest control specialists in different parts of the United States.

[d]USDA, 1974

[e]USDA, 1965

[f]Pest losses [for 1960] + Actual Crop Production [for 1960 (USDA, 1961)] = Potential Crop Production $9.9 billion + $19.6 billion = $29.5 billion

[g]USDA, 1954

[h]Hyslop, 1938

[i]Not available

[j]Insect losses and crop production estimates for 1935 (USDA, 1936)

[k]Marlatt, 1904

Cotton losses to insect pests in spite of all control measures are estimated to be 19% (USDA, 1965). Without any insecticide used it was estimated that cotton losses would increase to about 31% (Pimentel, 1973; Pimentel and Shoemaker, 1974). To hold insect losses at an estimated 19% for cotton and an estimated 12% for corn, about 200 million pounds of insecticides are applied to these 2 crops (USDA, 1970; 1975a). This amounts to about 64% of all the insecticides used in agriculture (USDA, 1970; 1975). Of all the acres treated, corn, sorghum, and cotton represent 63% of the cropland area treated (USDA, 1975a).

The total value of these insecticide applications, including materials plus application costs, totals nearly a half billion dollars. This represents a significant cost in cotton and corn production.

In addition to the economic costs, there is an important environmental cost. The available evidence suggests that current methods of pesticide use are a hazard to a few species of birds and several species of fishes and beneficial insects (Pimentel, 1971). The full extent of the damage to the life system (biota) from the use of pesticides is difficult to assess because the investigations have involved less than 1% of the estimated 200,000 species of plants and animals existing in the United States.

We should be concerned about the environmental impact of pesticides on the life system because the maintenance of our life system is vital to us. We cannot survive with only our crop plants and livestock. The great variety of species are essential for a viable life system. We depend upon the many species for the maintenance of a quality atmosphere, for growing crops, and for the biological degradation of wastes. Oxygen is produced by plants for man and animals. This oxygen (as both oxygen and ozone) also screens out the lethal ultraviolet rays from the earth's surface. In addition, the plants are food for many animals, passing their life-support elements (C, H, N, P, K, etc.) to the animals in the food chain. The microorganisms assist in degrading wastes and dead organisms and releasing the vital elements for recycling in the ecosystem. In this way, species of the life system interact and keep the life system functioning--of which man is a part.

In addition to this effect of pesticides on man's vital life system, pesticides may directly affect the health of man. At present the prime danger of pesticide poisons is the increased use of insecticides with higher levels of toxicity to man (Cronin et al., 1969). An estimated 14,000 individuals are poisoned (200 fatalities) in farms and homes annually from exposure to pesticides (EPA, 1974). Although the public is exposed daily to low levels of pesticides in their food, there is as yet no clear evidence of danger. However, the available data on long-term, low-level effects of pesticides to public health are scarce and incomplete. Indeed, the data suggest that we should be watchful and cautious (Cronin et al., 1969).

Because of widespread pesticide pollution and because of high economic costs of pesticide controls, alternate ways of controlling insect pests should be considered. Hence, the objectives of this study are to: (1) Determine what control techniques are currently being employed in cotton and corn insect pest control in the major production regions of the U.S.; (2) Determine what potential control techniques may be available in the near future; (3) Assess each of the control techniques for its economic and environmental benefits and costs; and (4) Analyze various insect pest control strategies on a national basis and estimate the economic benefits and costs of each program and quantities of insecticides used. The information gathered should aid the Environmental Protection Agency and other groups concerned with pest control and pesticide use in their policy decisions and at the same time help research planners determine priorities for pest management investigations.

SUMMARY AND CONCLUSIONS

From 31 leading entomological specialists in 29 states data were assembled on current, potential, and future insect control techniques on cotton and corn. Cotton and corn were selected for an analysis of alternative insect control technologies because 64% of all the insecticide used in agriculture in the U.S. is applied to these two crops. The insecticide levels and application costs supplied by entomological experts, plus estimates of the other costs involved with various insect control strategies, indicate that many insect strategies which may significantly reduce insecticide use on cotton and corn may be more economical than strategies currently being used. The findings of this study are included under the headings of the following three analyses that were made:

THE ANALYSIS OF INSECT CONTROL TECHNOLOGIES

An analysis of alternative insect control technologies in corn revealed that few opportunities exist to employ alternative strategies because of the relatively small amount (about 1 lb) of insecticide applied per acre. About 17% of the total agricultural insecticide is used on this crop because of the large acreage (65 million acres) of corn grown in the U.S. The prime pest on corn is the rootworm complex and the practical alternative control is crop rotation. Employing rotations would reduce the quantity of insecticide used in corn from about 30 million lbs to about 9 million lbs, but this would be accomplished at a cost of nearly $80 million (estimate of dynamic analysis).

Cotton is produced on only about 13.1 million acres and is currently treated an average of about 4.4 times annually with about 13.3 lbs of insecticide per acre. Several alternative technologies are available for reducing the large quantity of insecticide applied to cotton. If the United States adopted the following insect control programs in cotton regions where feasible, the number of treatments and insecticide applied per acre per season would be as follows: a scouting program reduced the number of treatments by 1.6 and insecticide by 4.8 lbs; a diapause/scouting program reduced treatments by 3.2 and insecticide by 10.2 lbs; trap crop/scouting program reduced treatments by 3.8 and insecticide by 10.9 lbs; a short season/scouting program reduced treatments by 3.9 and 11.7 lbs; a resistant/scouting program reduced treatments by 4.8 and insecticide by 14.4 lbs; and a resistant/short season/scouting program reduced treatments by 5.4 and 16.2 lbs.

STATIC ANALYSIS

If the location and acreage of cotton production remains constant, it is estimated that the implementation of several currently available insect control alternatives can reduce cotton insect control costs by $81 million and insecticide use by about 40%. The implementation of cotton insect control methods which should be available within 5 to 10 years are estimated to reduce annual insect control and insecticide use by 71% in quantity.

No single insect control strategy for cotton is best throughout the nation. Clearly a combination of insect controls is best and these will vary from region to region. Except for a couple of regions scouting is one strategy that is a part of the combination programs.

DYNAMIC ANALYSIS

Adoption of currently available cotton insect control strategies could reduce insecticide use by 16 to 34% and at the same time reduce insect control costs and total crop production costs to farmers. Since the optimum insect control strategy differs from area to area, adoption of any one control strategy, such as scouting, scouting-diapause or scouting-trap crop, for the entire U.S. would reduce insecticide use and production costs less than is achievable when each area used the strategy that is best for that region. Implementation and administration of a policy which required each region to use the best strategy for that region would be difficult. A set of criteria for selecting appropriate strategy for each area would be difficult to establish and there would be continued disagreement about the interregional equity of any set of criteria established.

The analysis above indicates that use of the strategy which is most economical from the farmer view point would also reduce insecticide use and total production costs more than adoption of any single strategy on a nationwide basis. This leads to the conclusion that an educational program designed to convince farmers that it is in their own best interest to adopt modern insect control strategies would likely be the most efficient policy to adopt. This would eliminate the need to arbitrarily determine strategies that farmers should use and eliminate the need for the policy which would be viewed by farmers as government harassment. While the costs of an effective educational program were not determined in this study, it is likely that the administrative and policing costs of a policy to adopt any of the strategies analyzed would be greater than the costs of an educational program.

Development of short-season and resistant varieties would reduce insecticide use 50 to 60% compared to current practice and would reduce production costs approximately $28 million per year compared to the best currently available technology evaluated. This implies that $56 million per year could be spent to develop these varieties if the development took 5 years and the cost efficiencies were achievable for 10 years. The period of time over which the cost efficiencies could be maintained would depend on the time required for development of new strains of insects.

If no limit were placed on the amount of acreage shift possible for cotton, insecticide use and production costs could be significantly reduced. Cotton production in this situation would be shifted from the southeast and far-west into Texas, Oklahoma, and the Delta states. This suggests that insecticide use and production costs in cotton could be reduced significantly more by allowing regional shifts in production than by adopting scouting or any other insect control strategy. The high level of insecticide use and associated environmental pollution is an externality of the government allotment programs (Pimentel and Shoemaker, 1973).

Another increase in the feed-food grain exports similar to that experienced between 1971 and 1973 would increase insecticide use on the crops considered in this analysis two to four times above those experienced during the 1971-73 period.

Corn as mentioned, uses about one-quarter as much insecticide as cotton. Rotations would reduce corn insecticide by over 70% but would significantly increase production costs to farmers. Scouting of corn is the only future technology on the horizon. It would reduce insecticide use by 57% but would significantly increase costs to farmers.

METHODS

Cotton and corn were selected for this investigation, as mentioned, because 64% of all agricultural insecticides are applied to these two crops in the U.S. and include more than 60% of all cropland acres that are treated. Attention was focused primarily on the major cotton and corn producing states. The states selected (Table III) in total are responsible for the production of 99% of the cotton and 91% of the corn (USDA, 1974).

The procedure was to contact the leading entomologist(s) with special knowledge for each crop in each of the major cotton and corn producing states (Table III). From these entomologists we obtained via personal visits and telephone conferences data on current insect pest control practices and "best estimates" of what various alternative controls would mean in economic cost/benefits and pesticide use patterns. Although some of the data are "best estimates" and speculative, it should be emphasized that this information came from the most knowledgeable entomological experts in this nation. Further confidence in the data emerges when the data from the specialists from each state are combined and examined as a whole.

The specialists first provided us with detailed information on current insect control practices being employed in their state. From these data, the experts were asked to give a best estimate of the potential economic benefits and costs of employing these known available alternatives singly and in various combinations. Next, the specialists were asked about potential pest controls that are currently being researched in their state or nearby states that might be employed in their control programs. They were asked to estimate the realistic pest control potential of each alternate control singly and in combination with current and other controls. From this information it was our aim to identify those potential controls that might provide in the future opportunities for effective economic pest control and at the same time improve the quality of our environment.

Information on the details of each pest control technology for cotton and corn for each region of the U.S., as mentioned, was obtained from each specialist, and this is tabulated in Appendix A, tables 1-55. Some of the background information related to these tables is presented in the main part of the report and all additional information is available (Pimentel, 1975).

The estimate given by the 31 entomological specialists concerning the percentage of cotton acres treated was 95% and corn acres treated was 52%.

Table III. Entomological Specialists for Major Cotton and Corn Producing States Who Aided in this Investigation.

<u>Cotton</u>		
Alabama	Dr. Floyd R. Gilliland, Jr.,	Dr. Roy J. Ledbetter
Arizona	Dr. Theo F. Watson,	Dr. Leon Moore
Arkansas	Dr. Charles G. Lincoln	
California	Dr. Louis A. Falcon,	Dr. Nick Toscano
Georgia	Dr. T. Donald Canerday,	Dr. Herbert Womack
Louisiana	Dr. L. D. Newsom,	Dr. Dan F. Clower
Mississippi	Dr. Fowden G. Maxwell,	Dr. F. Aubrey Harris
Missouri	Dr. Flernoy G. Jones	
New Mexico	Dr. Joe Ellington	
North Carolina	Dr. R. L. Robertson	
Oklahoma	Dr. Don C. Peters,	Dr. Jerry H. Young,
	Dr. Kenneth N. Pinkston,	Dr. Chin-Choy,
	Dr. Vernon R. Eidman	
South Carolina	Mr. L. M. Sparks,	
Tennessee	Dr. Allen Chambers	
Texas	Dr. Raymond E. Frisbie	
<u>Corn</u>		
Florida	Dr. John R. Strayer	
Illinois	Dr. William Luckmann,	Dr. Donald E. Kuhlman
Indiana	Dr. Thomas Turpin	
Iowa	Dr. Harold J. Stockdale	
Kansas	Dr. H. LeRoy Brooks,	Dr. Del Gates
Kentucky	Dr. W. W. Gregory, Jr.	
Michigan	Dr. Robert F. Ruppel	
Minnesota	Dr. Huai C. Chiang,	Dr. David M. Noetzel
Missouri	Dr. Mahlon L. Fairchild,	Dr. George W. Thomas,
	Dr. Robert L. Stoltz,	Dr. William H. Kearby,
	Dr. Armon J. Keaster	
Nebraska	Dr. Z. B. Mayo	
New York	Dr. A. A. Muka	Dr. D. Pimentel
North Carolina	Dr. Robert L. Robertson	
Ohio	Dr. Gerald J. Musick	Dr. Robert E. Treece
South Dakota	Dr. David D. Walgenbach	
Wisconsin	Dr. James W. Apple	
Wyoming	Dr. Christian C. Burkhardt	

Both estimates differ substantially from those of the Economic Research Service of the USDA (1975a) that report for cotton and corn 47% and 35%, respectively. We doubt that 53% of the cotton acreage is untreated as reported by the USDA, and thus feel that their estimates are much too low. At the same time we believe that entomological specialists may have overestimated the percentage of acres treated.

In evaluating these estimates we made a comparison of total quantity of insecticides used on cotton and corn from another source of information (NAS, 1975). Based on data on quantities of insecticides used in agriculture we estimated that currently about 180 million pounds of insecticides are used on cotton and corn. The entomological specialists' estimate was 205 million pounds and the USDA estimate for 1971 was 101 million pounds. These results would suggest that perhaps the entomological specialists' estimates were at least 12% too high. However, we had no justification for changing the estimates provided us by the leading entomological specialists on cotton and corn in the United States and, therefore used the estimates provided.

In order to estimate the effects of employing alternative insect control technologies upon insecticide use, production costs, and land use, three analyses were run: (1) Analysis of Insect Control Technologies; (2) Static Analysis; (3) Dynamic Analysis. The analysis of insect control technologies focuses primarily on the strategy and provides an estimate of the reduction in number of insecticide treatments to cotton and corn if implemented nationwide. The static analysis assesses the changes in cotton pest management only by total and average insecticide use as calculated under the assumption that the location of cotton production would remain constant.

The static analysis was performed only on cotton, and consisted of analysing the expected changes in insect control costs and total chemical use, if several strategies applicable in each region are put uniformly into effect without modifying present crop distribution. The following example should clarify the process.

In almost all cotton producing regions in the United States, scouting is presently a viable option. Thus, the tables in the Appendix contain, for all regions except the Texas High Plains, a possible cultural practice that involves scouting. Each table in the Appendix also contains current average insect control costs, crop yields, and insecticide use. The estimated static analysis then computes, for each region, the net changes in these measures if scouting were uniformly adopted. The resulting national net change in total insect control costs and total insecticide usage were obtained by computing total nationwide average, with such measures weighed by the total acerage figures for each region. (Additional information is available in Detailed Data for Static and Linear Analysis of Alternatives for Reducing Insecticides on Cotton and Corn--Supplement 1 to Alternatives for Reducing Insecticides on Cotton and Corn: Economic and Environmental Impact. The supplement is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22161, using the report number assigned to this document.)

The dynamic analysis considers not only insect control practices but also the location of cotton production. A linear programming model called PESTDOWN was used in this analysis. (The model is described in Procedures Used in Setting Up the Agricultural Production Model--Supplement 2 to Alternatives for Reducing Insecticides on Cotton and Corn: Economic and Environmental Impact. The supplement is available from the National Technical Information Service, 5285 Port Royal Road, Springfield, Va. 22161, using the report number assigned to this document.) Model data were obtained or estimated for base year 1973. The model equations and tableau are given below from Taylor and Swanson (1975):

$$\min_{X,T,TB} \sum_{ij}\sum C^D_{ij}X^D_{ij} + \sum_{ij}\sum C^I_{ij}X^I_{ij} - \sum_{ikm}\sum\sum T_{ikm} + \sum_{ik}\sum tb_{ik,12}TB_{ik,12}$$

Subject to:

a) Total cropland

$$\sum_i X^I_{ij} + \sum_i X^D_{ij} \leq L_j \qquad (j = 1,2,...540)$$

b) Irrigated cropland

$$\sum_i X^I_{ij} \leq I_j \qquad (j - 1,2,...540)$$

c) Cotton acreage

$$X^I_{ij} + X^D_{ij} \geq CA_j \quad (j = 1,2,...540), (i = \text{cotton})$$

d) Cotton lint demand

$$\sum_j Y^D_{ij}X^D_{ij} + \sum_j Y^I_{ij}X^I_{ij} \geq CLD \qquad (i = \text{cotton})$$

e) Commodity demand

$$\sum_{j\varepsilon k} Y^I_{ij}X^I_{ij} + \sum_{j\varepsilon k} Y^D_{ij}X^D_{ij} - \Sigma TRN_{ikn} + \Sigma T_{imk} + \Sigma TB_{imk} - \Sigma T_{ikm} - \Sigma TB_{ikm} \geq D_{ik}$$

$$(i = 1,2,...8), (k = 1,2,...21)$$

f) Nutrient demand

1) Total digestible nutrients:

$$\sum_i tdn_{in}TRN_{ikn} \geq TDN_{kn} \qquad (n - 1,2,3), (k = 1,2,...21)$$

2) Digestible protein:

$$\sum_i dp_{in} TRN_{ikn} \geq DP_{kn} \quad (n = 1,2,3), (k = 1,2,...21)$$

3) Dry weight of feed:

$$\sum_i TRN_{ikn} = DW_{kn} \quad (n = 1,2,3), (k = 1,2,...21)$$

g) Pea demand in the pea area of the Northwest

$$Y_{i,115}X_{i,115} + Y_{i,119}X_{i,119} - PD \quad (i = pea)$$

h) Barge transportation constraint

$$\sum_i TB_{ik,12} - B_k \quad (k = 1,2,3,5,9,10)$$

where:

X_{ij} = acreage of the i^{th} crop in the j^{th} producing region.

C_{ij} = short-run variable costs of producing one acre of the i^{th} crop in the j^{th} producing region.

T_{ikm} = transportation of one unit of commodity i from the k^{th} consuming region to the m^{th} consuming region by rail.

t_{ikm} = cost of transporting one unit of commodity i from the k^{th} consuming region to the m^{th} consuming region by rail.

Y_{ij} = per-acre yield of the i^{th} crop in the j^{th} producing region.

L_j = total cropland available in the j^{th} producing region.

I_j = total irrigated cropland available in the j^{th} producing region.

CA_j = cotton acreage constraint in the j^{th} producing region.

CLD = national cotton lint demand.

TRN_{ikn} = units of commodity i transferred to meet the demand for nutrients by livestock type n in the k^{th} consuming region.

tdn_{in} = the amount of total digestible nutrients in one unit of commodity i for livestock type n.

dp_{in} = the amount of digestible protein in one unit of commodity i for livestock type n.

DW_{kn} = total dry weight requirement for feed for the n^{th} livestock type in the k^{th} consuming region.

TDN_{kn} = demand for total digestible nutrients by the n^{th} livestock type in the k^{th} consuming region.

DP_{kn} = demand for digestible protein by the n^{th} livestock type in the k^{th} consuming region.

D_{ik} = demand for commodity type i in the k^{th} consuming region.

D,I = superscripts used to distinguish between dryland and irrigated production activities, respectively.

PD = pea demand in the pea area of Washington and Idaho.

TB_{ikm} = transportation of one unit of commodity i from the k^{th} consuming region to the m^{th} consuming region by barge.

tb_{ikm} = cost of transporting one unit of commodity i from the k^{th} consuming region to the m^{th} consuming region by barge.

B_k = total units of commodities that can be transported by barge from the k^{th} consuming region to consuming region 12.

As in the static analysis, the data in the Appendix were used to determ changes in costs, yields, and total insecticide use for each insect control option tested. In addition further options involving possible restrictions on cotton acreage, forced use of rotations and/or scouting on corn, and varying levels of export demands were tested, and are described in the section on results. (For details see Supplemental Report 1).

The assessment of economic benefits includes maintaining cotton and corn yield while employing a control program that either costs less or more. The program that costs less provides the grower with increased profits (benefits). The social costs (including economic) of shifting cotton and corn production among regions were not possible to evaluate at this time other than to point these shifts out in the dynamic analysis.

The assessment of environmental benefits focused primarily on reducing the quantity of insecticide used while maintaining cotton and corn yields. Changing methods of application (e.g., from aircraft to ground equipment) would reduce environmental problems, but for this study we logically assumed no change in insecticide application technology.

Table IV. Linear Programming Tableau for the PESTDOWN model used in the Dynamic Analysis. See Supplemental Report 2 for a complete description of the model[a].

Constraint	Crop production activities[b]																												
	Dryland																					Irrigated							
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29
	Corn	Sorghum	Barley	Oats	Rye	Durum W	Other SW	WW	Soybeans	Cotton	WW-F	Durum W-F	Other SW-F	Barley-F	Rye-F	S-W DC	S-O DC	S-BA DC	W-P-BA-F	W-P-W-F	W-P DC	Soybeans	Cotton	SW	WW	Barley	Oats	Corn	Sorghum
1 Cost	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
2 Cropland	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	1	1	1	4	4	1	1	1	1	1	1	1	1	1
3 Irrigated cropland																						1	1	1	1	1	1	1	1
4 Cotton allotment										1													1						
5 Wheat account						Y	Y	Y			Y	Y	Y			Y			Y	Y	Y			Y	Y				
6 Soybean account									Y							Y	Y	Y				Y							
7 Cottonseed account										Y													Y						
8 Sorghum account		Y																											Y
9 Corn account	Y																											Y	
10 Barley account			Y											Y				Y	Y							Y			
11 Oat account				Y													Y										Y		
12 Rye account					Y										Y														
13 Cotton lint demand										Y													Y						
14 Pea demand																			Y	Y	Y								
15 Cattle TDN																													
16 Cattle DP																													
17 Cattle feed bulk																													
18 Sheep TDN																													
19 Sheep DP																													
20 Sheep feed bulk																													
21 Swine TDN																													
22 Swine DP																													
23 Swine feed bulk																													
24 Barge transportation																													

[a]Most of the columns represent more than one activity, and most of the rows represent more than one constraint. For example, column 1 represents 91 crop production activities, and row 2 represents 131 cropland constraints. Therefore, the actual matrix is much larger than is indicated by this table.

[b]Ba = barley, DC = double-cropped, F = fallow, O = oats, P = peas, S = soybeans, W = wheat, SW = spring wheat, WW = winter wheat.

Table IV. (cont.)

Constraint	Activities that transfer commodities to nutrients: Cattle								Sheep							
	30 Wheat	31 Barley	32 Oats	33 Rye	34 Sorghum	35 Corn	36 Cottonseed	37 Soybeans	38 Wheat	39 Barley	40 Oats	41 Rye	42 Sorghum	43 Corn	44 Cottonseed	45 Soybeans
1 Cost																
2 Cropland																
3 Irrigated cropland																
4 Cotton allotment																
5 Wheat account	-1								-1							
6 Soybean account								-1								-1
7 Cottonseed account							-1								-1	
8 Sorghum account					-1								-1			
9 Corn account						-1								-1		
10 Barley account		-1								-1						
11 Oat account			-1								-1					
12 Rye account				-1								-1				
13 Cotton lint demand																
14 Pea demand																
15 Cattle TDN	tdn	tdn	tdn	tdn	tdn	tdn	tdn	tdn								
16 Cattle DP	dp	dp	dp	dp	dp	dp	dp	dp								
17 Cattle feed bulk	wt	wt	wt	wt	wt	wt	wt	wt								
18 Sheep TDN									tdn	tdn	tdn	tdn	tdn	tdn	tdn	tdn
19 Sheep DP									dp	dp	dp	dp	dp	dp	dp	dp
20 Sheep feed bulk									wt	wt	wt	wt	wt	wt	wt	wt
21 Swine TDN																
22 Swine DP																
23 Swine feed bulk																
24 Barge transportation																

Constraint	Activities that transfer commodities to nutrients: Swine								Rail transportation activities							
	46 Wheat	47 Barley	48 Oats	49 Rye	50 Sorghum	51 Corn	52 Cottonseed	53 Soybeans	54 Wheat	55 Soybeans	56 Cottonseed	57 Sorghum	58 Corn	59 Barley	60 Oats	61 Rye
1 Cost									t	t	t	t	t	t	t	t
2 Cropland																
3 Irrigated cropland																
4 Cotton allotment																
5 Wheat account	-1								V[c]							
6 Soybean account								-1		V						
7 Cottonseed account							-1				V					
8 Sorghum account					-1							V				
9 Corn account						-1							V			
10 Barley account		-1												V		
11 Oat account			-1												V	
12 Rye account				-1												V
13 Cotton lint demand																
14 Pea demand																
15 Cattle TDN																
16 Cattle DP																
17 Cattle feed bulk																
18 Sheep TDN																
19 Sheep DP																
20 Sheep feed bulk																
21 Swine TDN	tdn	tdn	tdn	tdn	tdn	tdn	tdn	tdn								
22 Swine DP	dp	dp	dp	dp	dp	dp	dp	dp								
23 Swine feed bulk	wt	wt	wt	wt	wt	wt	wt	wt								
24 Barge transportation																

Constraint	Barge transportation activities								Land retirement activity	Right-hand side
	62 Wheat	63 Soybeans	64 Cottonseed	65 Sorghum	66 Corn	67 Barley	68 Oats	69 Rye	70 Total retirement	
1 Cost	tb	tb	tb	tb	tb	tb	tb	tb		MIN
2 Cropland										≤L
3 Irrigated cropland										≤I
4 Cotton allotment										≥CA
5 Wheat account	V									$\geq D_1$
6 Soybean account		V								$\geq D_2$
7 Cottonseed account			V							$\geq D_3$
8 Sorghum account				V						$\geq D_4$
9 Corn account					V					$\geq D_5$
10 Barley account						V				$\geq D_6$
11 Oat account							V			$\geq D_7$
12 Rye account								V		$\geq D_8$
13 Cotton lint demand										≥CLD
14 Pea demand										≥PD
15 Cattle TDN										$\geq TDN_1$
16 Cattle DP										$\geq DP_1$
17 Cattle feed bulk										$=DW_1$
18 Sheep TDN										$\geq TDN_2$
19 Sheep DP										$\geq DP_2$
20 Sheep feed bulk										$=DW_2$
21 Swine TDN										$\geq TDN_3$
22 Swine DP										$\geq DP_3$
23 Swine feed bulk										$=DW_3$
24 Barge transportation	1	1	1	1	1	1	1	1		≤B

[c] V is a matrix of ones, minus ones, and zeroes such that the transportation activities will remove units of the commodity from the region of origin and add those units to the appropriate accounting row in the destination region.

RESULTS

The results will be discussed for ease of presentation in three separate sections: (1) The Analysis of the Insect Control Technologies; (2) The Static Analysis; and (3) The Dynamic Analysis.

THE ANALYSIS OF INSECT CONTROL TECHNOLOGIES

In this section of the results an analysis will be made of the various cotton and corn insect control technologies and alternatives. Included in this analysis will be an examination of cotton and corn losses with and without insecticides.

Cotton

Each of the important cotton insect-control program alternatives are described and discussed as follows:

Current Situation--

The first analysis that was made examined what percentage of the cotton acreage is being treated including the average number of treatments and amount of insecticide applied per acre each season. The current situation includes a mix of controls that include regular treatments, scouting, diapause controls, short season culture, trap crops, and combination of these.

About 95% of the cotton acreage is treated according to the "best estimates" of the nation's leading entomological specialists. The average number of treatments per cotton acre annually is 4.4 with about 13.3 lbs applied and costs about $18 per season including insecticide and application costs (Table V).

Regular Treatment Program--

Most cotton is treated on some type of a spray schedule and this is termed "regular treatment;" this may include some diapause control but does not include "scouting." We should point out, however, that a regular spray-schedule does not mean that cotton growers treat without examining their cotton and insect pest populations. In fact, most growers do "check" their cotton for the abundance of insect pests. This type of examination is not the type of monitoring of pest and natural enemy populations employed in the "Scouting Treatment Program" described later. However, the cotton specialists do feel that the "checking" carried out by the

Table V. The average number of insecticide treatments made per acre on certain cotton acreage during each season and the total quantity of insecticide used for current, potential, and future pest control alternatives.

Total Number of Acres Involved x 10^6	Regular Insecticide Treatments		Current Situation Insecticide Treatments		Scouting Insecticide Treatments		Diapause & Scouting Insecticide Treatments		Trap Crop and Scouting Insecticide Treatments		Short Season and Scouting Insecticide Treatments		Resistant and Scouting Insecticide Treatments		Resistant and Short Season and Scouting Insecticide Treatments	
	No.	Total lbs/A	No.	Total lbs/A	No.	Total lbs/A	No.	Total lbs/A	No.	Total lbs/A	No.	Total lbs/A	No.	Total lbs/A	No.	Total lbs/A
13.1	5.6	16.8	4.4	13.3	-	-	-	-	-	-	-	-	-	-	-	-
10.6	6.6	19.8	-	-	5.0	15.0	-	-	-	-	-	-	-	-	-	-
6.0	8.6	26.4	-	-	-	-	5.4	16.2	-	-	-	-	-	-	-	-
5.2	9.0	27.0	-	-	-	-	-	-	5.2	16.1	-	-	-	-	-	-
8.6	7.9	23.7	-	-	-	-	-	-	-	-	4.0	12.0	-	-	-	-
7.9	7.8	23.4	-	-	-	-	-	-	-	-	-	-	3.0	9.0	-	-
8.6	7.6	22.8	-	-	-	-	-	-	-	-	-	-	-	-	2.2	6.6

growers has resulted in reducing the number of treatments an estimated 10 to 20% during the past 10 years.

The regular treatment program, as expected, utilizes the largest number of treatments and the largest quantity of insecticides. If the total U.S. cotton acreage were treated employing the regular treatment program, the average number of treatments per season would be about 5.6 (ranging from approximately 0 to 17) and requires about 17 lbs (Table V) of insecticide per acre and costs about $22 (Appendix, Tables 1-32). Note, that under regular treatment about 1.2 more treatments are made per acre than under the current situation. The current situation includes nearly half the acres under a scouting program.

Scouting Program--

The objective of the "scouting program" is to treat cotton acreage only when the density and potential threat of insect pest populations justify insecticide treatments. Both insect pest populations and natural enemy populations must be monitored to obtain information on the potential threat of the pests to the cotton crop. Stage of cotton growth and fruiting influence the susceptibility of cotton to pest injury and, thus, this information is also included in the scouting program and decision-making processes. If the scouting program were adopted on all cotton acreage where applicable (10.6 million acres), the number of treatments would be reduced from the 6.6 regular average on this acreage to about 5.0 (Table V). Thus, scouting on an average reduces the number of treatments per acre about 1.6 compared with regular. The amount of insecticide used per acre is reduced about 24%. Because of resistance of certain pests to insecticides and inadequate identification to species (e.g., cotton bollworm vs. tobacco budworm), the regular treatment program is likely to result in greater pest insect losses than the scouting program. Scouting added over the insecticide and application costs about $1.50 per acre for monitoring cotton pests and natural enemy populations.

Diapause and Scouting Program--

Diapause control programs are directed specifically at boll weevils. The aim of diapause control is to substantially reduce over-wintering weevil populations so in the spring fewer weevils are present and insecticide treatments can be delayed until later in the summer season when weevils reach potentially damaging densities. The benefit of delaying weevil treatments as long as possible is that natural enemies that are especially important for control of bollworms and budworms are protected and remain active in controlling these pests for a longer period of the cotton growing season.

For diapause control, one (sometimes 2) treatment is made before the cotton defoliant is applied to the crop. Then another treatment is made about 2 weeks after the cotton is harvested, provided defoliation is not complete and stalk destruction is delayed. It should be pointed out that when the cotton is harvested, stalks and other parts of the cotton plant are shredded. This is also considered an essential part of the diapause control program.

The effectiveness of diapause control for the weevil requires that all the cotton acreage in the region be in the diapause control program. The obvious reason for the requirement is that weevils disperse when they emerge in the spring. Thus, a grower who used diapause control and who is surrounded by growers who do not will hardly notice a reduction in weevil populations on his surrounded farm. Diapause control must be a community-wide effort.

Diapause control is employed as a supplement to other pest control methods such as "scouting." If a diapause-scouting program were adopted on cotton acreage when applicable (6.0 million acres), the number of treatments would be reduced from the 8.6 treatments under regular to an average of about 5.4 (Table V). Thus, a diapause-scouting program on an average reduces the number of treatments per acre about 3.2 compared with regular. This is about twice that of scouting alone. The amount of insecticide used per acre would decrease about 39% or about 10.2 lbs per acre. About 1/2 lb of insecticide per acre had to be applied for diapause control and this is included in the total of 10.2 lbs per acre.

Trap Crop and Scouting Program--

The use of a trap crop concentrates the pest on the trap crop. In the case of a cotton trap crop, the trap crop is treated with a heavy dosage of insecticide, thus killing a large percentage of the pest population (e.g., boll weevil). With other trap crops such as alfalfa, the objective is to attract plant bugs from cotton to alfalfa.

Three types of trap crops have been employed for control of cotton pests and one of these includes the use of early cotton. This trap crop technique included planting an early cotton to attract boll weevils. About 5% (in well distributed strips) of the total cotton acreage of a farm is planted to early cotton about 2 to 3 weeks before the regular crop planting time. The emerging boll weevils are attracted to this early cotton. Then a heavier than normal dosage of insecticide is applied to this early cotton to destroy the boll weevils that congregate on this cotton.

Certain added costs are associated with employing a trap crop. These include: (1) the nuisance cost of having to get the machinery and labor ready to plant cotton 2 to 3 weeks early, and (2) failure of the trap crop in some years. Since the trap crop fails approximately one in 4 years, average reduction in insecticide use is only three-fourths of the 11.8 lb/acre, or 8.8 lb; for an insecticide treatment cost saving of $9.40. The cost of replanting the 5 percent of the acreage 1/4 of the time and labor and machinery costs for early planting are assumed to be 250 and 200 percent of normal planting costs, respectively. Adding these costs to normal production costs increased these costs by an average of $2.55 (Table VI) per acre of cotton grown. This assumes that the yield on trap crop acreage

Table VI. Cost of trap crops[a/] per acre of cotton excluding change in insecticide and insecticide application costs.

Region	Cost per acre of cotton ($)
Central Alabama	2.17
Northeastern Alabama	2.94
Western and Central Arizona	14.11[b/]
San Joaquin Valley California	18.21[b/]
Louisiana	2.93
Hill Region Mississippi	2.46
Southwest Oklahoma (Irrigated region)	3.93[c/]
Coastal Plain, South Carolina	2.35
Piedmont region, South Carolina	2.35

a/ Cotton planted on 5% acreage two to three weeks before normal planting except where indicated otherwise
b/ Alfalfa trap crop
c/ Sorghum trap crop

(the 5%) is the same as achieved with all cotton acreage. This indicates a saving of $6.85 per acre.

The alfalfa trap crop technology utilizes alfalfa strips planted in rows about 20 ft wide in the cotton fields. The rows of cotton were about 300 to 400 ft wide; hence, about 6% of the field is in alfalfa. This procedure utilized in the San Joaquin Valley of California was reported to reduce the number of treatments to cotton (Appendix, Table 7). The added costs must be included where using alfalfa as a trap crop. Alfalfa increases the production losses by reducing the cotton acreage. The added production costs include: (1) alfalfa strips that are a nuisance to plant and harvest in cotton fields; and (2) costs of irrigation and fertilizer to maintain the alfalfa.

If only loss of cotton yield due to the alfalfa produced and the change in water and fertilizer costs are considered, these factors add an average of approximately $18.20 per acre (Table VI) to the cost of growing cotton in the San Joaquin Valley. Thus use of an alfalfa trap crop increases production costs in that area by at least $3.20 per acre.

The sorghum trap crop is planted with 4 rows of sorghum to each 24 rows of cotton. This trap crop in some years reduced the number of treatments in Oklahoma (Appendix, Table 19). Even adding the costs of the nuisance factor involved in planting sorghum in cotton fields, it appears that the sorghum trap crop offers several advantages, including reduced insecticide use as well as reduced production costs.

If trap crop and scouting programs were adopted in U.S. cotton production where applicable (5.2 million acres), the number of treatments would be reduced from the 9.0 regular treatments per acre to about 5.2 (Table V). Thus, a trap crop-scouting program on an average reduces the number of treatments per acre about 3.8 compared with regular. This reduction is about the same as that of diapause-scouting. The amount of insecticide used would be reduced about 40%.

Additional costs for growing the sorghum include: (1) the increased costs of planting and harvesting the sorghum in cotton fields; (2) the reduced sorghum crop due to use of sorghum varieties that are attractive to greenbugs; and (3) the increased fertilizer and water costs for sorghum since it receives the same treatment as cotton. Assuming that the sorghum yield is 85% of normal and that the added machine and labor costs of planting the sorghum are $3 per acre, added costs for growing the sorghum, including water and fertilizer costs, are approximately $7 per acre (Appendix, Table 4).

Short-Season and Scouting Program--

Earlier we mentioned that bollworms and budworms appear late in the season (late August and September) at numbers that may be damaging to cotton. By forcing the cotton to mature early through cultural changes, this then reduces the opportunities for the bollworms and budworms from reaching high densities and damaging cotton. A cultural technique that has proven effective in reducing the length of cotton growing season is irrigation management. In early August the amount of irrigation water is intentionally limited which forced the cotton plant to mature and produce its crop earlier than normal.

This short-season culture does not reduce cotton yields but only reduces the threat from bollworms and budworms. For example, in parts of Arizona and California if short-season culture is used, it would reduce the number of treatments by about 3 per season (Appendix, Tables 4 and 8).

Similar to short-season cultural control, employing a short-season cotton variety would provide an effective means of reducing the threat to cotton from bollworms and budworms in the cotton growing regions that cannot use irrigation as a management tool. Also, it should be pointed out that shortening the cotton fruiting season reduces the boll weevil problem. The weevil is essentially a one-host plant. Thus, reducing the time for boll weevil population increase, the weevil threat is greatly reduced (the weevil generation time is about 2.5 weeks).

Currently a good commercial short-season cotton variety does not exist. If such a short-season variety(s) were developed, it would be possible to reduce significantly the number of treatments of cotton (Appendix, Tables 1, 2, 9-17, 21-26, 28-32).

If a short-season variety were available and combined with a scouting program and employed where applicable (8.6 million acres) in the U.S., the number of treatments would be reduced from the 7.9 regular treatments on this acreage to about 4.0, (Table V). Thus, a short season scouting program on average reduces the number of treatments per acre to about 3.9 compared with regular. This is similar to trap crop-scouting. The amount applied per acre would be reduced nearly 50%. The savings in treatment costs would be about $11.

Resistant and Scouting Program--

Varieties of cotton such as "Frego bract" have natural resistance to boll weevils. Although this variety is resistant to the boll weevil, it does not yield as well as the commercial varieties under regular insecticide schedules (Appendix, Tables 12 and 13).

Tremendous potential exists for reducing the number of treatments of cotton if a good commercial variety of cotton could be developed that was also resistant to the boll weevil. The specialists estimated that a good resistant variety would significantly reduce the number of treatments (i.e., perhaps as much as 68%) (Appendix, Tables 1, 2, 5, 9-13, 16, 17, 21-26, 28-30, 32).

If a boll weevil resistant cotton variety were combined with a scouting program in the U.S. and employed where applicable (7.9 million acres), the number of treatments would be reduced from the 7.8 regular treatments on that acreage to only 3.0 (Table V). Thus, a resistant-scouting program on an average would reduce the number of treatments to about 4.8 compared with regular. The amount of insecticide applied per acre would be reduced by about 62% with a saving of about $19.

Resistant, Short-Season, and Scouting Program--

If good commercial varieties that combined boll weevil resistance and short-season characteristics were available, pest control in cotton would be revolutionized. If these varieties were available, employed where applicable (8.6 million acres), and combined with scouting, the number of treatments would be reduced from the 7.6 regular treatments on this acreage to about 2.2, (Table V). Thus, this program on an average would reduce the number of treatments per acre about 5.4 compared with regular. The amount of insecticide used could be reduced about 71%.

Corn

Each of the important corn insect-control program alternatives are described and discussed below:

Regular or Current Control--

In corn "regular control" is not easily definable because how and where the corn is cultured (e.g., continuous vs. rotation) in large measure determines what the pest control problem is and the treatment. An estimated 52% of all corn acreage is being treated with about 1 pound of insecticide per acre (Appendix, Tables 33-55). The prime pest is the rootworm complex (Northern, Western, and Southern rootworms). The average cost of treatment is about $4.50 per acre each season.

For continuous corn acreage on which rootworms are the most serious pest, an estimated 87% of the acreage is treated (Appendix, Tables 34-55). For corn in rotation with other crops, only an estimated 29% of the acreage is treated.

Scouting--

All the specialists agree that scouting of the major corn pests (rootworms, cutworms, European corn borers, armyworms, and corn leaf aphids) would be a valuable aid in reducing the number of treatments in corn. However, several specialists seriously question whether it is now practical or would ever be practical (because of scouting costs) to employ commercial scouting on corn.

Some specialists, as in the State of Illinois, feel they have an effective procedure for scouting corn pests—especially the rootworm complex. If scouting were implemented throughout the state, the Illinois specialists estimated that the percentage of acres treated could be reduced from more than 60% to less than 15%. If we estimated that the average insecticide treatment of corn in Illinois costs $6.00 per acre and on an average scouting would reduce insecticide treatments by 75%, then the costs of treating those acres previously would decline from $6.00 to an average of about $1.50. If we assume scouting costs of $2.00 per acre, then the total saving per acre is about $2.50 in Illinois. Compared with savings per acre in cotton, that averaged about $20 per acre, this $2.50 is a relatively low return.

Some specialists, as in Missouri, believe that while sufficient information is not available for an effective scouting program, scouting corn may prove useful in the future. And yet other specialists, as in Iowa, estimate that even with effective monitoring procedures for corn pests, the reduction in insecticide treatment costs would not pay for the scouting costs. Scouting costs for corn were estimated to range between $1 and $4 per acre. At $2 per acre, an estimated 50% reduction in number of current treatment costs (at $4.00 per acre) would be necessary just to pay for the scouting. For rootworms, the most serious pest of corn, most specialists project that a 33% reduction in number of treatments is impossible. Therefore, this group of specialists argues that corn scouting appears impractical, given the current relative price structure.

Rotations for Rootworm Control--

The prime rotation of corn in the U.S. is with soybeans but other rotations include wheat, oats, barley, alfalfa and sod. Seldom is there a problem in first year corn from rootworms. About 60% of the corn is now grown in the U.S. in rotation with other crops (Appendix, Tables 33-55). The reasons that farmers give for rotating corn with other crops are many. They include: rootworm control; tradition; relative prices of other crops; nitrogen fertilizer availability (soybeans and alfalfa); and others.

Since most rotations are carried out for reasons other than rootworm control, the benefits and costs of rotating corn are numerous. In addition to rootworm control, rotations aid in adding nitrogen to the soil (legumes), reducing disease problems in corn, and reducing soil erosion problems.

Since corn rotation reduces the number of insecticide treatments by 1 and at a saving of about $6 per acre, any rotation scheme often has to have more than rootworm control as its economic impetus to benefit the grower. The relative value of crops that are in rotation is obviously a dominant factor for growers deciding whether to rotate corn with other crops or grow corn continuously. The main place where rotation fits is where other crops will be grown on land of similar quality regardless of the planting sequence.

"No-till" Culture for Rootworm Control--

"No-till" corn culture involves leaving corn or other crop remains on the soil surface, using 2 to 4 lbs of herbicide to chemically kill weeds or previous crops, and then planting directly through the surface mulch. Several variations of this technology are employed and are collectively referred to as minimum tillage (USDA, 1975b).

The surface mulch and not disturbing the soil increases rootworm problems in "no-till" corn (Chiang et al., 1971; Musick and Collins, 1971; Pruess et al., 1968; USDA, 1975b). Other pest problems associated with "no-till" corn culture include increased problems from cutworms, armyworms, and slugs. These pests in "no-till" corn often require treatment. Another potential disadvantage of "no-till" culture is the low soil temperature may reduce stands and slow the rate of corn growth early in the season.

"No-till" corn culture, however, has several important advantages (USDA, 1975b). It may be more economical by reducing labor inputs. Especially important is the reduction in soil erosion. The estimated loss of topsoil for continuous corn culture is about 21 tons per acre per annum (Whitaker et al., 1973; Burwell et al., 1974). "No-till" corn culture reduces this loss to less than 1 ton per acre (USDA, 1975b; Pimentel et al., 1976). "No-till" corn culture also has the advantage of reducing water run-off and otherwise conserving soil moisture.

Cutworm Control--

Cutworms are common on bottom land (i.e., in lowland areas in which the soil is rich and relatively heavy). The recommended procedure for determining whether treatments are needed for cutworms on a particular piece of bottom land is "history;" that is, if cutworms have been a problem in the past, then this land should be treated.

In Iowa, for example, the estimate is that about 60% of the bottom land has an annual cutworm threat and should be treated annually with about 1 lb of insecticide (Appendix, Table 37). Thus, employing the procedure of recording past cutworm problems on land can play a valuable role in reducing the number of cutworm treatments that normally occur on bottom land.

Wireworm Control--

Wireworms are sometimes a problem when corn is planted following sod. Compared to rootworms, however, the problem is minor and occurs on only about 1% of the corn acreage (Appendix, Tables 33-55). The reasons for the problem being minor are: (1) a relatively small amount of the total corn (about 2%) acreage is planted following sod; and (2) only about half of sod acreage has infestations of wireworms that are serious and require treatment.

European Corn Borer Control--

A relatively small percentage (about 1%) of the nation's corn acreage is treated for European corn borer control (Appendix, Tables 33-55). Most specialists feel that some resistance to the corn borer has been bred into most corn that is planted today. This resistance along with natural enemies is keeping corn borer populations sufficiently low so that treatment is rarely required for this pest.

The development of a resistant corn borer variety will reduce the amount of insecticide being used in corn production. However, with onlv about 1% being treated and perhaps twice this acreage requiring treatment, further corn borer resistance will not benefit corn production as much as would the development of resistance in corn to the rootworms.

Corn Leaf Aphid Control--

The corn leaf aphid can reduce yields but it is not an annual pest but occurs sporadically (Appendix, Tables 33-55). The corn leaf aphid is a serious pest that requires treatment on about 2% of the corn acreage. Annual treatment for the corn leaf aphid, however, on current corn acreage is estimated to be less than 1%.

Mites and Other Pests--

On irrigated corn as in Nebraska and Kansas, mites may become a serious problem and require treatment. On a national basis treatment for mites occurs on less than 1% of the corn acreage (Appendix, Tables 33-55).

Combinations--

The combination of controls in corn is not as dramatic as in cotton. Again, the prime pest on corn is the rootworm. Corn in rotation with other crops will control rootworms, but the net benefits of rotations depend upon a great many factors in corn production. The advantages and disadvantages have been discussed.

Adding some European corn borer resistance to corn has significantly reduced the threat of the corn borer. A higher level of resistance is needed and it would be desirable to have this combined with rootworm resistance. This combination, however, is at least 10 years in the future.

The options for employing combination controls in corn pest control appear to be less than that in cotton.

Losses in Cotton and Corn to Insects

In cotton the estimate is that a 19% loss occurs in cotton in spite of all insect control efforts (USDA, 1965). This estimate appears to be about right for 1975 based on comments by several specialists.

Pimentel (1973) has estimated that the increased loss of cotton in the U.S. if all fields were not treated, would be about 31%. Adding the increase of 31% to 19% gives approximately 50%. In the present study, the specialists estimated an increased overall loss of 35% (range 0 to 90%) if acres currently treated were left untreated. Adding the 35% to 19% gives a 54% total loss; hence, the earlier 50% estimated loss agrees in general with the current estimate of 54%.

The high cotton losses (up to 90%) if insecticides were not used, occurred primarily in the regions where the boll weevil is a serious pest (Appendix, Tables 1-32). These regions are also the regions where the largest quantity of insecticide is used.

Losses in corn on those acres not treated were estimated to total about 21% (Pimentel and Shoemaker, 1974). The average estimate from the specialists for losses on untreated corn is about 20% and ranges from 1% to 65% (Appendix, Tables 33-55). Hence, these results suggest that the earlier rough estimate (Pimentel, 1973) was generally good.

STATIC ANALYSIS

The effects of implementing new insect control strategies depend upon the location of crop production. As a result several patterns of cropland use are considered in our analysis of insect control methodologies for cotton and corn production. In the Static Analysis discussed in this section, cotton is assumed to have its current location of production as estimated in the Appendix. In a later section entitled "Dynamic Analysis," the effects of shifts in the location of crop production are analyzed.

Both the static and dynamic analyses are based upon the costs, yields, acreages and insecticide use figures obtained from an extensive nationwide survey of agriculturalists (Appendix). However, in order to use these figures it was necessary to calculate expected costs and insecticide use for each insect control alternative in the static analysis.

Based upon the current averages given for each region, we have calculated that over $250 million is spent currently for cotton insect control.

This represents an average of $19.31 per acre on 13.1 million acres. Over 174 million pounds of insecticide are used including 102 million pounds of chlorinated hydrocarbons, 68 million pounds of organophosphorous compounds and 4 million pounds of carbamates.

Each of the cotton insect control methods are feasible on a fraction of the total cotton acreage. The total number of acres on which each method has been reported to be a feasible option is listed in Table VII (column III). For example, methods using diapause and scouting are currently feasible on 6.26 M (million) acres, which is only 48% of the 13.12 M acres currently in cotton production.

In column IV of Table VII, the average cost of using an alternative is given. This is calculated by dividing the total cost of implementing the alternative by the number of acres in the area of implementation in column III. The average savings in insect control costs (column VI) is the difference between column V and column IV. The average current cost (column V) is obtained by summing the current costs (per acre costs multiplied by the number of acres) over all regions in the area of implementation. Notice that the average current cost is significantly higher than the average of $19.31 per acre in areas where methods such as diapause control and trap crops are feasible. Column VII is the average savings from column VI multiplied by the number of acres in the area of implementation.

The economic consequences of implementing an insect control method depend upon changes in yield as well as changes in insect control costs. The total increase in cotton production expected over the area of implementation is given in column VIII. The increase in yield in each region is the yield that is expected with the implementation of the specified insect control alternative minus the current average yield.

In order to compare the benefits of increased cotton production to those of reduced insect control costs, it is necessary to estimate the value of the increase in cotton production. Cotton is valued at $.45 per pound. Thus, the value of increases in cotton production listed in column IX is based upon calculations that assume the price of cotton does not change as a function of the quantity produced. Since the changes in quantity in column VIII are small relative to the total amount of cotton produced, the assumption of constant price does not appear to introduce a significant error. The net benefit (column X of Table VII) is then the sum of the savings in insect control costs and the increase in income due to increased yields.

The insect control alternatives considered in the analysis are listed in column I of Table VII. In column II is given the potential time of implementation. Alternatives denoted by "present" include methods that are currently being used or that could be implemented at present. Such options are denoted by comment codes 1 or 2 as used in the Appendix. (Comment code 1 = current practices; code 2 = alternative pest controls that could be put into practice within one year; code 3 = alternative

Table VII. Effect of implementation of cotton insect control alternatives on insect control costs.

I	II	III	IV	V	VI	VII	VIII	IX	X
Insect Control Alternative	Time of Implementation[1]	Area of Implementation[2] (acres)	Average Cost of Alternative[3] ($ per acre)	Average Current Costs[4] ($ per acre)	Average Savings in Insect Control Costs[5] ($ per acre)	Total Savings in Insect Control Costs[6] ($)	Total Cotton Lint[7] (lb)	Increases in Production Value[8] ($)	Net Benefits[9] ($)
Most Economical[10]	present	13.1 M	13.10	19.30	6.20	81.3 M	+58.8 M	+26.5 M	109.19 M
	in 5 to 10 years	13.1 M	8.95	19.30	10.35	136.1 M	+51.3 M	23.1 M	159.16 M
Least Insecticide Feasible[11]	present	13.1 M	14.10	19.30	5.20	68.3 M	+58.3 M	26.5 M	94.75 M
	in 5 to 10 years	13.1 M	9.00	19.30	10.15	132.9 M	-15.3 M	-6.9 M	126.04 M
Scouting	present	10.6 M	21.35	23.71	2.45	26.0 M	+58.8 M	26.5 M	52.5 M
Diapause/ Scouting	present	6.0 M	26.60	30.00	3.45	19.8 M	63.9 M	28.9 M	48.6 M
Trap Crop/ Scouting	present	5.2 M	22.60	31.70	9.10	47.5 M	0	0	47.5 M
Short Season/Scouting	in 5 to 10 years	8.6 M	14.65	27.35	12.72	110.5 M	-191.3 M	-86.07 M	24.4 M
Resistant/ Scouting	in 5 to 10 years	7.9 M	13.25	26.50	13.25	104.9 M	-11.2 M	-5.0 M	99.9 M
Resistant, Short Season, Scouting	in 5 to 10 years	8.6 M	10.55	27.35	16.80	144.6 M	-122.4 M	-55.1 M	89.5 M

FOOTNOTES FOR TABLE VII

1. Time when the insect control alternative can be implemented in all regions included in the area of implementation.

2. The total number of acres on which the insect control alternative has been reported to be feasible.

3. Average cost per acre of the alternative over the area of implementation.

4. Average cost per acre of current insect control practices over the area of implementation of the insect control alternative being considered.

5. The average current cost (column V) minus the average cost of the alternative (column IV).

6. Average savings in insect control costs (column VI) multiplied by the area of implementation (column III).

7. Based upon estimates of the effect of the insect control alternative on yield as reported in Appendix A.

8. Assuming a value of $.45 per pound.

9. The total savings in insect control costs (column VII) plus the value of increased cotton production (column IX).

10. The most economical alternative in each region is implemented. (See text for further discussion.)

11. In each region the option is implemented which uses the least insecticide among those which are economically feasible. (See text for further discussion.)

pest controls that require additional research and potentially could be put into practice in 5 to 10 years.) Insect control alternatives with a time of implementation of 5 to 10 years include the currently available alternatives as well as those expected to be available in the future. These options have comment codes 1, 2, or 3 in the Appendix. Diapause control, scouting, and trap crops are methods that are currently available. Methods that require new plant varieties that are resistant or that mature in a shorter season will not be available for commercial use for another 5 to 10 years.

Two of the insect control alternatives listed in Table VII are entitled "most economical". For this alternative the insect control method selected in each region is the least costly among the methods available in the time period specified. Both insect control costs and yield losses are considered. If no yield losses occur in a region, the method selected will be the one with the lowest insect control cost. If yield losses do occur, the loss is valued at $.45 per pound and added to the insect control cost. The most economical option is then the method for which the combined cost of insect control and yield loss is smallest. For future alternatives, the options were chosen in a similar fashion except that they are chosen from all methods: those currently available and those available in 5 to 10 years.

The "least insecticide feasible" alternative selects the insect control method in each region that uses the least insecticide among those control methods that are available within the appropriate time limit and that are economically feasible. An option is considered to be economically feasible if the combined cost of insect control and yield loss is not more than 15% greater than current insect control costs. In a majority of cases the least insecticide option is actually less expensive than the current practice.

From Table VII, the implementation of the most economical option currently available in each region could reduce control costs by a total of $81.31 M, which is an average of $6.20 per acre. There are also increases in yields associated with the implementation of the most economical alternative in Arkansas. The yield increase is 58.8 M lbs which is valued at $26.46 M. The net benefit from implementing the most economical options currently available is then $109.19 M.

The analysis of the most economical options available in 5 to 10 years predict even larger benefits. The total savings in insect control costs is $136.08 M. There are yield increases in Arkansas and decreases in Mississippi for a net increase of 51.29 M pounds valued at $23.08 M. The net benefit is $159.16 M.

The effect of implementing insect control alternatives on insecticide use is given in Table VIII. Columns III, V and VII of this table give the total amounts of chlorinated hydrocarbons, organophosphates, and carbamate insecticides, respectively, used in the area of implementation. The average rates per acre in the area of implementation are given in columns IV, VI and VIII of Table VIII.

Table VIII. Effect of implementation of cotton insect control alternatives on insecticide use.

I	II	III	IV	V	VI	VII	VIII	IX	X	XI
Insect Control Alternative	Time of Implementation	Estimated Insecticide Use on Cotton with Implementation of Insect Control Alternative						Ratio of Insecticide to Current Use[2]		
		Chlorinated Hydrocarbons		Organophosphates		Carbamates				
		Total[3] (M lbs)	Average[4] (lbs/acre)	Total[3] (M lbs)	Average[4] (lbs/acre)	Total[3] (M lbs)	Average[4] (lbs/acre)	CH[5]	OP[6]	C[7]
Most Economical	present	61.9	4.72	37.2	2.83	3.9	.30	.61	.54	1.88
	in 5 to 10 years	42.5	3.24	27.2	2.08	3.5	.26	.41	.40	.88
Least Insecticide Feasible	present	59.1	4.50	34.5	2.63	1.7	.13	.58	.50	.44
	in 5 to 10 years	34.3	2.61	19.5	1.49	.1	.01	.33	.28	.02
Scouting	present	83.8	7.87	49.0	4.60	1.8	.17	.82	.72	.45
Diapause/ Scouting	present	50.7	8.81	33.3	5.78	1.7	.29	.64	.76	.62
Trap Crop/ Scouting	present	41.7	7.97	21.0	4.01	3.71	.71	.59	.46	3.49
Short Season/Scouting	in 5 to 10 years	43.9	5.11	25.0	2.91	.18	.02	.44	.39	.06
Resistant/ Scouting	in 5 to 10 years	37.3	4.70	20.2	2.54	.10	.01	.41	.34	.04
Resistant/ Short Season/ Scouting	in 5 to 10 years	29.8	3.47	18.3	2.13	.01	.00	.30	.29	.00

FOOTNOTES FOR TABLE VIII

1. Time when the insect control alternative can be implemented in all regions included in the area of implementation.

2. Ratio of the total insecticide (columns III, V or VII) to the total amount presently applied with the current insect control practices in the area of implementation. (See Table VI for definition of area of implementation.)

3. Total amount of insecticide used in the area of implementation.

4. Total amount of insecticide divided by the area of implementation.

5. Chlorinated hydrocarbons

6. Organophosphates

7. Carbamates

8. See footnote 10 of Table VI.

9. See footnote 11 of Table VI.

It is useful to compare the alternative control estimates of insecticide use to the currently used patterns. The ratio of insecticide use to current insecticide use is the amount of chemicals estimated to be used with the specified insect control alternative divided by the amount of insecticide currently used in the area of implementation. Columns IX, X and XI of Table VIII give the ratios for chlorinated hydrocarbons, organophosphates, and carbamates, respectively.

From the ratios, we note that implementation of the most economical options that are currently available is estimated to reduce the use of chlorinated hydrocarbons by 39% and organophosphates by 46%. There is an increase in the use of carbamate but the amount is small. The implementation of the most economical options available in the future are predicted to reduce insecticide use even more. Chlorinated hydrocarbons are reduced by 59% and organophosphates by 60%.

As would be expected, insecticide use and insect control cost savings are lower for the least insecticide feasible options than for the corresponding most economical options. What is surprising is that the differences are not very great. For options that are currently available, the difference in insect control costs between the least insecticide feasible options and the most economical is only $14 M or about $1 per acre. The insecticide use varies by about 0.5 lb per acre.

With insect control methods available in the future, both the least insecticide feasible and the most economical options have large savings in insect control costs of $133 M and $136 M, respectively. There is a significant difference in cotton production between the two alternatives. This is primarily due to yield changes in Arkansas.

Of the insect control methods currently available, scouting is clearly important. It is an available option on over 80% of the cotton acreage. However, one can see from the results in Tables VII and VIII that the benefits of scouting are greatly enhanced by its use in combination with other methods of control. For example, the implementation of scouting saves only $26 M ($2.45 per acre) in insect control costs. However, the implementation of the most economical options, which almost always involve scouting, has an additional saving of $81 M (Table VII, column VII). In addition, insecticide use is reduced by about 20% for scouting alone but is reduced by about 40% with the implementation of the most economical options currently available (Table VIII, columns IX, X and XI).

Diapause control used in conjunction with scouting is currently a feasible option on 6 M acres. In this area the current average cost of insect control is $30 per acre. The implementation of diapause control and scouting reduces this cost by over $3 an acre. Because of substantial increases in yields in Arkansas, the total net benefit on 6 M acres is calculated to be $48.6 M.

The use of trap crops is currently a feasible option on 5.23 M acres. These regions include areas where insect control costs are high, an average of $31.70 per acre. The savings in insect control costs are substantial, $9.10 per acre. Insecticide use is reduced by about 43%. However, the total net benefit is not as high for trap crop/scouting as for scouting or diapause/scouting because there are no yield increases associated with trap crops. However, as noted above, the yield increases associated with scouting and diapause/scouting alternatives occur primarily in Arkansas. Trap crops are not an option in Arkansas. Therefore, on the 5.23 M acres where trap crops are a feasible option, the use of trap crops in combination with scouting is more profitable than either scouting alone or scouting and diapause control.

The last three alternatives in Tables VII and VIII utilize special plant varieties that have resistance to insect damage or that mature in a shorter time. These varieties will not be ready for commercial use for another 5 to 10 years. It is estimated that varieties that have a short season because they mature more quickly will be available on 8.6 M acres. Resistant varieties that do not have short season characteristics are expected to be available on 7.94 M acres.

The savings in insect control costs are $111 M for varieties that have only short season characteristics and $145 M for varieties with both short season and resistance characteristics. However, in both cases there are some yield losses, mainly in Mississippi. Outside Mississippi, the implementation of insect control programs that utilize short season, resistant varieties appears to be advantageous from both economic and environmental viewpoints.

In summary, the most outstanding aspect of the results presented in Tables VII and VIII is that, contrary to popular belief, reductions in insecticide use need not increase the cost of producing cotton. All of the alternatives considered substantially reduce total costs (insect control costs plus yield losses) while reducing insecticide use. The implementation of the most economical among currently available options reduces insecticide use by about 40% and control costs by $81 M (Tables VII and VIII). The implementation of control methods that will be available in the future reduces insecticide use and control costs even further.

An examination of the results in Table VII also indicates that no single method of insect control is best throughout the nation. (If this were not true, one of the methods would have had net benefits that were close to those derived for the most economical options.) The indication is that the best combination of methods will vary from region to region. Scouting is usually a part of the control programs that are most economical. The use of resistant varieties in conjunction with scouting is estimated to be the most profitable among technologies available in the future.

The relative importance of each insect control alternative is measured in part by comparing the total savings (Table VII, column VII) and net benefits (Table VII, column X). It should be emphasized that these values are based upon total costs and yield increases throughout the area of implementation. In some cases a method was not as advantageous throughout the area of implementation as some other methods, but it was very profitable in certain regions. For example, the net benefits from resistant, short season varieties are greatly reduced by yield losses in Mississippi and Arkansas. However, in some other area, the use of these varieties are predicted to generate a considerable reduction in cotton production costs.

One difficulty in using the results of Tables VII and VIII to compare different pest control methods is that the location and size of the area of implementation of each method is different. These Tables give a detailed description of the effects of implementing a method in those regions where it has been acknowledged to be a feasible option. However, it is difficult to use these values to compare one method to another in terms of their national significance.

In order to give another basis for comparison, the nationwide effect of implementation of each of the pest control methods was analyzed. The results are presented in Tables IX and X. These calculations are based upon the costs, benefits and insecticide use over the entire 13.1 M acres of cotton production. Outside the area of implementation of each method, it was necessary to make some assumptions about the pest control methods being used. Since scouting is an available and economical option in most areas, it was assumed that outside the area of implementation, scouting would be used in the regions where scouting is an available option. In the remaining area, pest control methods are not changed from current practice.

Table IX. Costs and benefits resulting from the nationwide implementation of insect control alternatives[1].

I	II	III	IV	V	VI	VII	VIII	IX
Insect Control Alternative	Time of Implementation	Area of Implementation (acres)	Average Cost of Alternative ($ per acre)	Average Savings in Insect Control Costs[2] ($ per acre)	Total Savings in Insect Control Costs ($)	Total Cotton Lint[3] (lbs)	Increases in Production Value[4] ($)	Net Benefits[5] ($)
Scouting	present	10.6 M	17.30	2.00	26.0 M	58.8 M	26.5 M	52.5 M
Diapause/ Scouting	present	6.0 M	16.00	3.20	42.6 M	63.9 M	28.8 M	71.3 M
Trap Crops/ Scouting	present	5.2 M	15.80	3.50	45.7 M	58.8 M	26.5 M	72.2 M
Short Season Variety/ Scouting	in five to ten years	8.6 M	10.50	8.80	115.0 M	-191.3 M	-86.1 M	28.9 M
Resistant Variety/ Scouting	in five to ten years	7.9 M	10.30	9.00	118.4 M	-11.2 M	-5.0 M	113.3 M
Resistant, Short Season Variety/ Scouting	in five to ten years	8.6 M	7.90	11.40	150.1 M	-122.4 M	-55.1 M	95.0 M

Footnotes for Table IX

1 All costs and benefits are calculated over the entire 13.1 M acres of cotton production. Outside the area of implementation of a method, scouting is assumed to be practiced wherever it is available. In the remaining regions, the current pest control practices are assumed to be used.

2 The current average cost on the 13.1 M acres of land presently in cotton production is $19.30. Column V is $19.30 minus the values given in column IV.

3 Based upon estimates of the effect of the insect control alternative on yield as reported in Appendix A.

4 Assuming a value of $.45 per pound

5 The total savings in insect control costs (column VI) plus the value of increased cotton production (column VIII)

The values in Tables VIII and X give results that are qualitatively similar to those in Tables VII and VIII. Diapause/scouting and trap crop/scouting have net benefits that are nearly equal. The use of resistant varieties is the most profitable of the methods available in the future. Short season varieties are not as beneficial as other techniques because of yield losses. There is a difference in cotton production with trap crop/scouting between Table VII and Table IX. This is due to an increase in cotton production in Arkansas resulting from the implementation of a scouting program. Trap crops are not an available option in Arkansas.

In the dynamic analysis discussed in the next section, the location of crop production as well as pest control methods are allowed to change. Since this analysis is nationwide, the same criterion is used in Tables IX and X for choosing pest management methods outside the area of implementation. Namely, scouting is used if it is an available option. Otherwise the methods currently used are assumed to be practiced.

DYNAMIC ANALYSIS

The dynamic analysis was conducted using the linear programming model described in Rovinsky et al. (1977). Alternate pest management practices were reflected through regional production costs and yields which were specified as input parameters to the model. Each pest management strategy required a separate model analysis. For each pest management strategy the model calculates the optimum location of crop production, production costs, insecticide use and insect control costs.

Table X. Insecticide use resulting from the nationwide implementation of insect control alternatives.[1]

I	II	III	IV	V	VI	VII	VIII	XI	X
	Chlorinated Hydrocarbons		Organophosphates		Carbamates		Ratio of Insecticide Use to Current Use[2]		
Insect Control Alternative	Total (M lbs)	Average (lbs/acre)	Total (M lbs)	Average lbs/acre)	Total (M lbs)	Average (lbs/acre)	CH[3]	OP[4]	C[5]
Scouting	83.8	6.39	49.0	3.74	1.8	0.14	0.82	0.72	0.45
Diapause/ Scouting	55.0	4.95	43.7	3.33	2.1	0.16	0.64	0.64	0.54
Trap Crop/ Scouting	68.2	5.20	40.0	3.05	5.2	0.39	0.67	0.58	1.32
Short Season Variety/ Scouting	45.7	3.48	27.0	2.06	0.5	0.04	0.45	0.39	0.13
Resistant Variety/ Scouting	43.9	3.35	25.4	1.94	0.5	0.04	0.43	0.37	0.12
Resistant, Short Season Variety/ Scouting	31.6	2.41	20.3	1.55	0.3	0.03	0.31	0.30	0.09

Footnotes for Table X

1 All insecticide totals and ratios are calculated over the entire 13.1 M acres of cotton production. Outside the area of implementation of a method, scouting is assumed to be practiced wherever it is a feasible option. In the remaining regions, the current pest control practices are assumed to be used.

2 ratio of the total insecticide (columns II, IV, or VI) to the total amount presently applied with the current insect control practices in the entire 13.1 M acres of cotton production

3 chlorinated hydrocarbons

4 organophosphates

5 carbamates

In addition to considering both cotton and corn, the analysis evaluates the impact of two levels of pest management technology and three levels of export demand. Both limited and unlimited shifts in regional cotton acreage were considered. The first pest management technology (current technology) included only those pest management practices that are currently available, i.e., strategies that could be adopted by farmers within one year. The future technology level includes insect control strategies that entomologists believe will be available within 5 to 10 years. The three export levels include: (1) the level experienced during 1973; (2) 50 percent below 1973--which is approximately equal to 1971 quantities for many crops; and (3) 50 percent above 1973 levels--which assumes that the effective demand of developing countries will continue to expand.

With limited cotton acreage shifts, the amount of cotton that could shift out of any region was limited by a lower bound on acreage by region. The lower bound represented approximately 80 percent of the historical cotton allotment. With unlimited cotton acreage shift, there were no limits on the amount of cotton to be produced in any area. This assumes that farmers adjust completely to the technological and economic conditions specified.

Cotton: Current Technology

Several insect control practices and combinations of practices are possible on cotton. The complexity is increased when the peculiarities of regions and states are included. The analyses described below are limited to those pest management strategies that are considered most promising or are widely used.

The Short Run--

Many physical and economic factors limit the ability of farmers to respond to changes in the economic and regulatory factors influencing crop production. This is particularly important for cotton since acreage allotment practically regulated the amount of cotton grown on farms for many years. This regulation and the threat of its return, at least in farmers' minds limits the rate at which cotton will shift out of economically noncompetitive areas. Fixed factors of production and normal resistance to change also contribute to slow regional shift in response to economic change. To illustrate the impact of differential adjustment, analyses have been made under what have been termed a short run situation and a long run situation. The basic difference between these two situations is the amount of regional shift in cotton acreage allowed. Lower bounds on cotton acreage by region as defined by Rovinsky et al. (1977) were used to portray the short run situation. No lower bounds were used with the long run situation.

Current situation--This analysis included the insect control strategies presently in use on U.S. farms. The results approximate 1973 production with allowance for adjustment by farmers to basic economic conditions prevalent in 1973. Total cotton insecticide use was estimated at 123 million pounds with total insect control costs of $184 million (Table XI). Cotton production used approximately 12.7 (the model estimate differed from the 13.1 mentioned earlier) million acres and total production cost was $1.25 billion. Acreage, production and production cost for corn and the other feed grains are shown in Table XII. This analysis using current farm practices will be used as a basis for comparison in evaluating the effectiveness of other insect control strategies.

Scouting--If scouting were adopted in all areas where entomologists believe that the procedure has been sufficiently developed and tested to be adopted immediately by all farmers, cotton insecticide use would drop to 103 million pounds and insect control costs would be $171 million (Table XI). This represents a 16% saving in insecticide use and a 7% saving in insect control costs compared to the current situation. The only significant regional shift in production caused by this strategy is a movement of 1.2 million acres of cotton from Texas and Oklahoma into other areas including the Arkansas/Louisiana/Mississippi region (Table XIII). Cotton displaced from the Texas/Oklahoma area was replaced by sorghum and corn. The shift from the Texas/Oklahoma area is apparently caused by the high cost of scouting relative to other insect control strategies in parts of Texas.

Diapause and scouting--When diapause control is combined with scouting wherever diapause control is a currently viable option, the use of chlorinated hydrocarbons declines significantly and total insecticide use declines to 81 million pounds (Table XI). This represents a 34% decline in insecticide use compared to the current situation and a 21% decline from the level achieved with use of scouting alone. This reduction in insecticide use involved a slight increase in insecticide control costs over use of scouting alone, but was somewhat less costly than current situation. The location of cotton production with this insect control strategy is similar to that found with the current situation.

Table XI. The use of insecticide in cotton utilizing current alternative insect control strategies during the short run.

Insect Control Strategy[1/]	Pounds of Insecticide Used (x 10^6)				Insect Control Costs (x 10^6)
	CH[2/]	OP[3/]	C[4/]	Total	
Regular	77.9	47.6	2.3	127.8	$188.8
Current Situation	75.5	45.3	1.9	122.8	184.4
Scouting	65.7	36.9	0.9	103.5	170.6
Diapause/Scouting	47.1	32.9	1.1	81.1	174.2
Trap-Crop/Scouting	54.9	30.9	4.0	89.8	158.5
Most Economical (Current)	48.6	28.0	4.0	80.7	134.9
No Insecticide	0	0	0	0	0

1/ See text for description of strategies
2/ Chlorinated insecticides
3/ Phosphate insecticides
4/ Carbamate insecticides

Trap crop and scouting--Use of a trap crop and scouting wherever the combination is feasible and scouting in all other areas reduced insecticide use to 90 million pounds. This is 26 percent less than with current practice and 13 percent less than with scouting alone. Insect control cost decreased by 14 and 7 percent, respectively.

Most economical insect control strategy--The most economical insect control strategy for each region was defined as the strategy with the lowest insect control costs when insecticide, insecticide application costs, value of yield differential and other strategy implementation costs (such as cultural practice costs of trap crops) were considered. Selecting the most economical insect control strategy for cotton for each producing region from an array of known and applicable technologies resulted in a savings of about $49.9 million in cotton insect control costs (Table XI). This 27% reduction in cotton insect control costs would also result in reducing the total amount of insecticide used by about 33%.

No insecticide use on cotton and corn--To determine the impact of withdrawal of insecticides on land use, on regional shifts in cotton and corn production and on production costs, an analysis was made assuming no pesticides were used. This analysis has to be viewed with care since the

Table XII. Total production and production costs for various crops when when current alternative insect control strategies are employed on cotton during the short run.

Insect Control	Cotton			Corn			Soybean			Wheat			Sorghum			Other Small Grains			Totals	
Strategy 1/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Costs 4/
Regular	13.0	6,929	1,267	53.1	276,692	2,820	42.9	75,629	1,344	71.9	130,129	1,599	20.7	70,956	661	38.1	66,721	621	239.6	8,312
Current Situation	12.7	6,697	1,246	52.6	271,104	2,801	42.9	74,744	1,343	71.9	124,658	1,599	21.1	70,741	677	38.1	60,051	622	239.4	8,288
Scouting	11.9	6,929	1,245	53.0	275,189	2,804	43.0	75,751	1,344	72.0	130,145	1,588	21.9	73,374	696	37.5	65,691	610	239.4	8,208
Diapause/Scouting	12.2	6,929	1,227	52.6	274,753	2,791	42.9	75,586	1,342	71.9	130,145	1,598	21.1	70,320	677	38.5	67,355	629	239.3	8,265
Trap Crop/Scouting	11.6	6,929	1,226	53.1	275,190	2,796	42.3	75,746	1,344	72.0	130,145	1,587	22.0	73,373	701	37.5	65,691	609	238.5	8,264
Most Economical (Current)	11.6	6,929	1,202	53.1	275,180	2,796	42.9	75,746	1,344	72.0	130,145	1,587	22.0	73,373	701	37.5	65,691	609	239.1	8,240
No Insecticide	16.3	6,929	1,313	53.6	274,539	2,879	43.9	76,153	1,355	71.2	127,031	1,587	20.8	72,673	665	38.0	66,494	632	243.8	8,432

1/ See text for description of strategies
2/ Millions of acres
3/ Millions of pounds
4/ Production costs in millions of dollars

Table XIII. Distribution of cotton production in different consuming regions utilizing current alternative insect control strategies during the short run.

Consuming Regions	Insect Control Strategy[1/]: Regular	Current Situation	Scouting	Diapause/ Scouting	Trap-Crop/ Scouting	Most Economical (Current)	No Insecticide
	- - - - - -	- - - - - -	- - - - - Thousand Acres	- - - - - -	- - - - - -	- - - - - -	
Iowa/Missouri	179	179	179	179	179	179	179
Va./W.Va./N.C.	247	217	247	247	247	247	217
Ky./Tenn.	310	242	310	311	310	310	243
Ala./Ga./S.C.	1,205	1,205	1,205	1,205	1,205	1,205	1,205
Florida	15	15	15	15	15	15	15
Ark./La./Miss.	2,122	2,244	2,626	2,354	2,782	2,782	2,451
Texas/Okla.	8,218	7,411	6,639	7,244	6,181	6,181	10,756
Ariz./N.M.	258	253	253	258	258	253	296
Calif.	418	370	418	418	418	418	459
Total	12,972	12,136	11,892	12,231	11,595	11,596	15,821

1/ See text for description of strategies.

entomologists estimating the yield impacts of no pesticide use for individual options were likely not taking into account the full impact of a complete withdrawal of all insecticide in all areas. Further the analysis does not take into consideration the changes in inter-farm and inter-year variability that such a practice may cause. This analysis does, however, provide some general indication of the impact of insecticide withdrawal.

With this alternative, insecticide use on cotton and corn, of course, drops to zero reflecting a reduction in insecticide use of nearly 123 million pounds compared to the current situation. Acreage used in cotton production increases 29% over the amount used under the current situation and 30% to 40% over other strategies. Total land used for all crops increased about 2%. Cotton production costs were 6% above costs under current practice and total production costs for all crops included in the model were nearly 2% higher. Since no land or other fixed costs are included in the production cost estimates, these data significantly underestimate the costs of cropping the increased acreage. This is particularly true for cotton.

The Long Run--

Given a sufficient period of time farmers will completely adjust to a changed economic environment. As implied above the rate of adjustment will depend upon the degree of change in crop economy, the magnitude of fixed factors of production and the available alternatives. A linear programming analysis with no restriction on regional production shifts indicates the result that could be expected after complete adjustment has taken place. While the real world is never static long enough for complete adjustment to any particular economic environment to take place, an analysis under these conditions indicates the direction and magnitude of changes that can be expected. Thus, the short run analysis presented above and the long run analysis presented below bracket the results that could be expected with any particular strategy (Table XIV). Initial consequences of implementing a particular strategy can be expected to look something like the results from the short run analyses while the long run results will be more closely approximated as time progresses (Tables XI, XII, XIII, XIV, XV, and XVI).

The long run situation was approximated by allowing unlimited shift in regional production of all crops. Under these conditions nearly all cotton production shifted to the Arkansas/Louisiana/Mississippi and Texas/Oklahoma areas (Table XVI). The particular insect control strategy used has little impact on the general location of production. It appears that the Arkansas/Louisiana/Mississippi and Texas/Oklahoma areas have a large enough production advantage over other areas that the differential cost of alternate insect control strategies does not cause changes in the location of production. Under these conditions the amount of pesticide used and the magnitude of insect control costs are a function of the specific levels of cost and insecticide use in these geographic areas (Tables XIV and XV). This implies that the expected relationship between the insect control costs and insecticide use for the strategies examined that was apparent in the short run, may no longer hold.

Table XIV. The use of insecticide in cotton utilizing current alternative insect control strategies during the long term.

Insect Control Strategy[1/]	Pounds of Insecticide Used ($x 10^6$)				Insect Control Costs ($x 10^6$)
	CH[2/]	OP[3/]	C[4/]	Total	
Regular	38.2	23.7	.1	62.1	96.2
Current Situation	35.8	22.2	.1	58.2	91.6
Scouting	33.9	24.9	.2	59.0	133.0
Diapause/Scouting	23.1	21.1	.2	44.4	111.8
Trap-Crop/Scouting	26.5	20.5	.5	47.5	117.4
Most Economical (Current)	24.7	21.1	.5	46.1	116.5
No Insecticide	0	0	0	0.	0

1/ See text for description of strategies
2/ Chlorinated insecticides
3/ Phosphate insecticides
4/ Carbamate insecticides

The shift in location of production that could be expected to occur in the absence of regional acreage limitation would reduce insecticide use by 52% with continued use of current practices (Tables XI and XIV). Compared to current practice, universal use of scouting alone would result in a slightly higher level of insecticide use and higher insecticide control costs and total production costs. Use of diapause and scouting would reduce insecticide use by 64% with lower insect control costs and total production costs than scouting alone (Tables XI, XII, XIV, XV). Use of the most economical strategy in all areas resulted in a 62% reduction in insecticide use with insect control costs that are slightly higher than the diapause-scouting system option but with the lowest total production costs for crops of all the options considered (Tables XI, XII, XIV, and XV).

It is important to note that the level of insecticide use, insect control costs and total production costs are lower for all long run analyses compared to short run analyses (Tables XI, XII, XIV, and XV). This implies that insecticide use (and production costs) could be reduced more by allowing regional shifts in production than by forcing universal use of any of the currently available technologies. Environmental pollution from the current high level use of insecticides is therefore an externality of the government allotment programs. The allotment programs restricted regional shifts in cotton production in the nation.

Table XV. Total production costs for various crops when current alternative insect control strategies are employed in cotton during the long run.

Insect Control	Cotton			Corn			Soybean			Wheat			Sorghum			Other Small Grain			Totals	
Strategy[1/]	Acres[2/]	Production[3/]	Costs[4/]	Acres[2/]	Production[3/]	Costs[4/]	Acres[2/]	Production[3/]	Costs[4/]	Acres[2/]	Production[3/]	Costs[4/]	Acres[2/]	Production[3/]	Costs[4/]	Acres[2/]	Production[3/]	Costs[4/]	Acres[2/]	Costs[4/]
Regular	12.9	6,929	934	54.9	282,112	2,887	43.0	75,904	1,346	71.8	130,167	1,604	18.8	67,289	635	36.9	64,879	603	238.4	8.011
Current Situation	12.7	6,929	927	54.0	280,520	2,872	42.9	75,807	1,345	71.8	130,149	1,598	19.0	68,152	639	37.3	65,675	608	237.8	7.988
Scouting	12.4	6,929	967	53.7	278,787	2,853	43.0	75,805	1,344	71.6	130,149	1,592	18.9	69,999	657	37.3	65,517	607	237.8	8.020
Diapause/Scouting	12.1	6,929	945	53.3	276,591	2,828	42.9	70,654	1,340	71.6	125,210	1,590	20.1	70,497	662	38.2	67,346	627	238.3	7.991
Trap Crop/Scouting	12.2	6,929	954	53.2	276,592	2,825	42.9	75,608	1,341	71.6	130,149	1,590	20.1	70,497	661	38.2	67,345	627	238.2	7.999
Most Economical (Current)	12.2	6,929	941	52.7	276,025	2,821	42.7	75,460	1,589	71.5	130,157	1,589	20.1	69,856	659	39.0	68,638	639	238.3	7.986
No Insecticide	14.5	6,929	1,015	55.5	312,848	2,882	44.0	76,489	1,366	71.1	128,226	1,599	20.9	74,112	680	35.9	63,207	598	242.1	8,141

1/ See text for description o. strategies
2/ Millions of acres
3/ Millions of pounds
4/ Production costs in millions of dollars

Table XVI. Distribution of cotton production in different consuming regions utilizing current alternative insect control strategies during the long run.

Consuming Regions	Insect Control Strategy[1/]						
	Regular	Current Situation	Scouting	Diapause/ Scouting	Trap Crop/ Scouting	Most Economical (Current)	No Insecticide
	- - - - - - - - - - - - -	- - Thousand Acres - -				- - - - - - - - - - - - - - - - -	
Iowa/Missouri	0	0	0	0	0	0	0
Va./W.Va./N.C.	30	30	30	30	30	30	30
Ky./Tenn	68	68	68	68	68	68	68
Ala./Ga./S.C.	0	0	0	0	42	42	0
Florida	0	0	0	0	0	0	0
Ark./La./Miss.	1,977	2,281	2,665	2,794	2,841	2,998	2,794
Texas/Okla.	10,634	9,753	9,462	9,087	9,080	8,895	9,087
Ariz/N.M.	107	102	107	107	107	107	107
Calif.	48	48	48	48	48	48	48
Total	12,864	12,136	12,380	12,134	12,216	12,187	12,134

1/ See text for description of strategies.

Cotton: Future Technology

Adding the future possibility of boll weevil-resistant cotton and short season varieties to the available control technologies is expected to contribute importantly to cotton insect control. The analyses using these strategies provide an indication of the potential returns to development of these technologies.

The Short Run--

For this analysis the short run implies what would be expected if resistance and short season varieties became available before significant regional shifts in production had taken place. Alternately the short run could be interpreted as what would likely happen if these strategies were adopted under current conditions (Tables XVII, XVIII and XIX).

The major impact of resistant and short season technologies compared to currently available technologies on the location of production in the short run is to shift some cotton production from the Texas/Oklahoma area to the Arkansas/Louisiana/Mississippi region (Table XIX).

Short-season and scouting--Use of short season varieties and scouting in all areas where this technology is expected to be available within the next 5 to 10 years reduces both insecticide use and pest control costs be-

Table XVII. The use of insecticide in cotton utilizing future alternative insect control strategies during the short run.

Insect Control Strategy 1/	Pounds of Insecticide Used ($x 10^6$) CH 2/	OP 3/	C 4/	Total	Insect Control Costs ($x 10^6$)
Short Season/Scouting	34.9	22.9	0.3	58.1	129.5
Resistant/Scouting	35.9	20.5	0.3	56.7	117.0
Resistant/Short Season/ Scouting	25.0	16.5	0.2	41.8	94.5
Most Economical (Future)	35.5	21.4	3.1	60.0	98.3

1/ See text for description of strategies
2/ Chlorinated insecticides
3/ Phosphate insecticides
4/ Carbamate insecticides

Table XVIII. Total production and production costs for various crops when future alternative insect control strategies are employed in cotton during the short run.

Insect Contol Strategy 1/	Cotton			Corn			Soybean			Wheat			Sorghum			Other Small Grains			Totals	
	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Costs 4/
Short Season/Scouting	12.9	6,929	1,207	52.7	274,919	2,803	43.0	75,648	1,342	71.9	130,145	1,601	21.2	72,690	676	38.2	66,721	622	239.7	8,252
Resistant/Scouting	11.8	6,929	1,182	52.6	276,760	2,791	43.0	75,586	1,342	72.0	130,145	1,592	21.3	72,284	685	38.5	79,426	626	239.2	8,220
Resistant/Short Season/ Scouting	12.7	6,929	1,169	52.6	274,920	2,800	43.0	75,647	1,343	71.9	130,145	1,601	21.2	72,689	678	38.1	66,721	622	239.6	8,212
Most Economical (Future)	11.3	6,929	1,157	52.9	274,976	2,794	43.0	75,663	1,342	72.0	130,145	1,589	21.9	72,829	699	38.1	66,509	620	239.0	8,202

1/ See text for description of strategies.
2/ Millions of acres
3/ Millions of pounds
4/ Production costs in millions of dollars

Table XIX. Distribution of cotton production in different consuming regions utilizing future alternative insect control strategies during the short run.

Consuming Regions	Insect Control Strategy[1/] Short Season/ Scouting	Resistant/ Scouting	Resistant/ Short Season/ Scouting	Most Economical (Future)
	- - - - - - - - - Thousand Acres	- - - - - - - - - -		
Iowa/Missouri	179	179	179	179
Va./W.Va./N.C.	247	247	247	247
Ky./Tenn.	310	310	310	310
Ala./Ga./S.C.	1,205	1,205	1,205	1,205
Florida	15	15	15	15
Ark./La./Miss.	2,435	2,671	2,438	2,943
Texas/Okla.	7,785	6,540	7,692	5,773
Ariz./N.M.	258	258	258	258
Calif.	418	418	418	418
Total	12,852	11,843	12,762	11,348

1/ See text for description of strategies

low the levels achieved with any of the technologies currently available. Insecticide use would be 53% lower than with current practices (Tables XI, XVII). Total production costs are similar to those experienced with most economical current technology (Tables XII, XVIII).

Resistant-variety and scouting--Resistant variety reduces insecticide use to approximately the same level as is achieved with short-season varieties (Tables XI, XVII). Insect control costs are somewhat lower than for short-season varieties. Total production costs are lower than was found for any of the currently available technologies (Tables XII, XVIII).

Short-season, resistant and scouting--When boll weevil-resistance and short season varieties are combined, insecticide use, insect control costs and total production costs are lower than for any other strategy considered (Tables XI, XII, XVII, XVIII). Insecticide use is 66% less than found for the current situation (Tables XI, XVII). Compared to the lowest total cost achievable under current technology (most economical) a savings of $28 million per year in the cost of producing the crops included in the model is achieved through use of short-season and resistant varieties (Tables XII, XVIII).

The Long Run--

In general, insecticide use and insect control costs show the same relative pattern in the long run analysis as was found in the short run analysis (Tables XVII and XX). Resistance with scouting shows a greater reduction in both insecticide use and costs than short-season with scouting (Table XX). However, the greatest reduction in insecticide use is achieved with both short season and resistance.

Although the most economical option uses slightly more insecticide than the resistant/short-season/scouting option and has slightly higher insect control costs, a 68% reduction in insecticide use compared with the current situation is achieved (Table XX). Total production costs are less with the most economical option than the resistant/short-season/scouting option (Table XXI).

Table XX. The use of insecticide in cotton utilizing future alternative insect control strategies during the long run.

Insect Control	Pounds of Insecticide Used (x 10^6)				Insect Control
Strategy1/	CH2/	OP3/	C4/	Total	Costs (x 10^6)
Short Season/Scouting	25.8	19.5	>0	45.4	$104.1
Resistant/Scouting	22.9	16.5	>0	39.4	97.8
Resistant/Short Season/ Scouting	19.4	16.4	>0	35.8	84.6
Most Economical (Future)	20.3	18.6	0.2	39.1	101.7

1/ See text for description of strategies
2/ Chlorinated insecticides
3/ Phosphate insecticides
4/ Carbamate insecticides

Table XXI. Total production and production costs for various crops when future alternative insect control strategies are employed in cotton during the long run.

Insect Control	Cotton			Corn			Soybean			Wheat			Sorghum			Other Small Grains			Totals	
Strategy1/	Acres2/	Production3/	Costs4/	Acres2/	Production3/	Costs4/	Acres2/	Production3/	Costs4/	Acres2/	Production3/	Costs4/	Acres2/	Production3/	Costs4/	Acres2/	Production3/	Costs4/	Acres2/	Costs4/
Short Season/Scouting	12.8	6,929	945.2	53.2	279,280	2,851	42.9	75,640	1,337.1	71.5	130,149	1,596.5	19.8	68,467	649.3	38.0	66,636	616.9	238.2	7,996.1
Resistant/Scouting	12.3	6,929	911.1	52.8	277,609	2,834	42.8	75,674	1,338.9	71.7	130,152	1,588.5	20.1	70,419	668.5	37.9	66,306	613.0	237.7	7,954.2
Resistant/Short Season/ Scouting	12.8	6,929	925.7	53.2	279,281	2,851	42.9	75,638	1,337.9	71.5	130,149	1,594.8	19.8	68,467	649.3	38.0	66,634	617.0	238.2	7,975.8
Most Economical (Future)	12.2	6,929	925.9	52.6	276,530	2,822	42.8	75,673	1,338.9	71.8	130,149	1,585.8	20.8	71,481	679.7	37.9	66,306	613.0	236.0	7,965.6

1/ See text for description of strategies
2/ Millions of acres
3/ Millions of pounds
4/ Production costs in millions of dollars

In the long run more cotton is grown in the Arkansas/Louisiana/Mississippi region with future technology than with current technology (Table XXII). Assuming that cotton is a profitable crop for those areas, the return to research to develop the future technologies would be greater for this region than for the rest of the country.

Cotton: Alternate Export Levels

As the level of exports increase the competition for land with low insect control costs increases and, in general, both the amount of insecticide used and total insect control costs increase (Table XXIII). The magnitude of this increase appears to be 3% or less in moving from approximately 1971 (low) export levels to 1973 (medium) export levels. However, a further increase of approximately the same magnitude would increase insecti-

Table XXII. Distribution of cotton production in different consuming regions utilizing future alternative insect control strategies during the long run.

	Insect Control Strategy[1/]			
Consuming Regions	Short Season/ Scouting	Resistant/ Scouting	Resistant/ Short Season/ Scouting	Most Economical (Future)
	- - - - - - - -Thousand Acres - - - -			- - - -
Iowa/Missouri	0	0	0	0
Va./W.Va./N.C.	30	30	30	30
Ky./Tenn.	68	68	68	68
Ala./Ga./S.C.	202	0	202	202
Florida	0	0	0	0
Ark./La./Miss.	3,310	3,381	3,401	3,725
Texas/Okla.	9,049	8,752	9,014	8,010
Ariz./N.M.	107	28	72	71
Calif.	48	48	48	48
Total	12,814	12,307	12,835	12,154

1/ See text for description of strategies

Table XXIII. The use of insecticide in cotton and corn utilizing current and future alternative insect control strategies in cotton during the short run for export levels of low, medium, and high.

Cotton Insect Control Strategies and Export Levels	Cotton: Pounds of Insecticide Used(x 10^6) CH 2/	OP 3/	C 4/	Total	Cotton: Insect Control Costs(x 10^6)	Corn: Pounds of Insecticide Used(x 10^6) CH 2/	OP 3/	C 4/	Total	Corn: Costs(x 10^6)	Total: Pounds of Insecticide Used(x 10^6) CH 2/	OP 3	C 4/	Total	Total: Insect Control Costs(x 10^6)
						Current Technology									
Scouting 1/															
Low Exports	63.3	36.3	0.9	100.6	165.7	3.1	8.0	10.1	21.2	80.9	66.5	44.3	11.0	121.8	246.6
Medium Exports	65.7	36.9	0.9	103.5	170.6	4.0	11.3	13.8	29.1	109.3	69.5	48.1	14.7	132.6	279.9
High Exports	71.9	42.4	0.9	115.1	206.4	10.0	16.1	27.1	53.2	174.4	81.9	58.5	28.0	168.4	380.7
Most Economical (Current) 1/															
Low Exports	48.6	27.8	5.0	81.4	132.8	3.1	8.0	10.1	21.2	80.9	51.8	35.8	15.1	102.7	213.7
Medium Exports	48.6	28.0	4.0	80.7	134.9	4.0	11.2	13.7	28.9	108.4	52.6	39.2	17.7	109.6	243.2
High Exports	52.1	29.7	5.0	86.8	152.4	9.8	15.9	26.9	52.6	172.1	61.9	45.5	31.9	139.3	324.5
						Future Technology									
Resistant/Scouting 1/															
Low Exports	39.7	22.5	0.3	62.5	113.1	3.1	8.0	10.1	21.3	80.9	42.8	30.5	10.4	83.7	194.1
Medium Exports	35.9	20.6	0.3	56.7	116.9	4.1	11.4	13.9	29.4	110.7	39.9	32.0	14.2	86.1	227.6
High Exports	44.4	25.9	0.3	70.5	132.6	9.3	15.9	26.9	52.5	172.2	54.2	41.7	27.1	123.1	304.9
Resistant/Short Season/Scouting 1/															
Low Exports	25.8	17.4	0.2	43.4	95.7	25.8	17.4	0.2	43.4	95.7	51.6	34.9	0.3	86.8	191.3
Medium Exports	25.0	16.6	0.2	41.8	94.5	4.1	11.3	13.9	29.3	110.2	29.1	27.9	14.0	71.1	204.7
High Exports	27.9	18.6	0.2	46.6	99.0	9.9	16.3	27.2	53.5	176.3	37.8	34.9	27.4	100.1	275.3

1/ See text for description of strategies
2/ Chlorinated insecticides
3/ Phosphate insecticides
4/ Carbamate insecticides

cide use 7 to 12% and insect control costs 13 to 21% with current technology. With future technology insect control costs increase with increasing exports but the impact on insecticide use is variable. As might be expected varying export levels influenced production costs, amounts produced, and acreages (Table XXIV).

It should be pointed out that this analysis does not consider the impact of different cotton export levels; only changes in the level of feed-food grain exports are considered.

Varying the level of feed-food crop exports had relatively minor impact on the location of cotton production in the short run (Table XXV). The major general change was an increase of cotton acreage in Arkansas/Louisiana/Mississippi and a decline in Texas/Oklahoma as the level of exports increased. Also the total acreage of cotton declined slightly.

Corn: Current Technology

The number of alternatives for reducing insecticide use on corn are limited. Rotation is the only currently available technology that could be employed for the control of the major pest, the rootworm complex. Scouting is being developed and may be adaptable within a few years. The analysis below assesses the impact of adopting these alternatives.

This analysis included the corn insect control strategies presently in use on U.S. farms. Total insecticide use on corn was estimated at 29.1 million pounds and total corn insect control costs were $109.3 million (Table XXVI).

An obvious difference between corn and cotton is that about one-quarter as much insecticide is used on corn as on cotton and this relatively small quantity of insecticide is spread over about 4 times as many acres (Tables XXVI, XXVII, XXVIII). On a per acre basis about one-sixteenth as much insecticide is used on corn compared to cotton. This fact limits the impact of corn insect control strategies in reducing insecticide use on corn.

Rotations--

The primary insect pest on corn is the rootworm complex. The current control alternative available for rootworm control is rotation with a nonhost crop. Universal use of rotation would reduce insecticide use from 29.1 to 8.5 million pounds or 71%. Total insect control costs would be reduced 68% (Table XXVI). However, total production costs for all crops would increase $125 million or approximately 1.5% (Table XXVII).

Corn: Future Technology

Some opportunity exists for improving the current resistance in corn to the European corn borer. The amount of insecticide used in corn is relatively small (only about 1% of acreage is treated) for the corn borer; therefore, the potential reduction in total insecticide for corn borer resistance is relatively small.

Table XXIV. Total production and production costs for various crops when current and future insect control strategies are employed in cotton during the short term at low, medium, and high exports.

Cotton Insect Control Strategies and Export Levels	Cotton			Corn			Soybean			Wheat			Sorghum			Other Small Grain			Totals	
	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Costs 4/
							Current Technology													
Scouting 1/																				
Low Exports	12.5	6,929	1,238	42.9	231,585	2,267	30.1	54,882	913	47.5	88,583	972	21.1	67,701	592	37.2	67,489	581	191.4	6,562
Medium Exports	11.9	6,929	1,245	53.0	275,189	2,804	43.0	75,751	134	72.0	130,145	1,588	21.9	73,374	696	37.5	65,691	610	239.4	8,288
High Exports	11.4	6,929	1,321	75.5	389,914	4,196	63.3	100,190	2,158	92.9	165,683	2,338	10.9	41,753	488	20.7	33,645	384	274.8	10,886
Most Economical (Current) 1/																				
Low Exports	11.9	6,929	1,200	42.9	231,626	2,267	30.0	54,882	913	47.6	88,523	971	21.1	67,712	592	37.2	67,489	581	190.8	6,523
Medium Exports	11.5	6,929	1,202	53.1	275,190	2,796	42.9	75,745	1,344	72.0	130,145	1,587	22.0	73,372	701	37.5	65,691	609	239.2	8,240
High Exports	11.0	6,929	1,282	74.7	383,845	4,139	62.5	100,018	2,129	92.9	160,744	2,339	12.9	77,956	555	20.6	33,645	385	274.7	10,824
							Future Technology													
Resistant/Scouting 1/																				
Low Exports	11.9	6,929	1,190	42.9	231,639	2,267	30.0	54,882	912	47.6	88,503	972	21.1	67,716	592	37.2	67,489	581	190.8	6,513
Medium Exports	11.8	6,629	1,182	52.6	276,760	2,791	42.9	75,586	1,342	72.0	130,145	1,592	21.3	72,284	685	38.5	79,426	626	239.2	8,220
High Exports	11.0	6,929	1,269	74.7	383,871	4,140	62.5	100,019	2,129	93.0	165,683	2,341	12.9	47,930	555	20.6	33,645	384	274.7	10,817
Resistant/Short Season/Scouting 1/																				
Low Exports	13.2	6,929	1,158	42.9	231,620	2,267	30.1	54,882	914	47.5	88,532	973	20.7	67,711	589	37.2	67,489	581	191.6	6,482
Medium Exports	12.8	6,929	1,169	52.6	274,920	2,800	43.0	75,647	1,343	71.9	130,145	1,601	21.2	72,689	678	38.1	66,721	622	239.6	8,212
High Exports	12.5	6,929	1,239	75.5	383,721	4,225	63.3	100,194	2,163	92.5	165,683	2,345	10.2	37,946	457	20.9	33,645	384	275.0	10,812

1/ See text for description of strategies
2/ Millions of acres
3/ Millions of pounds
4/ Production costs in millions of dollars

Table XXV. Distribution of cotton production in different consuming regions utilizing current and future insect control strategies during the short run at low, medium and high export levels.

	Current Technology									Future Technology		
	Scouting Strategy[1/]			Most Economical (Current) Strategy[1/]			Resistant/Scouting Strategy[1/]			Resistant/Short Season/Scouting Strategy[1/]		
Consuming Regions	Low Exports	Medium Exports	High Exports	Low Exports	Medium Exports	High Exports	Low Exports	Medium Exports	High Exports	Low Exports	Medium Exports	High Exports
	Thousand Acres											
Iowa/Missouri	179	179	179	179	179	179	179	179	179	179	179	179
Va./W.Va./N.C.	247	247	247	247	247	247	247	247	247	347	247	247
Ky./Tenn.	310	310	310	310	310	310	310	310	310	310	310	310
Ala./Ga./S.C.	1,205	1,205	1,205	1,205	1,205	1,205	1,205	1,205	1,205	1,205	1,205	1,205
Florida	15	15	15	15	15	15	15	15	15	15	15	15
Ark./La./Miss.	2,328	2,626	3,137	2,626	2,782	3,542	2,724	2,671	3,563	2,128	2,438	2,922
Texas/Okla.	7,567	6,639	5.589	3,975	6,181	4,742	6,530	6,540	4,724	8,449	7,692	6,856
Ariz/N.M.	258	253	305	256	253	305	257	258	305	258	258	305
Calif.	418	418	418	418	418	418	418	418	418	418	418	418
Total	12,528	11,892	11,405	9,233	11,596	10,963	11,885	11,843	10,966	13,309	12,762	12,457

1/ See text for description of strategies

Table XXVI. The use of insecticide in corn utilizing current and future alternative insect control strategies on corn and cotton during the short run.

Insect Control Strategy[1/]	Pounds of Insecticide Used (x 10^6) CH[2/]	OP[3/]	C[4/]	Total	Insect Control Costs (x 10^6)
	- - - - - - Current Technology - - - - - - - -				
Current situation on corn with scouting on cotton	4.0	11.3	13.8	29.1	109.3
Forced rotations on corn with scouting on cotton	2.0	4.0	2.6	8.5	34.7
	- - - - - - Future Technology - - - - - - - -				
Current situation on corn with resistant, short season/ scouting on cotton	4.1	11.3	13.9	29.3	110.2
Forced rotation and/or scouting on corn with resistant, short season/ scouting on cotton	2.5	6.3	3.7	12.5	72.3

1/ See text for description of strategies
2/ Chlorinated insecticides
3/ Phosphate insecticides
4/ Carbamate insecticides

The only technology that entomologists expect to be developed for corn insect control in the future is scouting. Although scouting is considered ready for use in some states, most entomologists believe that the scouting technology is not adequately developed.

When use of either scouting or rotation is forced in all areas insecticide use declines by 57% (16.8 million pounds) and total insect control costs decline by 34% (Table XXVI). However, total production costs increase by $116 million or 1.4% (Table XXVII). In addition nearly 5 million more acres of land are used in production. This magnitude of an increase in land use would imply an increase in fixed land, building and machinery costs which are not included in the model. Thus, total costs will increase by significantly more than the 1.4%.

Table XXVII. Total production and production costs for various crops when current or future alternative insect control strategies are employed on corn and cotton during the short run.

Insect Control	Cotton			Corn			Soybean			Wheat			Sorghum			Other Small Grains			Totals	
Strategies 1/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Production 3/	Costs 4/	Acres 2/	Costs
Current Technology																				
Current situation on corn with scouting on cotton	11.9	6,929	1,245	53.0	275,189	2,804	43.0	75,750	1,344	72.0	130,145	1,588	21.9	73,374	696	37.5	65,691	610	239.6	8,312
Forced rotation on corn with scouting on cotton	11.9	6,929	1,244	56.0	272,017	2,882	42.7	75,893	1,381	71.7	129,044	1,595	23.5	77,678	713	34.4	65,548	622	240.1	8,437
Future Technology																				
Current situation on corn with resistant/short season/ scouting on cotton	12.7	6,929	1,169	52.6	274,918	2,800	43.0	75,647	1,343	71.9	130,145	1,601	21.2	72,689	678	38.1	66,721	622	239.6	8,212
Forced rotation and/or scouting on corn with resistant/short season/ scouting on cotton	12.8	6,929	1,171	52.5	272,836	2,875	57.2	75,921	1,364	72.1	129,050	1,610	23.0	77,322	706	36.4	65,051	602	254.4	8,328

1/ See text for description of strategies
2/ Millions of acres
3/ Millions of pounds
4/ Millions of dollars

Table XXVIII. Distribution of corn production in different consuming regions utilizing current and future alternative insect control strategies during the short run.

Consuming Region	Current Insect Control Strategy[1/]		Future Insect Control Strategy[1/]	
	Scouting on cotton and-		Resistant/Short Season/ Scouting on cotton and-	
	Current Situation on corn	Forced Rotation on corn	Current Situation on corn	Forced Rotation and/or Scouting on Corn
	Thousand Acres			
Illinois	7,728	8,236	7,764	8,678
Iowa/Missouri	6,857	7,497	6,874	6,707
Minn./Wisc.	4,423	3,525	4,423	4,291
Michigan	492	497	492	496
Ohio/Indiana	5,689	5,148	5,697	5,275
Mid-Atlantic	2,816	3,257	2,816	2,816
Va./W.Va./N.C.	2,331	2,306	2,589	3,636
Ky./Tenn.	2,323	1,382	2,323	1,376
Ala./Ga./S.C.	1,162	2,235	1,175	1,854
Florida	337	352	337	18
Ark./La./Miss.	2,212	2,355	2,149	2,270
Texas/Okla.	2,474	3,558	1,671	3,612
Kansas/Neb.	7,957	7,139	8,107	7,859
N.D./S.D.	4,345	6,374	4,339	1,515
Idaho/Mont.	39	39	39	39
Colo./Wy.	393	394	393	394
Ariz./N.M.	34	34	34	34
Wash./Ore.	62	62	62	62
Calif.	1,345	1,588	1,345	1,588
Total	53,033	55,992	52,644	52,535

1/ See text for description of strategies

In interpreting the increased production costs associated with the corn insect control strategies it should be pointed out that the 1.5% increase in costs will likely imply a reduction in the farmers' return from labor and management of 5% or more. Farm profit would be reduced by a significantly higher percentage.

DISCUSSION

The analysis of alternatives for reducing insecticides on cotton and corn documented that several insect control strategies could be employed to reduce insecticide use in both cotton and corn. For cotton insect control, scouting, diapause control, trap crops, and short season culture are technologies that are available today that could be employed to reduce insect control costs and reduce the amount of insecticide used.

In one analysis that employed the most economical insect control strategy for cotton in each region resulted in an estimated annual saving for the nation of 49.9 million in cotton insect control. This amounts to about a 27% reduction in cotton insect control costs while at the same time reducing the total amount of insecticide used by about 33%.

With 27% reduction control costs, the immediate question is why aren't cotton growers employing this current and applicable technology? The adoption of technology by cotton growers as with all groups is complex. Before commenting specifically on problems of adoption of specific insect control technologies, it should be emphasized that cotton growers have been adopting new insect control technologies.

As mentioned earlier, few growers are now applying insecticides on a strictly routine basis. Most check their cotton for the seriousness of insect pests before treating. Most are shredding cotton following harvest to reduce the number of overwintering boll weevils and cotton bollworms. Some apply insecticides for diapause control of boll weevils and employ trap crops.

To explain why the most economic cotton insect control technologies are not being employed extensively necessitates consideration of each control technology. "Scouting" itself is a complex technology that requires knowledgeable specialists to advise growers. Also the grower has to pay for this service. In addition, the use of insecticides provides the grower with a type of insurance for his crop. Investing in a specialist to advise him when "not to treat" appears sound but is viewed as somewhat of a "gamble."

We should also point out that the insecticide companies have their "free advisors" telling growers how and what to treat. The number of "free advisors" constitute a large "public relations force" encouraging the use of insecticides.

The use of low concentrations of insecticides for diapause control of the boll weevil is hindered in part because the control must be adopted on a region-wide basis. No one has assumed responsibility for assuring regional participation. Demand by growers is also relatively weak because it is a technique that is employed in the fall of one year for the control of weevils the following season. This indirect relationship makes it difficult for the grower to relate his efforts to the direct control of boll weevils.

The difficulty of growers adopting trap crops for insect control in cotton was discussed in detail in the RESULTS, hence, nothing more will be said here.

The use of short season cotton culture for irrigated cotton is hindered because growers often do not fully understand the physiology and growth characteristics of the cotton plant. Withdrawing water late in the season restricts further foliage growth and forces the cotton plant to mature and produce its normal crop early. This occurs without a reduction in cotton yield. Restricting water and further cotton foliage growth appears to farmers an undesirable effect based on his perspective of the cotton plant. In defense of the grower, we should point out that cotton plant physiology and insect control are only two factors of a highly complex set of factors related to the whole cotton production system. A need exists to inform the farmer how insect control and water use are part of the total cotton production system.

Some new technologies represent programs with higher yield variability and thus risk to the farmer than a regular spray schedule. When this increased risk is combined with the necessity of learning a new insect control strategy, resistance to change is expected. Part of this resistance stems from the experience that farmers have had with new technology. If the change is unsuccessful the first year (for the farmer or his neighbor) the farmer will tend to continue with current practices. Of course, any added increased yield variability increases the probability that an "experiment" will be unsuccessful.

The results obtained from the dynamic analysis should be compared to the static analysis. The most significant difference in insecticide use trends between the two analyses is between calculations using the current averages of insecticide use in each region. Based upon the information given by entomology experts (see Appendix), a total of 174 million pounds of insecticide were used on 13.1 million acres of cotton. However, the linear programming model calculated that to obtain the same level of cotton production, the total amount of insecticide used when employing current practices, would be only 123 million pounds of insecticides used on 12.7 million acres of cotton. Thus, the relocation of production to more efficient areas not only reduces the number of cotton acres by 3%, it also reduces the total amount of insecticide use by 29%.

Both the static and dynamic analyses were based upon the same data for the levels of insecticide use per acre. Thus, the reduction in insecticide use was caused by the fact that the regions into which cotton is being shifted require less insecticide than the regions from which cotton is removed.

In the static analysis the total amount of insecticide used was estimated to decrease by 41% when the "most economical (current)" insect control practices currently available were substituted for current practices in each region. An analogous comparison of the results of the dynamic analysis indicates that implementation of the "most economical (current)" insect control method in each region will result in a 53% reduction in insecticide use. The reason for this difference in the results is primarily that the initial shift of production in the base run reduced the amount of insecticide use so much that additional reductions due to the implementation of new technology are of less significance.

Assuming the most efficient allocation of cotton production and implementing the "most economical (future)" methods (includes resistant and short season varieties) available in the future and removing all restrictions on the location of cotton production results in a reduction of 78% of the 174 million pounds estimated to be used currently. However a substantial amount of research will be required before these varieties are commercially available. The data in Table XXIX show the annual research expenditure which could be justified by these savings under various assumptions about the length of time taken to develop these varieties and the length of time over which the savings could be achieved. These latter assumptions take into account the fact that pests will eventually adapt to the new varieties.

Table XXIX. Amount that could be spent on research for resistance and short season cotton varieties.

Years before Resistance Breakdown 2/	Years for Development 5	Years for Development 10
	million dollars per year 1/	
5	22	10
10	39	17
15	53	22

1/ Assuming 5% discount rate
2/ Average years over which full benefits received. Resistance is likely to break down gradually.

Compared with cotton, the number of insect control strategies in corn were limited to crop rotations for control of the rootworm complex, scouting, and resistant varieties. Because there are fewer serious pests on corn than on cotton, about one quarter as much insecticide is used on corn as on cotton. Also this smaller quantity of insecticide is distributed over 4 times as many acres. Hence, on a per acre basis 1/16th as much insecticide is used on corn as cotton. This fact limits the opportunities for the use of different insect control technologies in corn.

REFERENCES

Burwell, R.E., G.E. Schuman, R.F. Piest, R.G. Spomer and T.M. McCalla. 1974. Quality of water discharged from two agricultural watersheds in southwestern Iowa. Water Resources Res. 10:359-365.

Chiang, H.C., D. Rasmussen, and R. Gorder. 1971. Survival of corn rootworm larvae under minimum tillage conditions. J. Econ. Entomol. 64(6):1576-1577.

Cronin, L.E., J.E. Johnson, D. Pimentel, and W.M. Upholt. 1969. Effects of pesticides on non-target organisms other than man. pp. 177-288. In Report of the Secretary's Commission on Pesticides and Their Relationship to Environmental Health. U.S. Department of Health, Education, and Welfare. U.S. Government Printing Office. Washington D.C. 677 pp.

EPA. 1974. Strategy of the Environmental Protection Agency for Controlling the Adverse Effects of Pesticides. Environmental Protection Agency, Office of Pesticide Programs, Office of Water and Hazardous Materials. Washington, D.C. 36 pp.

Fowler, D.L. and J.N. Mahan. 1975. The pesticide review 1974. U.S. Dept. of Agriculture, Agricultural Stabilization and Conservation Service, Washington, D.C. 58 pp.

Hyslop, J.A. 1938. Losses occasioned by insects, mites, and ticks in the United States. E-444 USDA. 57 pp.

Marlatt, C.L. 1904. The annual loss occasioned by destructive insects in the United States. Yearbook of the Dept. of Agr. (U.S. Govt. Printing Office), pp. 461-474.

Miller, M.F. 1936. Cropping systems in relation to erosion control. Bull. Mo. Experiment Station #366.

Musick, G.J. and D.L. Collins. 1971. Northern corn rootworm affected by tillage. Ohio Report on Research and Development in Agriculture, Home Economics, and Natural Resources 56(4):88-91.

NAS. 1975. Pest control: an assessment of present alternate technologies. Contemporary pest control practices and prospects. Vol. I. 506 pp.

Oka, I.N. and D. Pimentel. 1976. Herbicide (2,4-D) increases insect and pathogen pests on corn. Science 193:239-240.

Pimentel, D. 1971. Ecological effects of pesticides on non-target species. U.S. Govt. Printing Office. 220 pp.

Pimentel, D. 1973. Extent of pesticide use, food supply, and pollution. J. N.Y. Entomol. Soc. 81:13-33.

Pimentel, D. 1975. Notes on pest control technologies used in cotton and corn based on discussion with specialists in various regions of the United States. In manuscript.

Pimentel, D. and C. Shoemaker. 1974. An economic and land use model for reducing insecticides on cotton and corn. Environ. Entomol. 3:10-20.

Pimentel, D., E.C. Terhune, R. Dyson-Hudson, S. Rochereau, R. Samis, E. Smith, D. Denman, D. Reifschneider and M. Shepard. 1976. Land degradation: effects on food and energy resources. Science 194:149-155.

Preuss, K.P., G.T. Weekman, and B.R. Somerhalder. 1968. Western corn rootworm egg distribution and adult emergence under two corn tillage systems. J. Econ. Entomol. 61(5):1424-1427.

Rovinsky, R.B., N.P. Russell, E.L. LaDue, C.A. Shoemaker and D. Pimentel. 1977. Procedures used in setting up the agricultural production model for the Cornell pest management study.

Taylor, C.R. and E.R. Swanson. 1975. The economic impact of selected nitrogen restrictions on agriculture in Illinois and 20 other regions of the United States. Department of Agricultural Economics. University of Illinois. AERR 133.

USDA. 1936. Agricultural Statistics 1936. United States Dept. of Agr., U.S. Govt. Printing Office. 421 pp.

USDA. 1954. Losses in agriculture. Agr. Res. Ser. 20-1. 190 pp.

USDA. 1961. Agricultural Statistics 1961. U.S. Govt. Printing Office. 624 pp.

USDA. 1965. Losses in agriculture. Agr. Handbook No. 291, Agr. Res. Serv. U.S. Govt. Printing Office. 120 pp.

USDA. 1968. Extent of farm pesticide use on crops in 1966. Agr. Econ. Rep. No. 147 Econ. Res. Ser. 23 pp.

USDA. 1970. Quantities of pesticides used by farmers in 1966. Agr. Econ. Rep. No. 179, Econ. Res. Ser. 61 pp.

USDA. 1971. The pesticide review 1970. Agr. Stab. and Cons. Ser. 46 pp.

USDA. 1974. Agricultural statistics 1974. U.S. Govt. Printing Office, Washington, D.C. 619 pp.

USDA. 1975a. Farmers' use of pesticides in 1971...extent of crop use. Econ. Res. Ser., Agric. Econ. Rep. No. 268. 25 pp.

USDA. 1975b. Minimum tillage: a preliminary technology assessment. Office of Planning and Evaluation. May. 34 pp.

Whitaker, F.D., H.G. Heinemann and W.H. Wischmeier. 1973. Chemical weed controls affect runoff, erosion and corn yields. J. Soil Water Conserv. 28:174-6.

APPENDIX. COTTON AND CORN INSECT CONTROL ALTERNATIVES

Data on cotton and corn insect control alternatives were obtained from the leading entomologist(s) with special knowledge for each crop in each of the major cotton and corn producing states in the United States. These entomologists provided data on current insect pest control practices and "best estimates" of what various alternative controls would mean in economic cost/benefits and pesticide use patterns.

The detailed data on insect control alternatives for each distinct region are presented for cotton in Tables 1 through 32 and corn from Tables 33 through 55.

Table 1. Cotton Pest Control in Alabama, Central Region.

Acreage grown 165,000 Source Dr. Floyd R. Gilliland and Dr. Roy Ledbetter

Average yield 500 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular,[1] Diapause	90	Boll weevil Bollworm Budworm Mites, etc.	100	100	13 (12-14)	2	1		39.00	13.00	52.00	500	175 (150-200)		18	1
2	Scouting,[1] Diapause	10	Boll weevil Bollworm Budworm Mites, etc.	100	100	8.5 (8-9)	2	1		25.50	8.50	34.00	500		1.25	18	1
3	Scouting,[1] Diapause		Boll weevil Bollworm Budworm Mites, etc.	100		5-6 (2-3)	2	1		7.50	2.50	10.00	500		1.25	100	2
4	Resistant, Regular		Boll weevil Bollworm Budworm Mites, etc.	100		6.5	2	1		19.50	6.50	26.00	500				3
5	Resistant, Scouting,[1] Diapause		Boll weevil Bollworm Budworm Mites, etc.	100		6	2	1		7.50	2.50	10.00	500.		1.25	100	3
6	Short season Regular		Boll weevil Bollworm Budworm Mites, etc.	100		6	2	1		19.50	6.50	26.00	500				3
7	Trap crop[2] Short season, Regular		Boll weevil Bollworm Budworm Mites, etc.	100		4	2	1		12.00	4.00	16.00	500				3
	Diapause		Boll weevil			2		1/4		3.00	2.00	5.00					-
	Trap crop[3]		Boll weevil			3			3		-	1.05					-

Table 1. Continued.

Acreage grown ______________ Source ______________________

Average yield ______________ Period ______________________

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code*
8	Trap Crop Scouting			100		4-5	2	1		13.50	4.50	18.00	500		1.25		2
9	Short Season Variety Scouting			100		3	2	1		9.00	3.00	12.00	500		1.25		3
10	Resistant Scouting			100		6	2	1		18.00	6.00	24.00	500		1.25		3
11	Short Season Resistant Variety Scouting			100		2	2	1		6.00	2.00	8.00	500		1.25		3

Table 2. Cotton Pest Control in Alabama, Northern Region.

Acreage grown 385,000 Source Dr. Floyd R. Gilliland and Dr. Roy Ledbetter

Average yield 500 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Common Code[4]
1	Regular, Diapause[1]	75	Boll Weevil Bollworm Budworm Mites, etc.	100	96	8	2	1		24.00	8.00	32.00	500	250		18	1
2	Scouting, Diapause[1]	25	Boll weevil Bollworm Budworm Mites, etc.	100	100	7	2	1		6.00	2.00	8.00	500		1.25	18	1
3	Resistant, Regular		Boll weevil Bollworm Budworm Mites, etc.	100		4	2	1		12.00	4.00	16.00	500				3
4	Resistant, Scouting, Diapause[1]		Boll weevil Bollworm Budworm Mites, etc.	100		4	2	1		6.00	2.00	8.00	500		1.25	100	3
5	Trap crop[2] Regular		Boll weevil Bollworm Budworm Mites, etc.	100		5	2	1		15.00	5.00	20.00	500				
6	Short season Regular		Bollworm Boll weevil Budworm Mites, etc.	100		4	2	1		12.00	4.00	16.00	500				3
7	Trap crop,[2] Short season, Regular		Boll weevil Budworm Bollworm Mites, etc.	100		3	2	1		6.00	2.00	8.00	500				3
	Diapause		Boll weevil			2		1/4		3.00	2.00	5.00	-				-
	Trap crop[3]		Boll weevil			3			3	-	-	1.05	-				-

Table 2. Continued.

Acreage grown ______________ Source ______________

Average yield ______________ Period ______________

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code*
8	Diapause Scouting			100		1	2	1		3.00	1.00	4.00	500		1.25	100	2
9	Trap Crop Scouting			100		4	2	1		12.00	4.00	16.00	500		1.25		2
10	Short Season Variety Scouting			100		3	2	1		9.00	3.00	12.00	500		1.25		3
11	Resistant Scouting			100		5	2	1		15.00	5.00	20.00	500		1.25		3
12	Short Season Resistant Variety Scouting			100		2	2	1		6.00	2.00	8.00	500		1.25		3

Table 3. Cotton Pest Control in Arizona, Eastern Region.

Acreage grown 30,000 Source Dr. Theo Watson and Dr. ~~Leon Moore~~

Average yield 610 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	Pesticides Used: lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	40-50	Pink Bollworm Plant Bugs Bollworm complex Leaf Perforator	100	100	2	4	1				10.00	610	564			1
2	Scouting	50-60	Same	75	75	<1	2	1				5.00	610		1.65		1

Table 4. Cotton Pest Control in Arizona, Western and Central Region.

Acreage grown 320,000 Source Dr. Theo Watson and Dr. Leon Moore

Average yield 1,100 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost /A ($)	Application Cost /A ($)	Total Cost /A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	93-97	Pink Bollworm Plant Bugs Bollworm complex Leaf Perforator	100	100	9	2	1				45.00	1,100	715			1
2	Scouting	3-7	All	100	100	6	2	1				30.00	1,100		2.50		1
3	Trap crop[5] Regular		All	100		7.5	2	1				37.50	1,100				2
4	Trap crop[5] Scouting		All	100		4	2	1				20.00	1,100		2.50		2
5	Short season[6] Regular		All	100		6	2	1				30.00	1,100				2
6	Short season[6] Scouting Trap crop[5]		All	100		2.5 (2-3)	2	1				12.50	1,100		2.50		2

Table 4. Continued.

Acreage grown ______________ Source ______________________

Average yield ______________ Period ______________________

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment	Extent of Problem (%): Acreage Currently Being Treated	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code*
7	Short Season Variety Scouting			100		3	2	1				15.00	1,100		2.50		3

Table 5. Cotton Pest Control in Arkansas, Central, East Central, Southwest Region.

Acreage grown 675,800 Source Dr. Charles Lincoln

Average yield 513 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code
1	Regular [1] Diapause (1)	70	Boll weevil, Bollworm complex, Plant Bugs, Mites, Thrips	100	100	7 (5-8)	1.7	1	.7			15.00	513	375		15	1
2	Scouting, Diapause (1)	30	All	100	100	6	1.7	1.2	1/3			15.00	600		1.50	15	1
3	Resistant		Boll weevil	100		0						0	500				3
4	Short Season			100		0						0	400				3
5	Scouting Diapause (1)			100		5	1.6	1.4	.5			13.00	600		1.50	100	2
	Diapause					2	1/2	1/2				5.00	400				-

Table 5. Continued

Acreage grown ____________ Source ____________

Average yield ____________ Period ____________

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	Pesticides Used: lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
6	Short Season Variety Scouting			100		0									1.50		3
7	Resistant Scouting			100		0									1.50		3
8	Short Season Resistant Variety			100		0											3

Table 6. Cotton Pest Control in Arkansas, Northeast Region.

Acreage grown 654,800 Source Dr. Charles Lincoln

Average yield 493 lbs/A Period 1972

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	Treatments: Pesticides Used: lbs/A/Treatment CH	OP	C	Treatments: Materials Cost/A ($)	Treatments: Application Cost /A ($)	Treatments: Total Cost/A ($)	Treatments: Yield/A With Treatment	Treatments: Yield/A Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Common Code[4]
1	Regular[7]	50	Plant Bugs Thrips Mites	100	100	0-1	1/2	1/4	T			3.00	493	473			1
2	Scouting	50		100	66	0-1	1/2	1/4	T			$3.00			1.50		1

Table 7. Cotton Pest Control in California
San Joaquin Valley Region

Acreage grown 850,000 Source Dr. Louis Falcon
Average yield 900 (350-2000) lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular,[8] Trap Crop	78	Plant Bugs, Mites, Boll-worm Complex, Pink Bollworm	20	80	2.5 (2-3)	1	2	3/4	4.00-10.00	1.00-2.00	20.00	850	900			1
2	Scouting[9]	22	All	20	20-30	1.5 (0-3)	1	2	1			10.00	900	900	5.00 (2.50-10.00)		1
3	Trap Crop[10] Regular[8]		All	20		1.5 (0-1)	1.5	0	0			2.00	900	900			2
4	Trap Crop[10] Scouting[9]		All	20		0.5 (0-1)	1.5	0	0			2.00	900		5.00 (2.50-10.00)		2
	Trap Crop[3]											2.00					

Table 8. Cotton Pest Control in California, Southern Region (Imperial, San Bernardino, and Riverside Co.).

Acreage grown 50,000 Source Dr. Nick Toscano

Average yield 1,300 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost /A ($)	Application Cost /A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	40	Pink Bollworm Leaf Perforator Bollworm complex Plant bugs	100	100	10 2	0 0	1 0	0 1			72.00	1,300	650			1
2	Scouting	60	All	100	100	7 1	0 0	1 0	0 1			48.00	1,300		7.75		1
3	Scouting		All	100		5 1	0 0	1 0	0 1			33.00	1,300		7.75		2
4	Crop Mgt.[11] Scouting		All	100		4	0	1	0			24.00	1,300		7.75		2
5	Short season[6]		Pink Bollworm Leaf Perforator Bollworm complex	100		4.5		1				27.00	1,300				2
6	Crop Mgt.[11] Scouting Short season[6]		All	100		3.5		1				21.00	1,300		7.75		2

Table 8. Continued.

Acreage grown ______________ Source ______________________________

Average yield ______________ Period ______________________________

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code*
7	Short Season Variety Scouting			100		4.5	0	1	0			27.00	1,300		7.75		3
8	Short Season Resistant Variety Scouting			100		4.5	0	1	0			27.00	1,300		7.75		3

Table 9. Cotton Pest Control in Georgia, Above the Fall Line Region.

Acreage grown 75,000 Source Dr. Donald Canerday and Dr. Herbert Womack

Average yield 450 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	Pesticides Used: lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield /A: With Treatment	Yield /A: Without Treatment	Scouting Cost /A ($)	% Acres in Diapause control	Comment Code[4]
1	Regular Diapause (1)	75	Boll weevil Bollworm complex	100	95	12	2	1				60.00	450	200		20	1
2	Scouting Diapause (1)	25	All	100	95	10	2	1				50.00	450		1.59	20	1
3	Short Season Regular		All	100		8	2	1				40.00	450				3
4	Scouting Diapause (1)		All	100		9	2	1				45.00	450		1.59	100	2
5	Resistant Regular		All	100		7	2	1				35.00	450				3
6	Scouting Resistant Diapause (1)		All	100		6	2	1				30.00	450		1.59	100	3
	Diapause					1		1/4				4.00	450				-

Table 9. Cotton Pest Control in Georgia, Above the Fall Line Region. (Continued)

Acreage grown ____________ Source ____________

Average yield ____________ Period ____________

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	Treatments: Pesticides Used: lbs/A/Treatment: CH	Treatments: Pesticides Used: lbs/A/Treatment: OP	Treatments: Pesticides Used: lbs/A/Treatment: C	Treatments: Materials Cost/A ($)	Treatments: Application Cost/A ($)	Treatments: Total Cost ($)	Treatments: Yield/A: With Treatment	Treatments: Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code*
7	Short Season Variety Scouting			100		7	2	1				35.00	450		1.59		3
8	Resistant Scouting			100		6	2	1				30.00	450		1.59		3
9	Short Season Resistant Variety Scouting			100		6	2	1				30.00	450		1.59		3

Table 10. Cotton Pest Control in Georgia, Below the Fall Line Region.

Acreage grown 345,000 Source Dr. Donald Canerday and Dr. Herbert Womack

Average yield 450 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Common Code[4]
1	Regular Diapause (1)	75	Boll weevil Bollworm complex	100	95	16	2	1				80.00	450	200		20	1
2	Scouting Diapause (1)	25	All	100	95	14	2	1				70.00	450		1.59	20	1
4	Short season Regular		All	100		12	2	1				60.00	450				3
5	Scouting Diapause (1)		All	100		13	2	1				65.00	450		1.59	100	2
6	~~Resistant~~ ~~Regular~~		All	100		10	2	1				50.00	450				3
7	Scouting Resistant Diapause (1)		All	100		6	2	1				30.00	450		1.59	100	3
3	Regular Diapause			100		15	2	1				75.00	450			100	2
	Diapause					1		1/4				4.00					

Table 10. Cotton Pest Control in Georgia, Below the Fall Line Region. (Continued)

Acreage grown ________ Source ________

Average yield ________ Period ________

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	Pesticides Used: lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[a]
8	Short Season Variety Scouting			100		11	2	1				55.00	450		1.59		3
9	Resistant Scouting			100		9	2	1				45.00	450		1.59		3
10	Short Season Resistant Variety Scouting			100		6	2	1				30.00	450		1.59		3

Table 11. Cotton Pest Control in Louisiana. Acreage grown 550,000 Source Dr. L. D. Newsom and Dr. Dan Clower

Average yield 550 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost /A ($)	Application Cost /A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost /A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular Diapause (1)	25	Budworm Boll weevil Bollworm Plant bugs, etc.	100	100	10.5 (9-12)	2	1		31.50	10.50	52.00	550	320 (275-363)		66	1
2	Scouting Diapause (1)	75	All	100	100	8 (7-9)	2	1		24.00	8.00	32.00	550		2.00	66	1
3	Resistant Diapause (1) Regular		All	100		0						0	550			100	3
4	Resistant Scouting Diapause (1)		All	100		0						0	550		2.00	100	3
5	Trap crop (2) Scouting Diapause (1)		All	100		0						0	550		2.00	100	3
6	Trap crop (2) Scouting Resistant Diapause (1)		All	100		0						0	550		2.00	100	3
7	Short season Resistant Scouting		All	100		2	2	1		6.00	2.00	8.00	550		2.00		3
	Diapause					3		1/4				8.40	-				-
	Trap crop (3)					1	1	.5				.40					-

Table 11. Continued.

Acreage grown ______________ Source ______________

Average yield ______________ Period ______________

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code*
8	Diapause Scouting			100		2-4	2	1		9.00	3.00	12.00	550		2.00	100	2
9	Trap Crop Scouting			100		4	2	1		12.00	4.00	16.00	550		2.00		2
10	Short Season Variety Scouting			100		2	2	1		6.00	2.00	8.00	550		2.00		3
11	Resistant Scouting			100		2	2	1		6.00	2.00	8.00	550		2.00		3

Table 12. Cotton Pest Control in Mississippi, Delta Region.

Acreage grown 1,500,000. Source Dr. Fowden Maxwell and Dr. Aubrey Harris

Average yield 650 lbs/A Period 1972-74.

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments - Fixed Spray Schedule: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost /A ($)	Application Cost /A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	33	Boll weevil Bollworm Budworm Plant bugs	100	100	10	2	1				45.00	650	400			1
2	Scouted	67	All	100	100	6	2	1				27.00	650		1.75		1
3	Resistant (Frego)		Boll weevil			0						0	500				2
4	Resistant (Nectarless)		Boll weevil			0						0	550				2
5	Scouted Short season		All	100		4	2	1				18.00	575		1.75		3
6	Scouted Diapause (1)		All	100		4	2	1				18.50	650		1.75	100	2
7	Scouted Resistant (Frego)		All	100		3	2	1				13.50	650		1.75		2
8	Scouted Resistant (Nectarless)		All	100		4	2	1				18.00	650		1.75		2
9	Scouted Pheromone Traps		All	100		4	2	1				18.00	650		1.75		2

Table 12 continued,

Acreage grown ______ Source ______

Average yield ______ Period ______

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: # of Treatments	Pesticides Used lbs/A/Treatment: CH	OP	C	Materials Cost /A ($)	Application Cost /A ($)	Total Cost/A ($)	Yield/A: With Treatment	Without Treatment	Scouting Cost ($)	% Acres in Diapause Control	Common Code[4]
10	Short season Resistant (Frego)		Bollworm Budworm Boll weevil			0						0	450				3
11	Short season Resistant (Nectarless)		Bollworm Budworm Boll weevil			0						0	550				3
12	Short season Regular		All	100		5	2	1				21.90	575				3
13	Short season Pheromone Traps 29/		Bollworm Budworm Boll weevil	100		1		.1				.0.60	550				3
14	Scouted Short season Resistant (Frego)		All	100		3	1.3	1				12.40	575		1.75		3
15	Scouted Short Season Resistant (Nectarless)		All	100		2	2	1.25				10.65	575		1.75		3
16	Scouted Short season Pheromone Traps 29/		All	100		3	2	1				14.40	575		1.75		3
17	Regular Diapause (1) Resistant (Frego)		All	100		5	2	1.5				29.40	650			100	2
18	Regular Diapause (1) Resistant (Nectarless)		All	100		5	2	1.5				27.55	650			100	2

Table 12 Continued.

Acreage grown ______ Source ______

Average yield ______ Period ______

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: # of Treatments	Pesticides Used lbs/A/Treatment: CH	OP	C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code4
19	Pheromones Diapause (1) Resistant (Frego)		All	100		2		1				7.50	550			100	2
20	Pheromones Diapause (1) Resistant (Nectarless)		All	100		3		1				10.50	600			100	2
21	Scouted Pheromores Diapause (1) Resistant (Frego		All	100		4	1.5	1.25				15.20	650		1.75	100	2
22	Scouted Pheromones Diapause (1) Resistant (Nectarless)		All	100		4	1.5	1.25				13.45	650		1.75	100	2
23	Regular Diapause (1) Pheromones Resistant (Frego)		All	100		6	1.3	1				25.65	650			100	2
24	Regular Diapause (1) Pheromones Resistant (Nectarless)			100		6	1.3	1				25.65	650			100	2
25	Regular Diapause (1)			100		10	2	1				38.30	650			100	2
	Diapause					2		1				6.60	500				–
	Pheromone					1						5.00					–

Table 13. Cotton Pest Control in Mississippi, Hill Region.

Acreage grown 300,000 Source Dr. Fowden Maxwell and Dr. Aubrey Harris

Average yield 475 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	OP	C	Materials Cost/A ($)	Application Cost /A ($)	Total Cost/A ($)	Yield/A: With Treatment	Without Treatment	Scouting Cost /A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	80	Boll weevil Bollworm Budworm Plant bugs	100	100	10	2	1				33.75	475 (450-500)	200			1
2	Scouted	20	All	100	100	7	2	1				26.25	475 (450-500)		1.75		1
3	Short Season		Bollworm Budworm			0						0	363 (350-375)				3
4	Resistant		Boll weevil			0						0	363 (350-375)				3
5	Scouting Short season		All	100		3.5	2	1				13.50	450		1.75		3
6	Scouting Resistant		All	100		3.5	2	1				13.50	450		1.75		3
7	Scouting Diapause (1)		All	100		7	2	1.3				32.85	475 (450-500)		1.75	100	2
8	Scouting Trap Crop (2)		All	100		7	2	1				30.00	475 (450-500)		1.75		2
9	Short Season Resistant		Bollworm Budworm Boll weevil			0						0	385				3

Table 13 Continued

Acreage grown ______ Source ______

Average yield ______ Period ______

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code
10	Short season Regular		All	100		5	2	1.3				18.75	425				3
11	Scouting Short season REsistant		All	100		2	2	1.3				7.50	425		1.75		3
12	Scouting Short Season Trap Crop (2)		All	100		4	2	1				16.00	425		1.75		3
13	Resistant Diapause (1) Regular		All	100		7	1.5	1				25.35	475			100	3
14	Resistant Diapause (1) Regular Trap crop (2)		All	100		11	2	1				22.05	475			100	3
15	Scouting Resistant Diapause (1) Trap crop (2)		All	100		4	2	1.5				15.00	475		1.75	100	3
	Diapause					3		1/4				9.90	275				
	Trap crop (2)					2		1				3.15					

Table 14. Cotton Pest Control in Missouri.

Acreage grown 250,000 Source Dr. Flernoy Jones

Average yield 500 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: # of Treatments	Pesticides Used lbs/A/Treatment: CH	Pesticides Used lbs/A/Treatment: OP	Pesticides Used lbs/A/Treatment: C	Materials Cost /A ($)	Application Cost /A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Common Code[4]
1	Regular	95	Bollworm Thrips Mites Boll weevil	50	50	0.61		.6		0.90	1.50	2.40	500	487			1
2	Scouting	5		50	50	0.61		.6		0.90	1.50	2.40	500		1.75		1
3	Short season			50		0.61		.6		0.90	1.50	2.40	500				3
4	Diapause Scouting			50		0.61		.6		0.90	1.50	2.40	500		1.75		2
5	Trap Crop Scouting			50		0.61		.6		0.90	1.50	2.40	500		1.75		2
6	Short Season Variety Scouting			50		0.61		.6		0.90	1.50	2.40	500		1.75		3
7	Resistant Scouting			50		0.61		.6		0.90	1.50	2.40	500		1.75		3
8	Short Season Resistant Variety Scouting			50		0.61		.6		0.90	1.50	2.40	500		1.75		3

Table 15, Cotton Pest Control in New Mexico, Acreage grown 98,000 Source Dr. J. Ellington

Average yield 750 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%) Acreage Needing Chemical Treatment (%)	Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment CH	OP	C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield /A With Treatment	Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Common Code[4]
1	Regular	80	Pink Bollworm Bollworm complex Plant Bugs	2	2	2	0	1	0			8.00	750	750		0	1
2	Scouting	20	All	0	0	0[12]	0	0	0			0	750		1.75		1
3	Short season Scouting		All	0	0	0[12]	0	0	0			0	750		1.75		3

Table 16. Cotton Pest Control in North Carolina, Eastern Region.

Acreage grown 165,000 Source Dr. Robert Robertson

Average yield 400 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost /A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular Diapause (1)	50	Boll weevil Bollworm complex Two Spotted- Aphids, etc.	100	96	13.5 (13-14)	2	1		43.88	16.88	60.76	400	100		5	1
2	Scouting Diapause (1)	50	All	100	96	10	2	1		32.50	12.50	45.00	400		2.00	5	1
3	Scouting Diapause (1)		All	100		4.5	2	1		14.63	5.63	20.26	400		2.00	100	2
4	Resistant Scouting		All	100		4.5	2	1		14.63	5.63	20.26	400		2.00		3
5	Short season Scouting Diapause (1)		All	100		4	2	1		13.00	5.00	18.00	400		2.00	100	3
6	Short Season Resistant Scouting Diapause (1)		All	100		2 (0-4)	2	1		6.50	2.50	9.00	400		2.00	100	3
	Diapause					1		1/4		1.40	0	1.40	-				-

Table 16. Continued.

Acreage grown ______________ Source ______________

Average yield ______________ Period ______________

Line No.	Cultural Practice	%	Pests	Extent of Problem(%): Acreage Needing Chemical Treatment (%)	Extent of Problem(%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	Pesticides Used: lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
7	Short Season Variety Scouting			100		4-6	2	1		16.25	6.25	22.50	.400		2.00		3
8	Short Season Resistant Variety Scouting			100		2-4	2	1		9.75	3.75	13.50	400		2.00		3

Table 17. Cotton Pest Control in North Carolina, Western Region.

Acreage grown 11,000 Source Dr. Robert Robertson

Average yield 400 lbs/A Period 1972-74.

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	50	Boll weevil Bollworm complex Two spotted Aphids, etc.	100	96	9	2	1	0	28.25	11.25	39.50	400	100		0	1
2	Scouting	50	All	100	96	7	2	1	0	22.75	8.75	31.50	400		2.00	0	1
3	Resistant Regular		All	100		4.5 (4-5)	2	1	0	14.63	5.63	20.26	400				3
4	Short Season Scouting		All	100		4	2	1	0	13.00	5.00	18.00	400		2.00		3
5	Short season Resistant Scouting		All	100		2 (0-4)	2	1	0	6.50	2.50	9.00	400		2.00		3
6	Resistant Scouting			100		4-5	2	1	0	14.63	5.63	20.26	400		2.00		3

Table 18. Cotton Pest Control in Oklahoma, Dryland-Southwest Region.

Acreage grown 361,000 Source ~~Dr. Don C. Peters, Dr. Jerry Young,~~ Dr. Ken Pinkston, Dr. Chin-Choy and Dr. Vernon Eidman.

Average yield 240 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	Pesticides Used: lbs/A/Treatment CH	Pesticides Used: lbs/A/Treatment OP	Pesticides Used: lbs/A/Treatment C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A With Treatment	Yield/A Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	94	Heliothis complex Boll weevil Flea Hopper Thrips Mites Plant bugs	<50	<50	<1	1.5	1.5				3.15	240	210			1
2	Scouting[13]	6	As above	<50	<50	1/2	1.5	1.5				1.60	240		1.00		1

Table 19. Cotton Pest Control in Oklahoma, Irrigated Southwest Region,

Acreage grown 64,000 Source Dr. Don C. Peters, Dr. Jerry Young, Dr. Ken Pinkston, Dr. Chin-Choy and Dr. Vernon Eidman

Average yield 500 lbs/A Period 1972-74.

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	OP	C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	94	Heliothis complex, Boll weevil, Flea hopper, Thrips, Mites, Plant bugs	100	100	7	1.5	1.5				22.09	500	375			1
2	Scouting	6	As above	100	100	6	1.5	1.5				18.90	500		2.00		1
3	Trap crop[14] Scouting		As above			0[15]						0[15]	500		2.00		2
	Trap crop											3.00					=

Table 20. Cotton Pest Control in Oklahoma, Southeast Region.

Acreage grown 75,000 Source Dr. Don Peters, Dr. Jerry Young, Dr. Ken Pinkston, Dr. Chin-Choy and Dr. Vernon Eidman

Average yield 300 lbs/A Period 1972-74.

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Common Code[4]
1	Regular	94	Heliothis complex Boll weevil Flea hopper Thrips Mites Plant bugs		80	6	1.5	1.5				18.90	300	225			1
2	Scouting	6	As above		80	5	1.5	1.5				16.75	300		2.00		1

Table 21. Cotton Pest Control in South Carolina, Coastal Plains Region.

Acreage grown 305,000 Source Mr. L. M. Sparks

Average yield 470 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost /A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield /A: With Treatment	Yield /A: Without Treatment	Scouting Cost /A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	34	Bollworm Complex Boll weevil Mites Beet Armyworm	100	100	17	2	1		42.50	21.25	63.75	470	50			1
2	Scouted	66	All	100	100	14	2	1		35.00	17.50	52.50	470		1.50		1
3	Scouted Diapause (1)		All	100		12	2	1		30.00	19.00	49.00	470		1.50	100	2
4	Short season Scouted		All	100		9	2	1		22.50	12.50	35.00	470		1.50		3
5	Trap crop (2) Scouted		All	100		12	2	1		30.00	19.00	49.00	470		1.50		2
6	Trap crop (2) Scouted Short season Diapause (1)		All	100		9	2	1		22.50	12.50	35.00	470		1.50	100	3
7	Resistant Scouted		All	100		12	2	1		30.00	19.00	49.00	470		1.50		3
	Diapause					2		.5		3.00	2.50	5.50					-
	Trap crop (3)					2		.10				1.25					-

Table 21. Continued.

Acreage grown ________________ Source ________________

Average yield ________________ Period ________________

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
8	Short Season Resistant Variety Scouting			100		9	2	1		22.50	12.50	35.00	470		1.50		3

Table 22. Cotton Pest Control in South Carolina, Piedmont Region.

Acreage grown 15,000 Source Mr. L. M. Sparks

Average yield 470 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	Treatments: Pesticides Used: lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Treatments: Materials Cost /A ($)	Treatments: Application Cost /A ($)	Treatments: Total Cost/A ($)	Treatments: Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	75	Bollworm complex Boll weevil Mites Beet Armyworm	100	100	15	2	1		37.50	18.75	56.25	470	75			1
2	Scouted	25	All	100	100	13	2	1		32.50	16.25	48.75	470		1.50		1
3	Scouted Diapause (1)		All	100		11	2	1		27.50	13.50	41.00	470		1.50	100	2
4	Short season Scouted		All	100		8	2	1		20.00	12.00	32.00	470		1.50		3
5	Trap crop Scouted		All	100		11	2	1		27.50	13.50	41.00	470		1.50		2
6	Trap crop Scouted Short Season Diapause (1)		All	100		8	2	1		20.00	12.00	32.00	470		1.50	100	3
7	Resistant Scouted		All	100		11	2	1		27.50	13.50	41.00	470		1.50		3
	Diapause					2		.5		3.00	2.50	5.50					-
	Trap crop (3)					2		1				1.25					-

Table 22. Continued.

Acreage grown ______________ Source ______________________________

Average yield ______________ Period ______________________________

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code*
8	Short Season Resistant Variety Scouting			100		8	2	1		20.00	12.00	32.00	470		1.50		3

Table 23. Cotton Pest Control in Tennessee. Northern Region.

Acreage grown 250,000 Source Dr. Allen Chambers

Average yield 600 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield /A: With Treatment	Yield /A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	98	Boll weevil, Boll worm complex, Plant bugs, Thrips	25	25	3	2	1		9.00	3.00	12.00	600	500			1
2	Scouted	2	All		>0	>0						0	600				1
3	Resistant Regular		All			>0						0	600				3
4	Resistant Scouted		All			>0						0	600		1.50		3
5	Short Season Regular		All			>0						0	600				3
6	Pheromone Traps Scouting		All			>0						0	600		1.50		3
7	Short Season Variety Scouting		All			>0						0	600		1.50		3
8	Short Season Resistant Variety Scouting		All			0						0	600		1.50		3

Table 24. Cotton Pest Control in Tennessee, Southern Region.

Acreage grown 275,000 Source Dr. Allen Chambers

Average yield 600 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Common Code [4]
1	Regular	92	Boll weevil Bollworm complex Plant bugs Thrips	100	100	12.5	2	1		37.50	12.50	50.00	600	175			1
2	Scouted	8	All	100	100	10	2	1		30.00	10.00	40.00	600		1.50		1
3	Resistant Regular			100		4	2	1		12.00	4.00	16.00	600				3
4	Resistant Scouting			100		1	2	1		3.00	1.00	4.00	600		1.50		3
5	Short season Scouting			100		2.5	2	1		7.50	2.50	10.00	600		1.50		3
6	Pheromone Traps Scouting			100		4.5	2	1		13.50	4.50	18.00	600		1.50		3
7	Diapause (I) Scouting			100		8	2	1		24.00	8.00	32.00	600		1.50	100	2
	Diapause					2		1/4		3.00	2.00	5.00					-

Table 24. Continued.

Acreage grown ________ Source ________

Average yield ________ Period ________

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	Treatments: Pesticides Used: lbs/A/Treatment: CH	Treatments: Pesticides Used: lbs/A/Treatment: OP	Treatments: Pesticides Used: lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code*
8	Short Season Resistant Variety Scouting			100		1	2	1		3.00	1.00	4.00	600		1.50		3

Table 25. Cotton Pest Control in Texas, Black Lands Region.

Acreage grown 800,000 Source Dr. Ray Frisbie

Average yield 150 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	OP	C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Common Code[4]
1	Regular	96	Boll weevil Cotton Flea Hopper Thrips	100	100	4		1/3	1/10			8.00	150	0-60			1
2	Scouting	4	Boll weevil Cotton Flea Hopper	100	100	2 1/2 -3		1/3	1/10			5.50	150	0-60	1.50		1
3	Resistant (Boll weevil) Fleahoppers Short season Scouting		Boll weevil Cotton Flea Hopper Thrips	100 for Thrips		<1		1/3	1/10			2.00	150	140	1.50		3
4	Sanitation[16] Scouting		Boll weevil Cotton Flea Hopper Thrips	100		1 1/2 - 2		1/3	1/10			3.50	150	75	1.50		2
5	Short Season Variety Scouting			100		2		1/3	1/10			4.00	150		1.50		3
6	Resistant Scouting			100		<1		1/3	1/10			2.00	150		1.50		3

Table 26. Cotton Pest Control in Texas, Central Texas River Bottoms Region.

Acreage grown 68,000 Source Dr. Ray Frisbie

Average yield 500 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost /A ($)	% Acres in Diapause Control	Common Code[4]
1	Regular	71	Boll weevil Bollworm Budworm	100	100	3-7	1	1				18.75	500	< 200			1
~~2~~	Scouting	29	Boll weevil Bollworm Budworm	20	20	2	1	1				7.50	500	< 200	1.50		1
3	Resistant (Boll weevil) Scouting		Boll weevil Bollworm Budworm	100		1	1	1				3.75	500	250	1.50		3
4	Short season Regular		Boll weevil Bollworm	50-100		2-3	1	1				9.38	500	400			3
5	Short season Scouting		Boll weevil Bollworm Budworm	50-100		1	1	1				3.75	500	400	1.50		3
6	Crop Culture Scouting	17	Boll weevil Bollworm Budworm	100		1-2	1	1				13.13	500	350	1.50		2
7	Short Season Resistant Variety Scouting			100		< 2	1	1				7.00	500		1.50		3

Table 27. Cotton Pest Control in Texas, High Plains Region.

Acreage grown 2,476,000 Source Dr. Ray Frisbie

Average yield 270 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Common Code[4]
1	Regular	100	Thrips Cotton Flea-hoppers Boll weevil[18] Cotton Boll-worm[18]	6	6	1-2		1/10-1/4				1.50 - 2.00	270	230-260			1

Table 28. Cotton Pest Control in Texas, Lower Gulf Coast Region,

Acreage grown 121,000 Source Dr. Ray Frisbie

Average yield 400 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem(%): Acreage Needing Chemical Treatment (%)	Extent of Problem(%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Common Code[4]
1	Regular	92	Boll weevil Cotton Flea Hopper	100	100	4		1/3	1/10			8.00	400	200			1
2	Scouting	8	Boll weevil Cotton Flea Hopper	100	100	2		1/3	1/10			4.00	400	200	1.50		1
3	Resistant (boll weevil & flea hopper Short Season Scouting		Boll weevil Cotton Flea Hopper	<10		<1		1/3	1/10			2.00	400	375	1.50		3
4	Sanitation[16] Scouting			100		1 1/2 -2		1/3	1/10			3.50	400	300	1.50		2
5	Short Season Variety Scouting			100		1		1/3	1/10			2.00	400		1.50		3
6	Resistant Scouting			100		1		1/3	1/10			2.00	400		1.50		3

Table 29. Cotton Pest Control in Texas, Lower Rio Grande Valley Region.

Acreage grown 275,000 Source Dr. Ray Frisbie

Average yield 425 lbs/A Period 1972-74.

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	Treatments: Pesticides Used: lbs/A/Treatment: CH	Treatments: Pesticides Used: lbs/A/Treatment: OP	Treatments: Pesticides Used: lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield /A: With Treatment	Yield /A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular Sanitation[19]	75	Cotton Flea Hopper Boll weevil Bollworm Budworm	100	100	12	1	1				45.00	425	<100		70	1
2	Scouting Sanitation[19]	25	As above	100	100	9	1	1				33.75	425	<100	2.50	70	1
3	Scouting Sanitation[19]		As above	100		6	1	1				22.50	425	200	2.50	100	2
4	Resistant (Boll weevil & Cotton flea hopper)		As above	100		5	1	1				18.75	425	300			3
5	Short season Scouting		As above	100		4-5	1	1				16.87	425	200	2.50		3
6	Short season Scouting Sanitation[19]		As above	100		4	1	1				15.00	425	200	2.50	100	3
7	Resistant Scouting		As above	100		4-5	1	1				16.87	425		2.50		3
8	Short Season Resistant Variety Scouting		As above	100		4	1	1				15.00	425		2.50		3

Table 30. Cotton Pest Control in Texas, Rolling Plains Region.

Acreage grown 1,276,000 Source Dr. Ray Frisbie

Average yield 196 lbs/A Period 1972-74.

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost /A ($)	Application Cost /A ($)	Total Cost /A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause	Common Code[4]
1	Regular Diapause (1)	38	Boll weevil Low incidence of other pests	100	100	1-2		1/4-1/2				3.38	216	180		25	1
2	Scouting Diapause (1)	2	Boll weevil Low incidence of other pests	100	100	3-4		1/4-1/2				7.88	234	180	1.25 = Dryland 4.00 = Irrigated	25	1
3	No treatment Diapause (1)	60		30	0	0						0	180	180		25	1
4	Resistant Short season Diapause		Boll weevil Bollworm	25		>0						0	196	180		100	3
	Diapause			30		3		1/4-1/2				1.50 - 2.00					-

Table 30. Continued.

Acreage grown ______ Source ______

Average yield ______ Period ______

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	Pesticides Used: lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
5	Diapause Scouting					2		1/4- 1/2				4.50	200	180	1.25/Dry Land 4.00/ Irrigated		2
6	Short Season Variety Scouting					2		1/4- 1/2				4.50	200	180	1.25/Dry Land 4.00/ Irrigated		3
7	Resistant Scouting					1		1/4- 1/2				4.50	200	180	1.25/Dry Land 4.00/ Irrigated		3
8	Short Season Resistant Variety Scouting					1		1/4- 1/2				2.00	200	180	1.25/Dry Land 4.00/ Irrigated		3

Table 31. Cotton Pest Control in Texas, Trans-Pecos Region.

Acreage grown 200,000 Source Dr. Ray Frisbie

Average yield 550 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost /A ($)	Application Cost /A ($)	Total Cost /A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Common Code 4
1	Regular	92.5	Bollworm Budworm	100	100	10-12	1	1				41.25	550	300			1
2	Scouting	7.5	Bollworm Budworm	100	100	5	1	1				18.75	550	300	1.50		1
3.	Regular Short season		Bollworm Budworm	100		7	1	1				26.25	550	400			3
4	Regular Crop culture 1/		Bollworm Budworm	100		7	1	1				26.25	550	350			2
5	Scouting Short season		Bollworm Budworm	100		3	1	1				11.25	550	400	1.50		3
6	Scouting Crop culture 1/		Bollworm Budworm	100		3	1	1				11.25	550	400	1.50		2
7	Scouting Short season Crop culture 1/		Bollworm Budworm	100		2	1	1				7.50	550	400	1.50		3

Table 32. Cotton Pest Control in Texas, Upper Gulf Coast Region.

Acreage grown 131,000 Source Dr. Ray Frisbie

Average yield 400 lbs/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost /A ($)	Application Cost /A ($)	Total Cost /A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	% Acres in Diapause Control	Comment Code[4]
1	Regular	8	Boll weevil Cotton Flea hopper	100	100	4		1/3	1/10			8.00	400	200			1
2	Scouting	92	Boll weevil Cotton Flea hopper	100	100	2		1/3	1/10			4.00	400	200	1.50		1
3	Resistant (Boll weevil & Flea Hopper) Short season Scouting		Boll weevil Cotton Flea hopper	<10		<1		1/3	1/10			2.00	400	375	1.50		3
4	Sanitation[16] Scouting		Boll weevil Cotton Flea hopper	100		1 1/2 -2		1/3	1/10			3.50	400	300	1.50	100	2
5	Short Season Variety Scouting		-			1		1/3	1/10			2.00	400		1.50		3
6	Resistant Scouting					1		1/3	1/10			2.00	400		1.50		3

Table 33. Corn Pest Control in Florida.

Acreage grown 500,000 Source Dr. John Strayer

Average yield 43 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code
1	Regular (soil insects)	100	Lesser Corn Stalk Borer, Sugar Cane Borer, White Fringe Beetle, Wireworms	50	25	1		2	.5-2			13.50	43[20]	25		1
	Regular (above ground insects)	100	Army Worms, Corn Ear Worm, Leaf Miner, Mites	7.5	5	1			1/4			12.00	43	35		1

Table 34. Corn Pest Control in Illinois. Acreage grown 5,250,000 Source Drs. W. Luckman and Don Kuhlman

East Central, Southwest, Southeast Region Average yield 102-3 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[4]
1	Continuous	40	N. & W. Rootworm	5	60	1	0	1/2	1/2			4.00-8.00	102-3	90-92		1
2	Rotation	60		0	30	1	1/2	1/4	1/4			4.00-8.00	102-3	102-3		1
4	Scouting		N. & W. Rootworm Corn Borer Leaf aphid	5		1	1/3	1/3	1/3			4.00-8.00	102-3		1.00	3
	Continuous	40	Black Cutworm	3	50	1	1		4			5.00-8.00	102-3	50		1
	Rotation	60	Black Cutworm	3	30	1	1					5.00-8.00	102-3	50		1
	Continuous	40	Corn borer	2	1	1		1/2	1/2			5.00-6.00	102-3	92-93		1
	Rotation	60	Corn borer	2	1	1		1/2	1/2			5.00-6.00	102-3	92-93		1
	Continuous	40	Leaf Aphid	2	1	1		1				5.00-6.00	102-3	92-93		1
	Rotation	60	Leaf Aphid	2	1	1		1				5.00-6.00	102-3	92-93		1

Table 35. Corn Pest Control in Illinois, Northwest, Northeast, Central Region.

Acreage grown 5,250,000 Source Dr. W. Luckman and Dr. Don Kuhlman

Average yield 102-103 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[4]
1	Continuous	55-60	N. & W. Rootworm	25	90	1		1/2	1/2			4.00-8.00	102-3	90-92		1
2	Rotation	40-45	-	5	45	1	1/8	1/2	3/8			4.00-8.00	102-3			1
4	Scouting		N. & W. Rootworm Leaf Aphid Corn borer	25		1	1/3	1/3	1/3			4.00-8.00	102-3		1.00	3
	Continuous	55-60	Black Cutworm	3	20	1	1					5.00-8.00	102-3	50		1
	Rotation	40-45	Black Cutworm	3	20	1	1					5.00-8.00	102-3	50		1
	Continuous	55-60	Corn borer	2	1	1		1/2	1/2			5.00-6.00	102-3	92-93		1
	Rotation	40-45	Corn borer	2	1	1		1/2	1/2			5.00-6.00	102-3	92-93		1
	Continuous	55-60	Leaf Aphid	4	2	1		1				5.00-6.00	102-3	92-93		1
	Rotation	40-45	Leaf Aphid	4	2	1		1				5.00-6.00	102-3	92-93		1

Table 36, Corn Pest Control in Indiana

Acreage grown 6,000,000 Source Dr. Thomas Turpin

Average yield 92 bu/A Period 1972-73

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[4]
1	Continuous	40	N.& W. Rootworm Wireworm Cutworm	100	100	1	3/4	1/4		2.79	0.50	3.29	92	90		1
2	Rotation	60	Wireworm Cutworm	10	10	1		1/2	1/2	2.79	0.50	3,29	92	91		1
3	Scouting		N. & W. Rootworm Wireworm Cutworm	100		1	1/4	1/2	1/4	2.79	0.50	3.29	92		2.00	3

Table 37, Corn Control in Iowa, Bottom Land Region,

Acreage grown 1,500,000 Source Dr. Harry Stockdale

Average yield 111 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	Pesticides Used: lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[4]
1	Continuous	25	Cutworms Rootworms Corn borer Wireworms	60	64	1	1/2	1/4	1/4	3.50	0	3.50	111	110		1
	Rotation	75	Cutworm Corn borer Wireworm	60	67	1	1/2	1/4	1/4	3.40	0	3.50	111	106		1

Table 38, Corn Pest Control in Iowa, Other Land Region,

Acreage grown 10,500,000 Source Dr. Harry Stockdale

Average yield 111 bu/A Period 1972-74

Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treat-ments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost /A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[4]
Continuous	25	Rootworms	88	72	1	1/4	1/2	1/4	4.50	0	4.50	111	104		1
		Cornborer													
		Wireworms													
		Cutworms													
Rotations	75	Cornborer	0	64	1	1/4	1/2	1/4	4.50	0	4.50	111	104		1
		Wireworms													
		Cutworms													

Table 39. Corn Pest Control in Kansas, Dry Land Region.

Acreage grown 850,000 Source Drs. LeRoy Brooks and Del Gates

Average yield 80 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code [4]
1	Continuous [2]	65	Rootworm	62	100	1		1/2	1/2			5.00	80	50		1
2	Rotation [2]	35	Rootworm	0	29	1		1/2	1/2			5.00	80	80		1

Table 40, Corn Pest Control in Kansas, Irrigated Region.

Acreage grown 850,000 Source Drs. LeRoy Brooks and Del Gates

Average yield 115 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	Pesticides Used: lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[4]
1	Continuous	65	Rootworm	62	100	1		1/2	1/2			5.00	115	50		1
2	Rotation	35	Rootworm	0	29	1		1/2	1/2			5.00	115	115		1
	Continuous	65	Spider mite	71	71	1		1/2	1/2			4.25	115	85		1
	Rotation	35	Spider mite	71	71	1		1/2	1/2			4.25	115	85		1
	Continuous	65	Corn borer 28 Corn borer	12	3	1		1/2	1/2			4.25	115	76		1
	Rotation	35	Corn borer 28 Corn borer	12	3	1		1/2	1/2			4.25	115	76		1
	Continuous	65	Western Bean Cutworm	29	29	1		1/2	1/2			4.25	115	76		1
	Rotation	35	Western Bean Cutworm	29	29	1		1/2	1/2			4.25	115	76		1

Table 41. Corn Pest Control in Kentucky, Eastern Region.

Acreage grown 385,000 Source Dr. Wes Gregory

Average yield 85 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments – Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost /A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost /A ($)	Comment Code[4]
1	Continuous (conventional)	17	Subterranean Cutworm	6-7	8-10	1	1/2	1/4	1/4	3.00		3.00	85	68		1
2	Rotation (conventional)	12	Subterranean Cutworm	6-7	8-10	1	1/2	1/4	1/4	3.00		3.00	85	68		1
3	Continuous (No Till)	43	Root aphid, Wireworm, Cutworm	40	40	1	1/2	1/4	1/4	3.00		3.00	85	68-72		1
4	Rotation (No Till)	28	Root aphid, Wireworm, Cutworm	40	40	1	1/2	1/4	1/4	3.00		3.00	85	68-72		1
	Continuous (conventional)	17	Corn borer, Corn borer[28]	35	35	1	2		1/2	2.00	.75	2.75	85	70		1
	Rotation (conventional)	12	Corn borer, Corn borer[28]	35	35	1	2		1/2	2.00	.75	2.75	85	70		1
	Continuous (No Till)	43	Corn borer, Corn borer[28]	35	35	1	2		1/2	2.00	.75	2.75	85	70		1
	Rotation (No Till)	28	Corn borer, Corn borer[28]	35	35	1	2		1/2	2.00	.75	2.75	85	70		1

Table 42. Corn Pest Control in Kentucky, Western Region.

Acreage grown 715,000 Source Dr. Wes Gregory

Average yield 85 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[4]
	Continuous (conventional)	13	Subterranean Cutworm	10	20	1	1/2	1/4	1/4	3.00		3.00	85	68		1
	Rotation (conventional)	72	Subterranean Cutworm	10	20	1	1/2	1/4	1/4	3.00		3.00	85	68		1
	Continuous (No Till)	2	Root aphid Wireworm Cutworm	40	40	1	1/2	1/4	1/4	3.00		3.00	85	68-72		1
	Rotation (No Till)	13	Root aphid Wireworm Cutworm	40	40	1	1/2	1/4	1/4	3.00		3.00	85	68-72		1
	Continuous (conventional)	13	Corn borer Corn borer[28]	35	35	1	2		1/2	2.00	.75	2.75	85	56		1
	Rotation (conventional)	72	Corn borer Corn borer[28]	35	35	1	2		1/2	2.00	.75	2.75	85	56		1
	Continuous (No Till)	2	Corn borer Corn borer[28]	35	35	1	2		1/2	2.00	.75	2.75	85	56		1
	Rotation (No Till)	13	Corn borer Corn borer[28]	35	35	1	2		1/2	2.00	.75	2.75	85	56		1

Table 43. Corn Pest Control in Michigan.

Acreage grown 1,700,000 Source Dr. Robert Ruppel

Average yield 80 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code [4]
1	Continuous [22]	58	N. & W. Rootworm	41	41	1			1			6.00	80	66		1
2	Rotation [23]	42		0	0	0						0	80			1
	Continuous [22]	58	Corn borer	6	1	1			1.5	2.75	2.75	5.50	80	72		1
	Rotation [23]	42	Corn borer	6	1	1			1.5	2.75	2.75	5.50	80	72		1
	Continuous [22]	58	Armyworm	6	3	1			1.5	2.50	2.75	5.25	80	60		1
	Rotation [23]	42	Armyworm	6	3	1			1.5	2.75	2.75	5.50	80	60		1
	Continuous [22]	58	Cutworm	8	3	1			1.5	2.75	2.75	5.50	80	68		1
	Rotation [23]	42	Cutworm	8	3	1			1.5	2.75	2.75	5.50	80	68		1
3	Scouting [24]														3.10	3

Table 44. Corn Pest Control in Minnesota. Acreage Grown 6,800,000 Source Dr. Huai Chiang and Dr. David Hoetzel

Average yield 93 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[4]
1	Continuous	44	N&W Corn Rootworm, Corn borer	60	60	1		1/2	1/2			4.00	93	87 (86-88)		1
	Continuous	44	Wireworms, Cutworms		.3	1		1/2	1/2			5.00	93	87 (86-88)		1
2	Rotations	56	Corn borer, Wireworms, Cutworms		0.3	1		1/2	1/2			5.00	93	92		1

Table 45. Corn Pest Control in Missouri, Bottomland Region,

Acreage grown 1,200,000 Source Drs. Mahlon Fairchild, George Thomas, Robert Stoltz, and William Kearby and Armon Keaster

Average yield 105 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[4]
1	Continuous	65	Cutworm Rootworm Corn borer Wireworm	32	32	1	.45	1/3	1/3	3.50	0	3.50	105	50		1
2	Rotation	35	Cutworm Corn borer Wireworm	58	58	1	1	1/2	1/4	3.50	0	3.50	105	55		1

Table 46, Corn Pest Control in Missouri,
Other land than Bottomland,

Acreage grown 2,800,000 Source Drs. Fairchild, George Thomas, Robert Stoltz, William Kearby and Armon Keaster

Average yield 67 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[1]
	Continuous	40	Rootworm Corn borer Wireworm	5	5	1	.45	1/3	1/3	3.50	0	3.50	67	65		1
	Rotation	60	Corn borer Wireworm	0	0	0						0	67	67		1

Table 47. Corn Pest Control in Nebraska, Dryland Region.

Acreage grown 3,900,000 Source Dr. Z. B. Mayo

Average yield 80 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code
1	Continuous	50	W. Rootworm Wireworm Cutworm	80	80 (rootworm)	1		.5	.5			4.50-8.00	80	65-70		1
2	Rotation	50	Wireworm Cutworm	0	5 (rootworm)	1		.5	.5			4.50-8.00	80			1
3	Scouting Continuous	50	W. Rootworm	30-40		1		.5	.5			4.50-8.00	80		2.00	2
	All corn	100	Corn borer	20	20	1		1				6.00	80	60		1
4	All corn Scouting	100	Corn borer	16		1		1				6.00	80		2.00	2
5	All corn Corn borer resistance	100	Corn borer	10		1		1				6.00	80			3

Table 48. Corn Pest Control in Nebraska, Irrigated Region.

Acreage grown 2,100,000 Source Dr. Z. B. Mayo

Average yield 115 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	OP	C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Without Treatment	Scouting Cost/A ($)	Comment Code[a]
1	Continuous	90	W. Rootworm Wireworm Cutworm	85	85 (80-90) rootworms	1		.5	.5			4.50- 8.00	115	105-110		1
2	Rotation	10	Wireworm Cutworm	0	< 5 rootworms	1		.5	.5			4.50- 8.00	115			1
3	Scouting Continuous	90	Rootworm	30-40		1		.5	.5			4.50- 8.00	115		2.00	2
	All corn	100	Corn borer	10	10	1		1				6.00	115	105		1
4	All corn Scouting	100	Corn borer	8		1		1				6.00	115		2.00	2
	All corn Corn borer resistant	100	Corn borer	5		1		1				6.00	115			3
	All corn	100	Spider mite	10	15	1		1				6.00	115	100-105		1

Table 49. Corn Pest Control in New York.

Acreage grown 360,000 Source Drs. A.A. Muka and D. Pimentel

Average yield 77 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code
1	Continuous	30	W. Rootworm Corn Borer Leaf Aphid Armyworm	30	40	1		1/2	1/2			10.00	77	76		1
2	Rotation	70	Corn Borer Leaf Aphid Armyworm	2	2	1			1/2			7.00	77	77		1
3	Scouting			30		1		1/2	1/2			10.00	77		2.00	3

Table 50. Corn Pest Control in North Carolina. Acreage grown 1,500,000 Source Dr. Robert Robertson

Average yield 65 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem(%) Acreage Needing Chemical Treatment (%)	Extent of Problem(%) Acreage Currently Being Treated (%)	Treatments: # of Treat-ments per season	Pesticides Used lbs/A/Treatment CH	OP	C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A With Treatment	Yield/A Without Treatment	Scouting Cost /A ($)	Comment Code[4]
1	Continuous	17	Billbugs Wireworms S. Rootworm Corn borer	18 (17-19)	15 (10-20)	1	1/2		3/4			6.20.	65	40 (35-45)		1
2	Rotation	83	All	18 (17-19)	15 (10-20)	1	1/2		3/4			6.20	65	40 (35-45)		1
3	Scouting			15		1	1/2		3/4			6.20	65		2.00	3

Table 51. Corn Pest Control in Ohio, Eastern Region.

Acreage grown 1,100,000 Source Dr. Gerald Musick and Dr. Robert Treece

Average yield 70 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[4]
1	Continuous	35	N. Rootworm Corn borer Cutworm Wireworm	26 (20-30)	26 (20-30)	1	.26	.44	.53	4.00	T	4.00	70	66		1
2	Rotation	65	Corn borer Cutworm Wireworm	24 (20-30)	24 (20-30)	1	0	.36	.44	3.00	T	3.00	70	67		1
3	Scouting 25					1	.26	.44	.53	3.00	T	4.00	70		4.00	3

Table 52. Corn Pest Control in Ohio, Western Region.

Acreage grown 2,400,000 Source Dr. Gerald Musick and Dr. Robert Treece

Average yield 110 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Comment Code[4]
1	Continuous	60	N. Rootworm	60	80	1	.18	.22	.26	4.00	T	4.00	110	100		1
			Corn borer													
			Cutworm													
			Wireworm													
2	Rotation	40	Corn borer	40	80	1	1.0	.05	.07	3.00	T	3.00	110	100		1
			Cutworm													
			Wireworm													
	Scouting[25] Continuous		N. Rootworm	60		1	.18	.22	.26	3.00	T	3.00	110	100	4.00	3
			Corn borer													
			Cutworm													
			Wireworm													
	Scouting[25] Rotation		Corn borer	40		1	1.0	.05	.07	3.00	T	3.00	110	100	4.00	3
			Cutworm													
			Wireworm													

Table 53, Corn Pest Control in South Dakota.

Acreage grown 3,600,000 Source Dr. David Walgenbach

Average yield 65 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Chemical Treatment	Yield/A: Without Chemical Treatment	Scouting Cost/A ($)	Comment Code[4]
1	Continuous	42	N & W Rootworm	100	100	1		1/2	1/2			5.00	65	53		1
2	Rotation	58	N & W Rootworm	33	33	1		1/2	1/2			5.00	65	55		1
	Total	100	Grasshoppers	6	3	1		1/2	1			4.00	65	52		1
	Total	100	Cutworms Wireworms	1	17	1	1					4.00	65	50		1

Table 54, Corn Pest Control in Wisconsin,

Acreage grown 2,270,000 Grain Source Dr. James Apple

Average yield 90 bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%): Acreage Needing Chemical Treatment (%)	Extent of Problem (%): Acreage Currently Being Treated (%)	Treatments: Pesticides Used: # of Treatments per season	Pesticides Used: lbs/A/Treatment: CH	lbs/A/Treatment: OP	lbs/A/Treatment: C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A: With Treatment	Yield/A: Without Treatment	Scouting Cost/A ($)	Common Code[4]
1	Continuous	63	N&W Rootworm	75	100	1		1.0	1.0	5.00	1.00	6.00	90	82		1
	Continuous	63	Leaf aphid Corn borer Cutworm	2	1	1		.5	1.5	1.00-3.00	3.00	4.00-6.00	90	80		1
2	Rotation	37	Leaf aphid Corn borer Cutworm	2	1	1		.5	1.5	1.00-3.00	3.00	4.00-6.00	90	80		1
5	Scouting[26] Continuous		N&W Rootworm Leaf aphid Corn borer Cutworm	75		1	.1	.7	.2	3.50	T	3.50	90		2.00	3

Table 55. Corn Pest Control in Wyoming. Acreage grown 65,000 Source Dr. Chris Burkhardt

Average yield 70+ bu/A Period 1972-74

Line No.	Cultural Practice	%	Pests	Extent of Problem (%) Acreage Needing Chemical Treatment (%)	Acreage Currently Being Treated (%)	Treatments: Pesticides Used # of Treatments per season	lbs/A/Treatment CH	OP	C	Materials Cost/A ($)	Application Cost/A ($)	Total Cost/A ($)	Yield/A With Treatment	Without Treatment	Scouting Cost/A ($)	Comment Code[4]
1	Continuous	10	W. Rootworm Mites Wireworm Cutworms	10	7	1	1/4	1/2	1/4	5.00	0	5.00	70+	54		;
2	Rotation	90	W. Rootworm Mites	6	0	1	1/4	1/2	1/4	5.00	0	5.00	70+	65		1
4	Resistant Variety	27	W. Rootworm Others	0		0						0	70+			3

FOOTNOTES

1. For the added materials and costs for any control program that includes diapause control see "diapause" below "double line" on each respective table.

2. For the added materials and costs for any control program that includes trap crop control see "trap crop" below "double line" on each respective table.

3. Trap crop occupies only 5% of the total cotton acreage. Dosage and cost given is for the treatment of only the trap crop.

4. Comment codes are as follows:

   1 = Current practices
   2 = Alternative pest controls that could be put into practice within one year
   3 = Alternative pest controls that require additional research and potentially could be put into practice in 5 to 10 years

5. Trap crop in this situation refers to the alternate cutting of alfalfa fields to leave live alfalfa fields for plant bug control.

6. By ceasing to irrigate the cotton further in August, growth of the cotton can be terminated.

7. No one treats automatically anymore. Everyone scouts to some degree.

8. Fields are scouted by insecticide representatives and others.

9. Scouting in this case means "supervised pest control."

10. Trap crop in this situation refers to the interplanting of cotton with strips of alfalfa to attract plant bugs.

11. By managing the crops that are grown adjacent to cotton, it is estimated that the number of sprays would be reduced by 1-2.

12. Treatments may be required rarely. Scouting will determine when treatments are needed and time these accurately.

13. The advantage of scouting is timing.

14. Trap crop = sorghum interplanted in cotton, 4 rows to 24 of cotton. Added cost = $3.00.

15. Treatments reduced significantly.

16. Early and uniform destruction of cotton stalks on an area-wide basis for boll weevil control.

17. Reducing irrigation and lowering the amount of fertilizer will reduce the growth of the cotton plants and make them less attractive to the bollworms and budworms late in the season.

18. Only in certain counties; 5-7% of the acreage.

19. Early and uniform destruction of cotton stalks on an area-wide basis for boll weevil control. Destroying the stalks on 70% of the acreage is ineffective.

20. 43 bu reflects mean for Florida. With chemical treatment, it has shown consistently that yields may be increased 50-75%.

21. The spider mite, European and southwestern corn borer and western bean cutworm are not a problem in these sections.

22. Corn in two years before rootworms are a problem. Second year corn is not bothered.

23. 25% of the corn is in annual rotation.

24. Insect problems sporadic and diverse. A sound predictive index is needed.

25. May not decrease the number of treatments but would improve the timing of applications by having an effective insect pest monitoring program.

26. Monitoring of insect pest populations could be carried out by the growers themselves. Would improve timing of applications. Commercial scouting is not practical at present.

27. This resistance would be primarily tolerance in the ability of the corn plant to regenerate roots.

28. Southwestern corn borer. All other references are to European corn borer.

29. Trap crop sprayed with pheromones.

TECHNICAL REPORT DATA

(Please read Instructions on the reverse before completing)

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15. SUPPLEMENTARY NOTES

16. ABSTRACT

Insecticide levels and application costs supplied by 31 entomological experts, plus estimates of the other costs involved with various insect control strategies, indicate that many insect control strategies that may significantly reduce insecticide use on cotton and corn may be more economical than strategies currently being used. An analysis of alternative insect control technologies in corn revealed that few opportunities exist to employ alternative strategies because only about 1 pound of insecticide is applied per acre. The prime pest on corn is the rootworm complex and the practical alternative is crop rotation. Several alternate controls are available for cotton that would reduce the use of large quantities of insecticide, however. A detailed static analysis revealed that selecting the most economical control strategy for cotton in each growing region resulted in an annual reduction in insect control costs of $81 million and also reduced total insecticide use by about 40%. A significant finding was that if cotton production could be allowed to shift naturally in the Nation, insecticide use and cotton production costs would be greatly reduced.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
Insecticides Insect control Agricultural chemistry Agricultural economics Economic analysis		02A 57P 68E

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