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ABSTRACT

This report examines the economic implications of losing chlordimeform use on cotton and considers chlordimeform's role in managing the resistance of bollworms and tobacco budworms to synthetic pyrethroids. It estimates changes in prices, production, acreage, consumer expenditures, aggregate producer returns, regional crop effects, and returns to users and nonusers of chlordimeform and pyrethroids. The report bases the economic effects on the estimates and views of the chlordimeform assessment team of the National Agricultural Pesticide Impact Assessment Program. This report also examines the effects on deficiency payments and the implications for pesticide benefit assessments. (YLB)

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Department of
Agriculture

Economic
Research
Service

Agricultural
Economic
Report
Number 587

Losing Chlordimeform Use in Cotton Production

Its Effects on the Economy and Pest Resistance

Craig Osteen
Luis Suguiyama

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LOSING CHLORDIMEFORM USE IN COTTON PRODUCTION: ITS EFFECTS ON THE ECONOMY AND PEST RESISTANCE. By Craig Osteen and Luis Suguiyama. Resources and Technology Division, Economic Research Service, U.S. Department of Agriculture. Agricultural Economic Report No. 587.

ABSTRACT

U.S. consumers and producers could annually lose $148 million once chlordimeform, a cotton insecticide, is removed from the market. The action could accelerate the resistance of the bollworm and tobacco budworm to pyrethroids (a group of important cotton insecticides often used in conjunction with chlordimeform). If so, the U.S. consumer and producer loss could annually rise to $832 million. Pest damage would reduce cotton yields. Available alternative insect control measures, which are less effective and more expensive than chlordimeform and pyrethroids, would raise production costs. Reduced cotton production and acreage would raise cotton prices. So, some cotton producers would gain, while cotton consumers would lose. However, more corn, sorghum, and soybeans would be planted in place of cotton, lowering prices for those commodities. Thus, consumers of those commodities would gain, while producers would lose. If more effective alternatives to chlordimeform and pyrethroids became available, the economic effects of the removal would decline.

Keywords: Bollworm, chlordimeform, cotton insect pests, pyrethroids, tobacco budworm, pesticide regulation.

NOTE

The use of chemical product names in this publication does not imply endorsement by the U.S. Department of Agriculture.

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PREFACE

The Environmental Protection Agency (EPA) may conduct a comprehensive risk/benefit analysis, known as a special review, if evidence on a pesticide triggers concern about a significant health or environmental risk. During special reviews, EPA weighs risks and benefits of pesticide use to determine if regulatory actions are necessary to protect the public and the environment. Regulatory actions include cancellations of registered uses (bans on use for particular purposes after a certain date), use restrictions, or labeling changes. The U.S. Department of Agriculture (USDA) reviews proposed regulatory decisions that affect agricultural interests. USDA established the National Agricultural Pesticide Impact Assessment Program (NAPIAP) to evaluate the benefits of agricultural pesticides for which EPA proposes regulatory actions. Reports are prepared by assessment teams composed of crop scientists and specialists from USDA, State experiment stations, and State extension services. Each report evaluates the biological and economic effects of regulatory actions on the agricultural community.

This study expands on the evaluation of chlordimeform benefits by a USDA assessment team. Members of the chlordimeform assessment team follow:

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Charles Allen, Texas A&M University
Paul Bergman, U.S. Department of Agriculture
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The following individuals contributed valuable information to the assessment team effort, and their cooperation is greatly appreciated:

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CONTENTS

SUMMARY

U.S. consumers and producers could annually lose $148 million once chlordimeform, a cotton insecticide, is removed from the market. The action could accelerate resistance of the bollworm and tobacco budworm to pyrethroids (a group of important insecticides often used in conjunction with chlordimeform). If so, the U. S. consumer and producer loss could annually rise to $832 million. Pest damage would reduce cotton yields, and more expensive alternative insect control measures would raise production costs. Reduced cotton production and acreage would raise cotton prices. So, some cotton producers would gain, while cotton consumers would lose. However, more corn, sorghum, and soybeans would be planted in place of cotton, lowering prices for those commodities. Thus, consumers of those commodities would gain, while producers would lose. If more effective alternative insecticides became available, the economic effects of the removal would decline. This report examines the economic implications of banning chlordimeform and considers chlordimeform's role in managing the resistance of cotton insect pests to pyrethroids.

Bollworms and tobacco budworms, which cause the most insect damage to U.S. cotton, are primarily controlled with pyrethroids and chlordimeform. However, these insects may be developing resistance to pyrethroids. Using pyrethroids in conjunction with chlordimeform appears to increase effectiveness of control and to slow the development of resistance by these pests to pyrethroids.

The Environmental Protection Agency (EPA) was reviewing chlordimeform because it causes cancer in laboratory mice and is toxic to fish and wildlife. As a result, the manufacturers withdrew chlordimeform from the market following the 1988 growing season. The action might accelerate pest resistance to pyrethroids, reducing the effectiveness and useful life of pyrethroids. Thus, U.S. cotton producers could lose the use of both chlordimeform and pyrethroids.

The withdrawal of chlordimeform without a loss in pyrethroid effectiveness could cause an annual $148-million net domestic loss, consisting of a $345-million loss for consumers of crops and livestock and a $197-million gain for producers. However, if pyrethroids became ineffective as a result of the withdrawal, the annual net domestic loss would be $832 million, over five times that of withdrawing chlordimeform alone. Domestic consumers would lose $1.5 billion and producers would gain $691 million. However, the economic effects would decline, if effective alternatives to chlordimeform or pyrethroids were discovered.

Government income support payments would fall in both cases because of higher cotton prices. The drop in payments would offset higher market revenues. As a result, income to cotton producers could fall, a result contrary to some traditional analyses, which do not consider program payment effects. Lower program payments would mean that commodity program participants who do not use the affected pesticides (participant-nonusers) would gain less than nonparticipant-nonusers. In some cases, participant-nonusers would gain nothing, despite higher commodity prices. Participants-users would lose more than nonparticipant-users.

The chlordimeform withdrawal and pyrethroid ineffectiveness would reduce cotton acreage where bollworms and tobacco budworms are major cotton pests. The Southeastern, Appalachian, Delta, and Mountain States would be most affected. The Southeast (Florida, Georgia, South Carolina, and Alabama) would suffer the most dramatic proportional acreage declines. Without pyrethroids, given current alternatives, this region could virtually cease cotton production.

Losing Chlordimeform Use in Cotton Production

Its Effects on the Economy and Pest Resistance

Craig Osteen
Luis Suguiyama*

INTRODUCTION

Pesticides are used extensively in agriculture to reduce pest damage, and thus, to raise income and reduce income variability. However, pesticides are toxic chemicals subject to Federal and State regulations that include banning some or all uses when the alleged harmful effects to human health, safety, or environment outweigh the estimated benefits. Pest resistance to pesticides, which reduces or destroys the ability to control pests, is a constant threat when pests are exposed to pesticides. Pesticide bans or pest resistance may force the use of less effective control alternatives, thereby reducing yields and/or raising control costs. A large decline in crop productivity may increase crop prices, with repercussions throughout the economy, causing consumers to bear a cost and producers to change the acreages of crops grown.

Pyrethroids and chlordimeform are primary insecticides for two major cotton pests: bollworms and tobacco budworms. However, bollworms and tobacco budworms (Heliothis) may be developing resistance to pyrethroids. When pyrethroids and chlordimeform are used together, they become more effective than when used separately and appear to slow the development of resistance of these two pests to pyrethroids.

This report examines the economic implications of losing chlordimeform use on cotton and considers chlordimeform's role in managing the resistance of bollworms and tobacco budworms to synthetic pyrethroids.[1] The study estimates changes in prices, production, acreage, consumer expenditures, aggregate producer returns,

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1 Our examination of the economic effects of Heliothis resistance to synthetic pyrethroids is limited to cotton production. Other crops (corn, sorghum, soybeans, tobacco, and vegetables) on which Heliothis (bollworm, tobacco budworm, and tomato fruitworm) may cause severe damage and on which pyrethroids are used as control measures are not considered.

GLOSSARY OF TERMS CONNECTED WITH PRICE SUPPORT PROGRAMS

Deficiency payment. Government payment to farmers who participate in feed grain, wheat, rice, or cotton programs. The payment rate is per bushel, pound, or hundredweight, and is based on the difference between a target price and the higher of either the market price or nonrecourse loan rate.

Inkind payment. Payment in commodity rather than cash.

Marketing loan. Authorizes producers to repay their nonrecourse loans at a lower price.

Market price. The average per-unit price farmers receive for their crops.

Nonrecourse loans. Allows eligible producers to obtain a loan at the loan rate established by the Commodity Credit Corporation (CCC) by pledging crops in storage as collateral. These price support loans enable farmers to hold their crops for later sale. If the market price remains below the CCC loan rate, the producer can settle the loan by turning the stored commodity over to the Government. The Government has no recourse but to accept the commodity as complete settlement of the loan.

Paid land diversion. Gives producers a specific per-acre payment for each idle acre that would be paid in addition to any deficiency payment.

Target price. A unit value level established by law for wheat, feed grains, rice, and upland cotton representing a gross return that supports income for the commodity. If the market price falls below the target price, an amount equal to the difference (but not more than the difference between the target price and loan rate) is paid to participating farmers as a deficiency payment.

regional crop effects, and returns to users and nonusers of chlordimeform and pyrethroids. The economic effects are based on the estimates and views of the chlordimeform assessment team of the National Agricultural Pesticide Impact Assessment Program (NAPIAP). This report also examines the effects on deficiency payments (see Glossary) and the implications for pesticide benefit assessments.

THE PROBLEM

Cotton production's heavy reliance on insecticides makes it particularly vulnerable to pesticide bans and pest resistance to pesticides. Many damaging insects infest cotton, and every producing area of the United States controls one or more species with insecticides to profitably grow the crop. Annual losses attributed to cotton insects have been estimated at 6-8 percent of total production, despite current control efforts (26).[2]

[2] Underscored numbers in parentheses indicate sources listed in the References section.

The most damaging insect pests to U.S. cotton are the Heliothis species, specifically Heliothis (H.) zea (bollworms) and H. viriscens (tobacco budworms), which will be referred to as Heliothis. Insecticides, mostly pyrethroids, effectively control larval populations of Heliothis. Pyrethroids, introduced in 1977, have phenomenally reduced the amount of toxic ingredients used on cotton because less pyrethroid is needed to effectively control insects than would be needed with previously used insecticides. However, cotton insects tend to become rapidly resistant to insecticide compounds due to the intensity and frequency of exposure. Heliothis may be quickly developing resistance to pyrethroids. Evidence of increased resistance to pyrethroids surfaced in H. armigera within 2 years of pyrethroid introduction in Thailand (29) and within 6 years in Australia (11). Tobacco budworms collected in Texas in 1985 were over 300 times more resistant to pyrethroids than a susceptible laboratory strain (20).

Chlordimeform is often applied early in the growing season as an ovicide (a chemical that kills eggs) to keep Heliothis populations within manageable levels. By reducing the early insect populations, chlordimeform reduces total insecticide use in cotton production. Chlordimeform is registered for use only on cotton and has little or no effect on boll weevils, beneficial insects, or bees (5). Chlordimeform is distinctly different from the suggested alternatives, methomyl and thiodicarb. Methomyl lacks the residual vapor action that chlordimeform has on bollworms and tobacco budworms and is more toxic to beneficial insects and the cotton plant (25). Research on and use of thiodicarb is limited, and its ovicidal properties are not fully known (25). Chlordimeform is also registered for use as a yield enhancer (growth regulator) because of its physiological effect on the cotton plant.

Both chlordimeform and pyrethroids effectively control Heliothis; but when combined, a reaction known as synergism may develop: the combination of chemicals may be more toxic than the sum of the effects of each chemical applied separately. Tank-mixing pyrethroids and chlordimeform allegedly increases the toxic effects of pyrethroids on pyrethroid-resistant strains of Heliothis and also delays the development of resistance (18, 19). Therefore, chlordimeform plays an important role in cotton insect control and resistance management strategies.[3] Studies of chlordimeform's effects on cotton insect control and yields have generally demonstrated its effectiveness as an ovicide, the lack of a comparable mode of action by substitute chemicals, its physiological activity on the cotton plant, and its toxicological activity on other cotton chemicals (7, 14, 17, 18, 19, 20, 30).

U.S. cotton growers could lose the use of both chlordimeform and pyrethroids. The Environmental Protection Agency (EPA) was reviewing chlordimeform because it causes cancer in laboratory mice and is toxic to fish and wildlife. As a result, the manufacturers withdrew chlordimeform from the market following the 1988 growing season. The potential synergism between chlordimeform and pyrethroids means that the withdrawal of chlordimeform could reduce the effectiveness and useful life of pyrethroids by accelerating the development of pest resistance.

[3] Research and program implementation in Australian cotton (28) have demonstrated that chlordimeform and its synergistic effects are an important element in controlling or reversing pyrethroid resistance. However, the management of pyrethroid resistance does not depend exclusively on the availability of chlordimeform. Other strategies, such as the use of pathogens, predators, chemosterilization, and cultural practices, are available that complement or substitute for the effects of chlordimeform on Heliothis control.

Thus, chlordimeform's loss could force cotton producers to use pyrethroid alternatives earlier than they would otherwise. A shift to pyrethroid alternatives would have economic implications beyond those for chlordimeform alternatives.

IMPORTANT ISSUES FOR BENEFIT ANALYSES

Assessing benefits is an important component of the pesticide regulatory process. EPA compares a pesticide's benefits to its risks when deciding whether or not to remove it from the market. Recent studies have applied complex econometric or mathematical models to estimate the effects of pesticide bans on crop prices, production, acreage, and consumer and producer welfare (2, 15, 16, 24). The results typically indicate that, as affected producers shift to less cost-effective alternatives, production falls and prices of crops treated with the regulated pesticide rise. Consumers lose due to higher crop prices, and although crop productivity declines, producers often fare better as increases in gross revenues exceed the value of production lost and production cost increases. Consumer losses typically exceed producer gains. The result is sometimes called a social loss when the social effect is the sum of gains and losses to all segments of society.

Osteen and Kuchler (15, 16) showed that pesticide regulations reduce the number of alternatives and, therefore, concentrate all benefits of pest control on a smaller number of pesticides. If enough effective alternatives are removed, the benefits of the remaining pesticides might increase significantly. Carlson (4) studied the longrun productivity of cotton insecticides and found that pesticide bans encourage pest resistance by increasing selective pressure from fewer compounds.

Several studies (1, 8, 15) have also shown that nonusers of the regulated pesticide are unaffected by yield and cost changes. Moreover, they gain from crop price increases. Users of regulated pesticides could lose (gain) if yield losses and cost changes are greater (smaller) than the increases in gross revenues.

The effects of pesticide regulations on crop production and insect control vary by production region because crop mixes, pest incidence, and chemical use vary (2). A pesticide ban could induce windfall gains to unaffected regions, net productivity losses in others, and shifts in crop acreage between and within regions as producers adjust to changes in crop revenues.

Lichtenberg and Zilberman (13) argued that price support programs can alter the economic effects of a pesticide ban because higher prices and lower production reduce income support (deficiency) payments. According to Lichtenberg and Zilberman, a pesticide ban for a crop with price supports shifts (decreases) crop supply leftward from S_0 to S_1 (fig. 1). They assumed that farmers base production decisions on the target price (the basis for deficiency payments, see Glossary) when the market price is less than the target price because expected crop revenues are supplemented with deficiency payments. Since farmers respond to target price TP, which is unaffected by the pesticide ban, crop output falls from Q_0 to Q_1, but the market equilibrium price to consumers increases from P_0 to P_1 along demand curve D. The total savings in farm subsidy programs is equal to the sum of areas d + h + i + j + k + l (assuming 100-percent grower participation). The reduction in subsidy payments completely offsets the loss of consumer surplus (a measure of how changes in prices and output affect consumers) from higher market prices, which is the sum of areas i + j + k + l. Assuming that consumers are also taxpayers, Lichtenberg and Zilberman concluded that consumers are unaffected by declines in crop productivity. The producer income loss is equal to areas c + d + e + j + n as supply shifts from S_0 to S_1, where area d represents reductions in producer subsidies. These results run counter to traditional analyses, which show producer gains and consumer losses.

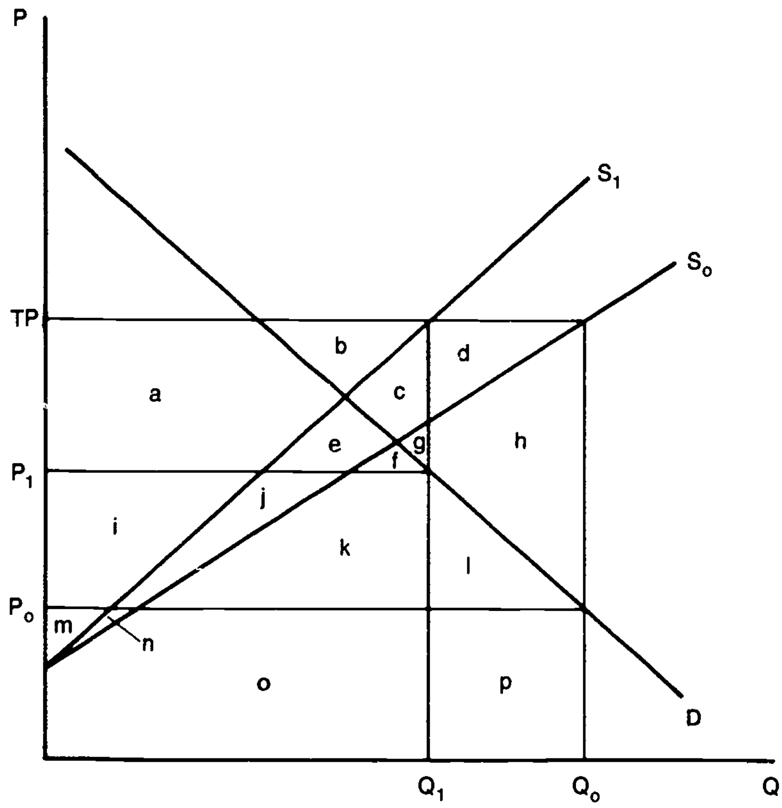
The net effect (sum of changes in consumer surplus, producer income, and deficiency payments) is then areas h - (c + e + j + n). Area h - c is the reduction in deadweight loss. (A deadweight loss occurs when the marginal cost of a commodity production exceeds what consumers are willing to pay for it.) Area -(e + j + n) is the sum of consumer and producer losses caused by lower yields and/or higher production costs under competitive equilibrium. Lichtenberg and Zilberman also argued that the net effect of a pesticide ban could be positive, which some economists interpret as a social gain, because the gain caused by reduced deadweight loss could exceed the sum of consumer and producer losses.

SCENARIOS AND BACKGROUND INFORMATION

A NAPIAP team of cotton experts, including extension and research entomologists, investigated the implications of losing chlordimeform. The team estimated the acreage of chemical control practices by target pest and projected changes in yields, control practices, and pest severity. The estimates of yield and cost changes were input into an econometric model that simulated the economic effects.

Figure 1

Effects of pesticide regulation on a crop with price supports



Scenarios

The team developed the following scenarios to assess the effects of losing chlordimeform and potentially losing synergism to arrest pyrethroid resistance:

Scenario 1. Chlordimeform is lost, and pyrethroids remain effective for Heliothis control.

Scenario 2. Chlordimeform is lost, and pyrethroids become ineffective because synergism no longer retards resistance.

The team members believed that pyrethroid effectiveness could be maintained through alternative management programs but that the loss of chlordimeform would make such programs difficult to implement with currently available controls (25). However, this study does not estimate a resistance management benefit for chlordimeform; it only examines the after-effects if pyrethroid ineffectiveness resulted from losing chlordimeform. To fully estimate the resistance management benefit, one must estimate the probability of chlordimeform's loss affecting pyrethroid resistance and the rate of resistance development with and without chlordimeform. The team was unable to provide those estimates.

National farm-level surveys of cotton insecticide use for target pest species have not been conducted since 1979 (22), so the assessment relied heavily on expert or subjective estimates. The assessment team divided U.S. cotton acreage into 37 subregions (fig. 2) and designed a questionnaire to record pest-specific information on insecticide use for each subregion. The team assumed the following:

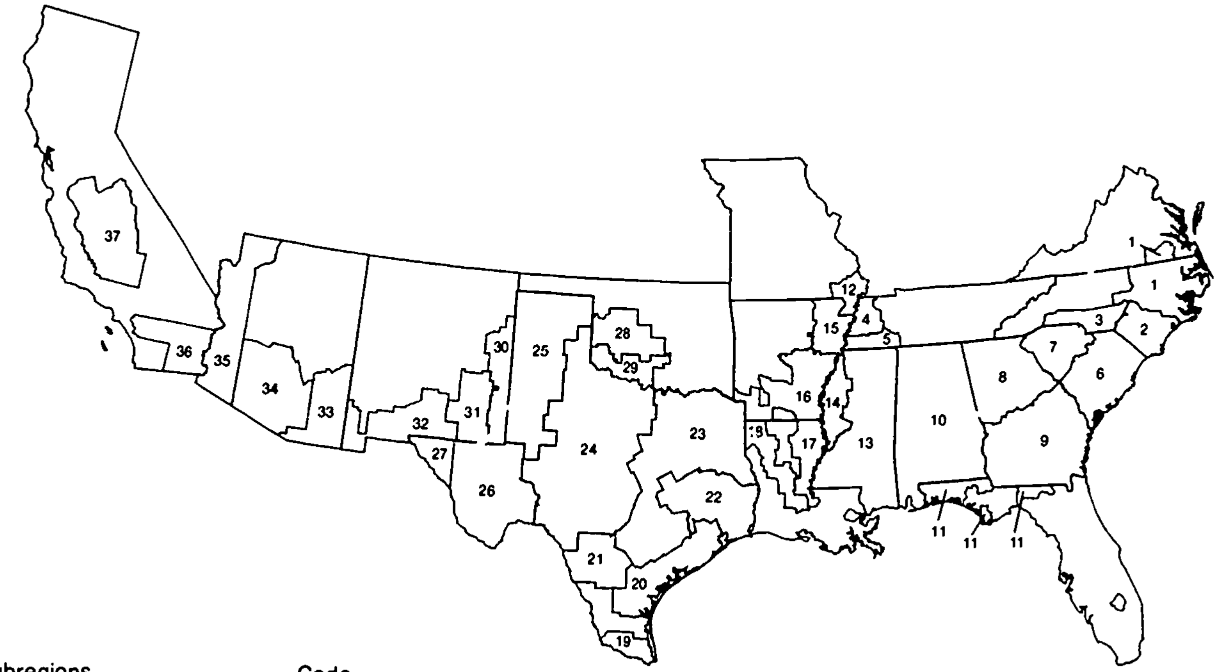
- Current insect pest infestations and control practices represented average conditions over the last 4 years.
- Control estimates represented actual grower practices, not what the experts thought growers should be doing.
- Chemical use on nonharvested acreage was insignificant.

For each scenario, one or more experts familiar with a subregion estimated the change in insect control practices and yield between current conditions and those under the scenarios. These projections required a detailed account of the shift in insect pest severity and alternative control practices. Furthermore, the use of alternative controls was limited to currently available chemical or nonchemical practices. Finally, team members conferred with their peers in the cotton-producing regions and relied on surveys and field tests where available.

The scarcity of data make evaluating the accuracy of the team's estimates difficult. However, cotton entomologists have much experience in assessing changes in pest control practices and pest losses. For example, all benefit assessments of cotton pesticides have relied on expert estimates of changes in yield and cost resulting from pesticide regulatory decisions. Annual insect loss data estimated by experts since 1979 have been published in proceedings of the Beltwide Cotton-Insect Research and Control Conferences (26). Experts also made detailed biological estimates for the analysis of boll weevil management strategies (27). Such experience with pest control research, field conditions, and subjective estimation justifies some confidence in the study's estimates.

Figure 2

Cotton production subregions



Regions and subregions	Code
Appalachia:	
Virginia and North Carolina--North	1
North Carolina--South	2
Piedmont	3
Tennessee--North Brown Loam	4
South Brown Loam	5
Southeast	
South Carolina--Coastal Plains	6
Piedmont	7
Georgia--Piedmont	8
East and Southwest	9
Alabama--Limestone Valley and South	10
Florida	11
Corn Belt	
Missouri--Bootheel	12
Delta States:	
Mississippi--Non-Delta	13
Delta	14
Arkansas--Northeast	15
Southeast	16
Louisiana--Northeast	17
Red River Valley	18
Southern Plains:	
Texas--Lower Rio Grande	19
Upper and Lower Coast	20
Winter Garden	21
Central River Bottom	22
Blacklands	23
Rolling Plains and Upper Concho	24
High Plains	25
Trans Pecos	26
El Paso and Hudspeth Counties	27
Oklahoma--North	28
South	29
Mountain States:	
New Mexico--Southern Plains	30
Pecos Valley	31
Upper Rio Grande	32
Arizona--Southeast	33
Central	34
Yuma and Mohave Counties	35
West	
California--Lower Desert Valleys	36
San Joaquin Valley	37

Current Chlordimeform and Pyrethroid Use Estimates

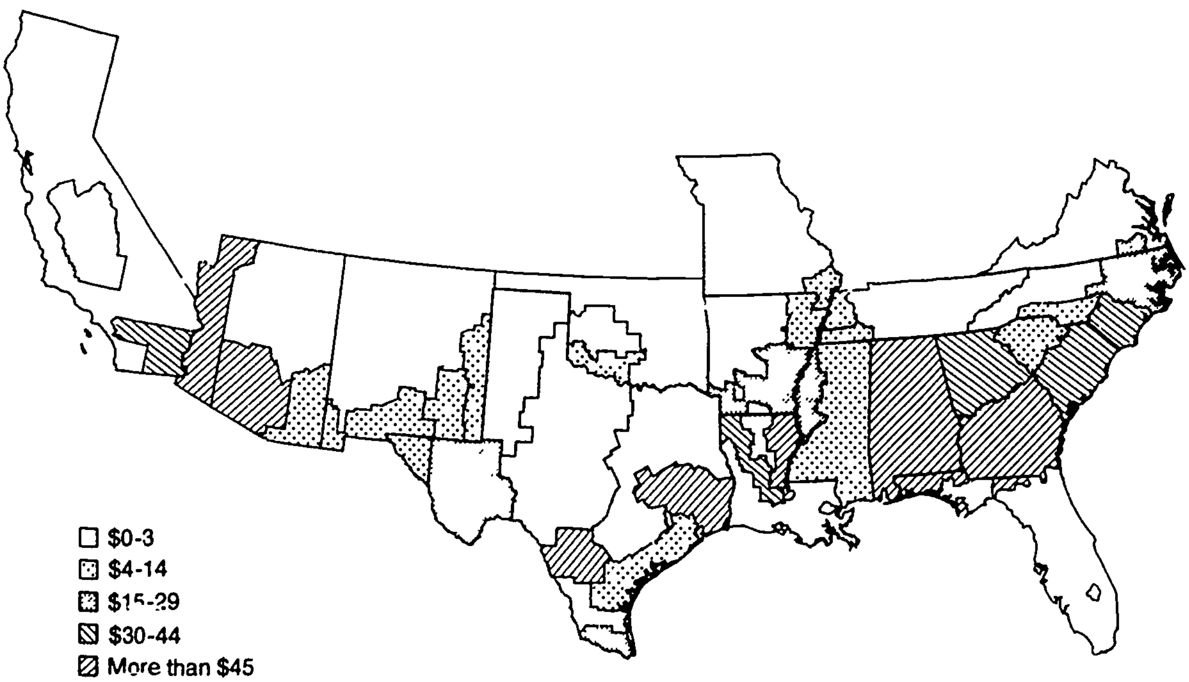
Figure 3 shows the cotton areas infested by Heliothis currently under chlordimeform and pyrethroid control. Heliothis control covers 53 percent of the harvested cotton area, predominately in the Delta, Southeastern, Appalachian, and Mountain States. The team estimated that about 27 percent of the total cotton area is treated with chlordimeform and receives an average of about one treatment per harvested acre, including an average of 0.24 treatment for yield enhancement and 0.79 treatment for insect control (table 1). Approximately 83 percent of the insect control treatments are tank-mixed with pyrethroids.

The team's estimates of chlordimeform use compare favorably with the pesticide industry's estimates (3). The team's estimate of 10.6 million acre-treatments is somewhat greater than the industry estimate of 8 million. (An acre-treatment is one acre treated with a pesticide one time.) The team assumed an average application rate of 0.14 pound of active ingredient per acre-treatment for a total of 1.5 million pounds. That estimate is somewhat greater than industry's estimate of 1.2-1.4 million pounds.

Pyrethroids are recommended for mid- or late-season control of Heliothis at low rates, ranging from 0.046 pound to 0.20 pound of active ingredient per acre. Pyrethroids are used on 44 percent of the U.S. harvested cotton area at an average of 1.9 applications per acre (table 2). Acreage in the Southeast, Delta, and Mountain States where Heliothis incidence is relatively high, receives multiple applications of pyrethroids.

Figure 3

Average expenditures by cotton growers for Heliothis control per harvested acre



17

Bioeconomic Effects of the Scenarios

For Scenario 1, where chlordimeform is lost, the team estimated that higher insect populations would reduce cotton yields about 2 percent and raise control costs $4.74 per harvested acre (table 3). The team predicted that yield would decrease 8.9 percent in the Southeast. Insect control expenditures in the Mountain States would rise $41.82 per harvested acre, and yields would drop 4.7 percent. The team agreed that chlordimeform would perform much better than such alternatives as methomyl or thiodicarb. Mid- and late-season applications for

Table 1--Current chlordimeform use by production region

Cotton production regions	Harvested acreage treated: Yield enhancement	Harvested acreage treated: Insect control	Harvested acreage treated: Total use	Treatments per harvested acre: Yield enhancement	Treatments per harvested acre: Insect control	Treatments per harvested acre: Total use	Rate per acre-treatment
	Percent			Number			Pounds 1/
Appalachia	15	9	24	0.49	0.22	0.71	0.15
Southeast	27	44	71	.96	3	3.96	.13
Corn Belt	12	3	15	.39	.08	.47	.13
Delta	24	37	61	.81	1.57	2.38	.13
Southern Plains	1	11	12	.02	.21	.23	.13
Mountain States	0	68	68	0	3.34	3.34	.19
West	0	6	6	0	.21	.21	.23
United States	7	20	27	.24	.79	1.03	.14

1/ Pounds of active ingredient.

Table 2--Effects of a chlordimeform loss on pyrethroid use in cotton production

Cotton production regions	Current pyrethroid use: Harvested acreage treated	Current pyrethroid use: Treatments per harvested acre	Use after chlordimeform ban: Harvested acreage treated	Use after chlordimeform ban: Treatments per harvested acre
	Percent	Number	Percent	Number
Appalachia	61	1.6	69	2.2
Southeast	99	7.6	99	9.0
Corn Belt	29	.9	42	2.8
Delta	93	4.6	94	6.3
Southern Plains	23	.5	24	.7
Mountain States	95	4.7	94	5.9
West	9	.4	9	.4
United States	44	1.9	45	2.5

Heliothis control would increase. The team estimated that pyrethroid use would increase from 1.9 applications per harvested acre to 2.5 and increase the risk that Heliothis resistance to pyrethroids will develop more rapidly (table 2).

Scenario 2, where pyrethroids are lost due to resistance, would affect cotton yields and production costs more dramatically than Scenario 1. The team estimated that if a chlordimeform ban caused pyrethroids to become ineffective, yields would fall about 13.2 percent and costs would rise about $13 per harvested acre (table 3). These changes are due to the use of less effective control alternatives, closer application intervals, increased primary and secondary pest problems, and adoption of cultural practices that shorten the growing season to avoid extended crop exposure to pest damage.

Estimates for Scenario 1 compare favorably with other estimates. Carlson (3) estimated a 1.7-percent yield loss from experimental data, assuming that no alternatives to chlordimeform were used. Alternative estimates are not available for comparison with Scenario 2, which imposes much greater changes on cotton insect control technology than Scenario 1. Therefore, the estimates for Scenario 2 may be less accurate than for Scenario 1.

ANALYTICAL METHODS

The authors used AGSIM, an econometric-simulation model for U.S. crop production and distribution, to analyze the economic effects of the scenarios (6, 23). AGSIM includes soybeans, corn, wheat, grain sorghum, barley, oats, cotton lint, cottonseed, and the meal and oil products of cottonseed and soybeans, as well as price support programs. The crops are included because a change in net returns for one crop can encourage producers to change planting decisions for that crop and the others. The resulting changes in production will affect prices and consumer demand for all the crops. AGSIM uses estimates of technological or regulatory changes (per-acre cost and yield changes) to simulate changes in prices, production, and acreage for each commodity in domestic regions. It also

Table 3--Effects of chlordimeform and pyrethroid losses on cotton

Cotton production regions	Without chlordimeform (Scenario 1)		Without chlordimeform and pyrethroids (Scenario 2)	
	Yield change	Cost change	Yield change	Cost change
	Percent	Dollars	Percent	Dollars
Appalachia	-5.1	-1.11	-14.4	5.35
Southeast	-8.9	9.10	-39.1	37.05
Corn Belt	0	17.38	-15	33.99
Delta	-1.9	10.19	-13.3	41.93
Southern Plains	-1.2	-.05	-12.6	2.49
Mountain States	-4.7	41.82	-23.7	23.95
West	-.3	-1.28	-2.3	-.79
United States	-2.1	4.74	-13.2	13.26

simulates changes in farm income and consumer surplus of each commodity and computes the net effect (the sum of changes in farm income and consumer surplus). Figure 2 delineates the multistate regions in AGSIM relevant to cotton.

The model links supply and demand relationships in a recursive adjustment process. When the cost of production or per-acre productivity in a particular commodity is altered in one simulated year, the expected profits for that commodity relative to all others are also altered, inducing shifts in planting decisions in the next year. The sum of acreage planted to crops or placed in cultivated summer fallow for each region is a function of average crop return over fixed and variable costs, acreage planted in previous years, and the expected diversion payment for the current year. (A diversion payment is a payment for program participants to place land in conserving use rather than crop use.) Individual crop acreage functions attempt to account for short-term dynamics, such as producers' reluctance to dramatically shift crops and production inputs. These functions determine the proportion of total planted acreage allocated to each crop in each region. Each crop equation includes the expected rent (the maximum of target price or market price from the previous year multiplied by regional average yield minus variable cost) of that crop and alternative crops, the proportion of total planted acreage allocated to that crop in the previous time period, and the effective per-acre diversion payment.

The model requires that all planted acreage be distributed among crops. It also allows the model user to define the amount of acreage allocated to the Conservation Reserve in each region. From the acreage functions and the associated per-acre production functions, production is determined for each region and summed to compute national production. Quantity supplied is production plus inventories.

National demand is estimated for cotton lint used for exports, stocks, and milling; hay; grains used for exports and stocks; grains and oils used for food; soybeans and soybean meal and oil products used for crushing, exports, and stocks; grains and oils used for feed; and cottonseed. Each commodity demand function typically includes the commodity's price and time as explanatory variables, while other commodity prices and explanatory variables are sometimes included. Equating supply and demand functions yields excess demand equations for each crop, and simultaneously solving the excess demand equations determines market prices and use patterns for the commodities. Simulated crop prices, quantities, and costs of production allow calculation of regional crop-specific profit levels and provide the link between simulated marketing years. The market-determined prices enter into the acreage response functions for the following year.

The model simulates commodity markets before and after the regulatory or technological change, computing changes in prices, quantities, and acreage. It then calculates the effects on farm income, its distribution, some direct purchasers of agricultural commodities, consumers, and food processors (12). The model separates domestic and foreign consumer surplus because some policymakers may be primarily interested in domestic consumer effects. The model also includes a component for retail livestock products (beef, pork, chicken, milk, and veal) so that the effect of changes in feed prices on livestock consumers and producers can be estimated.

Farm Program Payments

Producers of corn, wheat, barley, sorghum, and cotton, among the crops included in AGSIM, are eligible for deficiency payments.[4] Because AGSIM incorporates target prices into farmers' production decisions, the net effect implicitly accounts for the change in deadweight loss associated with deficiency payments.[5] However, AGSIM does not currently compute changes in program payments and does not explicitly include other program provisions, such as nonrecourse loans, acreage reduction programs, or payment limitations. The changes in deficiency payments for a crop were computed from AGSIM simulations as follows:

$$dDP = [\max(0, TP - P_0) \times Q_0 - \max(0, TP - P_1) \times Q_1] \times A \times B \qquad (1)$$

where:

dDP	= change in program payments
P_0	= market price before the regulation
P_1	= market price after the regulation
Q_0	= production before the regulation
Q_1	= production after the regulation
A	= allocation factor (see footnote 4)
B	= proportion of crop acreage under program
$\max(0, TP - P_0)$	= maximum of either 0 or $TP - P_0$
$\max(0, TP - P_1)$	= maximum of either 0 or $TP - P_1$

The computed change in program payments indicate changes in deficiency, nonrecourse loan default, marketing loan, and inkind payments (see Glossary). To show the effect of program participation on the change in payments, the computations assumed B to be 0.5 and 1.

This analysis separates the consumer and program payment effects because consumers still respond to market price changes. Federal agencies do not compensate consumers when prices rise or tax them when prices fall. Lower payments could reduce taxes or cause a reallocation of tax receipts to other purposes. Any reduction in program payments must be subtracted from the change

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[4] Individual program participants receive deficiency payments for a program crop when the average market price for a marketing year is less than the target price: DP = [TP - max(P,LR)] x FPA x FPY, where DP = deficiency payments to a farmer; TP = target price, which is determined by farm legislation; max(P,LR) = maximum of either the market price (P) or the nonrecourse loan rate (LR); FPY = farm program payment yield, which is determined by procedures in farm legislation; FPA = farm program acreage. FPA is the acreage planted to the program crop on the farm multiplied by the allocation factor. The allocation factor is the number of harvested acres needed for estimated domestic and export needs (less imports), adjusted for desired changes in carryover stocks, and divided by the estimated harvested acres. The factor can vary between 0.8 and 1 for wheat and feed grains, and between 0 and 1 for cotton. The factor is 1 for a crop under an acreage reduction program.

[5] In figure 1, the change in consumers' surplus for AGSIM is -(i + j + k + l). The change in farm income is (i - n) - (c + e - h - k - l) Summing the changes in consumers' surplus and farm income yields h - (c + e + j + n).

in market revenues to participants, thus reducing gains or magnifying losses, while any increases in payments must be added.

The model does not account for 1985 farm legislation that could reduce the effect of production and acreage changes on deficiency payments. It could take 5 years or more before yield and acreage changes fully affect deficiency payments. Hence, the results of this study and Lichtenberg's and Zilberman's study may overstate changes in deficiency payments and underestimate the net loss of a pesticide ban. As a result, the estimated changes in payments and the net effect must be viewed as longer term (5 years or more).[6]

Users and Nonusers

The analysis also projects the effects on producers who use the affected pesticide(s) (users) and those who do not (nonusers). The effects were computed externally to AGSIM for farmers who produced the crop before and continued doing so after the change. The analysis assumes that the users of the affected pesticide(s) bear all yield losses and cost changes.

The change in nonusers' net revenue per acre, on average, equals the product of average commodity yield and the change in crop price:

$$dR(N) = Y_0 \times dP \qquad (2)$$

where:

$dR(N)$ = change in per-acre net revenue to nonusers
Y_0 = average yield
dP = change in price

The change in per-acre net revenue to users diverges from that to nonusers by the value of yield loss plus the change in production cost:

$$dR(U) = dR(N) - (P_1 \times dY) - dC \qquad (3)$$

where:

$dR(U)$ = change in per-acre net revenue to users
P_1 = the output price after the regulation
dY = yield loss per treated acre (average loss per planted acre/percentage of acreage treated/100)
dC = change in variable production cost per treated acre (cost change per planted acre/percentage of acreage treated/100)

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[6] The 1986-87 farm program payment yield is the average of program yields for 1981-85, dropping the high and low years (10). So, changes in actual yields would not affect deficiency payments, but price changes would. For 1988-90, the farm program yield could be the 1986-87 program yield or a 5-year moving average using program yields for 1983-86 and actual yields thereafter, dropping the high and low years. With the second option, it could take 5 years before yield losses have their full effect on deficiency payments. The crop acreage base for computing farm program acreage is the average of acreage planted or considered planted for the 5 previous years. The cotton base cannot exceed the average of bases for the previous 2 years.

Participation in farm programs influences the per-acre effects on users and nonusers of the affected pesticide(s). When market prices rise, deficiency payments fall and vice versa. This analysis assumes that average yield equals farm program yield for computing payments (see footnote 4). The allocation factor influences the degree to which participants' returns vary with price changes. The change in per-acre net revenue to participant-nonusers becomes:

$$dR'(N) = A[\max(P_1 - TP, 0)]Y_0 + (1 - A)(Y_0 \times dP) \qquad (4)$$

where:

$dR'(N)$ = change in per-acre net revenue to participant-nonusers
$\max(P_1 - TP, 0)$ = maximum of either $P_1 - TP$ or 0

The change in per-acre net revenue to participant-users becomes:

$$dR'(U) = dR'(N) - A[\max(P_1, TP)]dY - (1 - A)P_1 \times dY - dC \qquad (5)$$

where:

$dR'(U)$ = change in per-acre net revenue for participant-users
$\max(P_1, TP)$ = maximum of either P_1 or TP

When the allocation factor is 1 and $TP > P_1$, net revenue to participant-nonusers does not change on average. The per-acre loss to participant-users, however, equals the yield loss valued at the target price plus the change in production costs:

$$dR'(U) = -TP \times dY - dC \qquad (6)$$

Explanation of Variables

The following variables and changes are presented as average annual changes for each scenario, once markets have fully responded:

Change in price. The estimated price change measured in dollars per pound of cotton and dollars per bushel of corn, sorghum, and soybeans.

Change in acreage. The percentage change in acreage planted to cotton, corn, sorghum, soybeans, and all modeled crops.

Change in production. The percentage change in total output of cotton, corn, sorghum, and soybeans.

Change in domestic crop consumer surplus. A measure of the effects of price and output changes on domestic purchasers of cotton, corn, sorghum, soybeans, and all modeled crops. Consumers lose from both higher prices and lower output of a commodity. Included are changes in returns to producers of meal and oil products and to the processing, transportation, and marketing industries for the modeled crops. A negative change indicates a loss to consumers.

Change in farm income. The change in income received by producers of cotton, corn, sorghum, soybeans, and all modeled crops, less variable costs.

Change in livestock consumer surplus. The effect on purchasers of livestock products (beef, pork, chicken, milk, and veal).

Change in livestock producer income. The effect on the income of livestock producers.

Total livestock effect. The sum of changes in livestock consumer surplus and producer income.

Net domestic effect. The sum of changes in domestic consumers' surplus, including returns to producers of meal and oil products and the processing, transportation, and marketing industries; farm income for cotton, corn, sorghum, soybeans, and all modeled crops; and total livestock effect. The net domestic effect implicitly includes the change in deadweight loss associated with the change in commodity program payments. This variable does not necessarily measure the gains or losses to society as a whole because it implicitly weighs all gains and losses equally. Policy decisions could weigh some effects more heavily than others. A decrease shows that agricultural production possibilities have been reduced and that those who gain from a regulatory or technological change, excluding gains from reduced environmental or safety risks, have not gained so much that they could compensate the losers.

Change in foreign consumer surplus. The effect on foreign purchasers of cotton, corn, sorghum, soybeans, and all modeled crops. The indicator includes all the same effects as domestic consumer surplus.

Change in net domestic and foreign effects. The sum of the net domestic effect and change in foreign consumer surplus for cotton, corn, sorghum, soybeans, and all modeled crops. The same caveats apply to this indicator as to net domestic effect.

Change in program payments. The change in deficiency payments, assuming 50-percent and 100-percent participation.

Corrected change in farm income. The sum of change in farm income and computed change in deficiency payments.

Change in per-acre returns. The change in returns per acre for farmers producing the crop before the change and continuing to do so after. Computations were made for program participants and nonparticipants and for users and nonusers of the affected pesticides.

Effects on corn, sorghum, and soybeans are reported because cotton acreage shifts and production losses had a greater effect on these crops than on other modeled crops. However, the change in farm income and consumer surplus on all modeled crops is also included, and the net effect is the sum of effects on all modeled crops and livestock. Table 4 presents the AGSIM baseline simulation of price, production, and acreage. (These values are simulated for research purposes but are not official USDA forecasts.) The estimate of cotton deficiency payments computed from the AGSIM simulation is $469 million. The estimate approximates actual cotton deficiency payments during 1981-85 when payments varied between $431 million and $860 million (21).

AGGREGATE ECONOMIC EFFECTS

The effects of pyrethroid ineffectiveness would be much greater than those of chlordimeform's loss before it affected pyrethroid resistance (table 5). For both scenarios, yield losses and higher production costs would reduce cotton production and acreage and, therefore, raise cotton prices. Farmers would replace some cotton acreage with soybeans or sorghum due to changes in expected returns. Most of the acreage taken out of cotton production would be replanted to other crops because total crop acreage would decrease by less than 0.1 percent. As a result, soybean and sorghum production would increase, causing price declines. Corn prices would fall less than 1 cent per bushel, and production would change less than 1 percent.

The net effect shows a loss, while the changes in consumer surplus and farm income predict an income transfer from consumers to producers. Returns to cotton would rise because of higher prices, while returns to corn, sorghum, and soybeans would fall due to lower prices. When price support programs are considered, deficiency payments would decline significantly, reducing gains to cotton producers. However, development of effective alternatives to chlordimeform and pyrethroids would alleviate yield losses and higher production costs, thus reducing the effects of a chlordimeform ban and pyrethroid resistance.

Table 4--AGSIM baseline simulation

Item	Units	Annual estimate
Prices:		
Cotton	Dollars per pound	1/ 0.65
Corn	Dollars per bushel	2.82
Sorghum	do.	2.79
Soybeans	do.	4.90
Planted acreage:		
Cotton	1,000 acres	12,319
Corn	do.	78,099
Sorghum	do.	12,575
Soybeans	do.	67,386
Conservation Reserve	do.	2/ 16,600
Production:		
Cotton	Million pounds	5,868
Corn	Million bushels	8,210
Sorghum	do.	714
Soybeans	do.	1,963
Cotton payments	Million dollars	3/ 469

1/ Estimates of prices, acreage, production, and payments are simulated for research purposes and are not official USDA forecasts.
2/ An assumed input to AGSIM.
3/ Computed from AGSIM results assuming 100-percent participation and an allocation factor of 1.

Table 5--Average annual aggregate economic effects of losing chlordimeform and pyrethroids

Changes	Units	Without chlordimeform (Scenario 1)	Without chlordimeform and pyrethroids (Scenario 2)
Prices:			
Cotton	Dollars per pound	0.072	0.250
Corn	Dollars per bushel	-.005	-.003
Sorghum	do.	-.026	-.066
Soybeans	do.	-.045	-.069
Planted acreage			
Cotton	Percent	-5.30	-9.90
Corn	do.	.02	1.30
Sorghum	do.	.90	2.20
Soybeans	do.	.70	1.60
All crops	do.	-.03	-.04
Production:			
Cotton	do.	-7.50	-20.00
Corn	do.	.03	-.90
Sorghum	do.	.80	1.90
Soybeans	do.	.40	1.10
Domestic consumer surplus:			
Cotton	Million dollars	-411.94	-1,359.08
Corn	do.	30.96	16.68
Sorghum	do.	17.66	45.51
Soybeans	do.	78.09	121.83
Other crops	do.	-20.27	-48.33
All crops	do.	-305.50	-1,223.39
Farm income:			
Cotton	do.	201.95	491.47
Corn	do.	-32.69	-25.33
Sorghum	do.	-12.47	-27.67
Soybeans	do.	-75.05	-105.87
Other crops	do.	13.34	38.13
All crops	do.	95.08	370.73
Livestock:			
Consumer surplus	do.	-39.55	-298.63
Producer income	do.	101.51	319.60
Total	do.	61.96	20.97
Foreign consumer surplus:			
Cotton	do.	-209.10	-639.90
All crops	do.	-163.05	-579.95

Continued--

Table 5--Average annual aggregate economic effects of losing chlordimeform and pyrethroids--Continued

Changes	Units	Without chlordimeform (Scenario 1)	Without chlordimeform and pyrethroids (Scenario 2)
Net effect:			
Domestic	Million dollars	-148.46	-831.69
Domestic and foreign	do.	-311.50	-1,411.64
Deficiency payments (Allocation factor = 1):			
100-percent participation--			
Cotton	do.	-465.07	-469.41
All crops	do.	-418.41	-484.55
50-percent participation--			
Cotton	do.	-232.53	-234.71
All crops	do.	-209.21	-242.28
Corrected farm income:			
100-percent participation--			
Cotton	do.	-263.74	22.06
All crops	do.	-333.33	-113.82
50-percent participation--			
Cotton	do.	-30.58	256.76
All crops	do.	-114.13	128.45

Scenario 1
(Chlordimeform is lost; pyrethroids remain effective)

Cotton prices would rise about 7 cents per pound, acreage would fall about 5 percent, and production would fall about 8 percent. The effects on corn, sorghum, and soybeans would generally be small, but sorghum production and acreage would increase about 1 percent.

The net domestic effect of losing chlordimeform would be an average annual loss of $148 million. Including the effects on foreign consumers (net domestic and foreign effect) would magnify the annual net loss to $312 million. Domestic crop consumers would lose $306 million. Cotton consumers would lose $412 million due to higher prices and lower production, while consumers of corn, sorghum, and soybeans would gain from lower prices. If the effects on price support programs are not considered, crop producers would gain $95 million. Cotton producers would gain $202 million because of higher prices, and producers of the remaining crops would lose $107 million due to lower prices. Livestock consumers would lose $40 million, and producers would gain $102 million.

Average annual deficiency payments would decrease $418 million with 100-percent participation and $209 million with 50-percent participation. Cotton payments would decline by 99 percent ($465 million assuming 100-percent participation). As a result, crop income would decline either $333 million with 100-percent participation or $114 million with 50-percent participation. Cotton income would decrease $264 million with 100-percent participation.

Scenario 2
(Chlordimeform is lost, pyrethroids become ineffective)

The effects of Scenario 2 are greater than those of Scenario 1. Cotton prices would rise about 25 cents per pound, while acreage would fall about 10 percent and production about 20 percent. Soybean production and acreage would rise about 1 percent, and prices would fall about 7 cents per bushel. Sorghum production and acreage would increase about 2 percent, and prices would decrease about 7 cents per bushel.

The average annual net domestic loss would be $832 million. Including the effects on foreign consumers causes a total annual loss of $1.4 billion. Domestic crop consumers would lose $1.2 million. Cotton consumers would lose $1.4 billion, while consumers of the remaining crops would gain. If price support programs are not considered, producers of the affected crops would gain $371 million. Cotton producers would gain $491 million, and producers of other crops would lose $120 million. Livestock consumers would lose $299 million, and producers would gain $320 million.

Annual program payments could fall $485 million with 100-percent participation and $243 million with 50-percent participation. Cotton payments would be eliminated because the simulated market price exceeds the target price. As a result, crop income would fall $114 million with 100-percent participation but would rise $128 million with 50-percent participation. Cotton producers would gain $22 million with 100-percent participation, despite the loss in payments.

REGIONAL ACREAGE EFFECTS

Cotton acreage would decline in five of the seven cotton regions for both scenarios (table 6). Acreage would shift in some regions more than in others because of regional differences in pesticide use and net revenue changes. Cotton acreage in the Southeastern, Appalachian, Mountain, and Delta States would decline more than in other regions due to higher yield losses and cost changes (see table 3). These four regions have greater Heliothis infestations and treat more acreage with chlordimeform and/or pyrethroids than the remaining regions (see table 1 and fig. 3). Acreage in the Southeast would change the most because that region treats the greatest proportion of acreage with chlordimeform and pyrethroids and would have the greatest yield losses.

If pyrethroids remain effective after chlordimeform is lost, the acreage planted to cotton in the Southeast would fall about 63 percent. Cotton acreage would decline 14 percent in Appalachia, 10 percent in the Mountain States, 5 percent in the Delta, 2 percent in the Corn Belt, and 1 percent in the Southern Plains. If pyrethroids became ineffective, the Southeast would stop producing cotton. Cotton acreage would decline 3 percent in Appalachia, 12 percent in the Mountain States, 16 percent in the Delta, and 4 percent in the Southern Plains. Cotton acreage in the West, where Heliothis currently is not a serious problem, would rise slightly under both scenarios.

PER-ACRE EFFECTS

The effects of price changes and the uneven distribution of pesticide use and pest infestations vary for producers of different crops, users and nonusers of the affected pesticide(s), and program participants and nonparticipants. The additional loss of pyrethroid effectiveness would magnify the differences caused by losing chlordimeform.

Cotton nonparticipant-nonusers would gain from higher prices an average of about $34 per acre per year after chlordimeform's withdrawal and $119 per acre if pyrethroid ineffectiveness resulted (table 7). Corn, sorghum, and soybean producers would lose from lower prices an average of less than $2 per acre if pyrethroids remained effective (Scenario 1). However, sorghum producers would lose about $7 per acre (Scenario 2). Cotton nonparticipant-users would gain from higher prices but lose from yield losses and cost increases. Overall, users

Table 6--Average annual changes in regional crop acreage from losing chlordimeform and pyrethroids

Scenario/region	Cotton	Corn	Sorghum	Soybeans	All crops
			Percent		
Without chlordimeform (Scenario 1):					
Appalachia	-14.2	0.1	1.9	0.8	**
Southeast	-63.3	-.1	3.0	8.8	-0.5
Corn Belt	-1.8	*	.2	-.2	**
Delta States	-5.2	.8	3.8	.7	**
Southern Plains	-.6	*	.9	**	***
Mountain States	-10.3	**	5.0	***	-.1
West	.8	-2.1	***	***	.1
Rest of United States	***	*	***	-.3	***
Without chlordimeform and pyrethroids (Scenario 2):					
Appalachia	-3.1	.1	-2.8	.3	**
Southeast	-100.0	-5.3	10.2	21.1	-.9
Corn Belt	1.7	.1	-.3	-.3	**
Delta States	-15.5	2.5	7.4	2.2	-.2
Southern Plains	-3.5	.2	4.6	.1	***
Mountain States	-11.6	-.1	5.3	***	-.2
West	4.0	-11.4	***	***	.1
Rest of United States	***	.1	*	-.5	***

* = Increase of less than 0.1 percent.
** = Decrease of less than 0.1 percent
*** = 0 or no significant change.

would lose $10 per acre under the chlordimeform ban and $40 if pyrethroid resistance resulted.

Deficiency payments and associated program payments would alter the magnitude of per-acre effects. Cotton prices would remain below the target price after chlordimeform is lost. So, if the allocation factor were 1, net revenues to participant-nonusers would not change. Users would lose $45 per acre per year. When the allocation factor is less than 1, price variability affects producer returns. For example, if the allocation factor were 0.8, nonusers would gain $7 per acre while users would lose $37. If pyrethroids became ineffective, cotton prices would exceed the target price. As a result, the loss in payments would only partially offset the price increase. With an allocation factor of 1, nonusers would gain $81 per acre while users would lose $78. With an allocation factor of 0.8, nonusers would gain $89 per acre and users would lose $57.

Participant-nonusers would gain less and participant-users would lose more than nonparticipants. Participation would also magnify the difference in the effects

Table 7--Average annual per-acre effects of losing chlordimeform and pyrethroids

Item	Without chlordimeform (Scenario 1)			Without chlordimeform and pyrethroids (Scenario 2)		
	Nonuser	User	Average	Nonuser	User	Average
			Dollars per acre			
Program nonparticipants:						
Cotton	34.29	-9.93	22.35	119.07	-39.66	49.23
Corn	NA	NA	-.53	NA	NA	-1.68
Sorghum	NA	NA	-1.48	NA	NA	-6.87
Soybeans	NA	NA	-1.31	NA	NA	-1.69
Program participants (Allocation factor = 1):						
Cotton	0	-44.60	-12.04	80.97	-77.77	11.13
Corn	NA	NA	-.53	NA	NA	-1.68
Sorghum	NA	NA	-1.48	NA	NA	-6.87
Soybeans	NA	NA	-1.31	NA	NA	-1.69
Program participants (Allocation factor = 0.8):						
Cotton	6.86	-36.92	-4.96	88.59	-57.29	24.41
Corn	NA	NA	-.53	NA	NA	-1.68
Sorghum	NA	NA	-1.48	NA	NA	-6.87
Soybeans	NA	NA	-1.31	NA	NA	-1.69

NA = Not applicable.

on users and nonusers. However, participant-users might still perceive that program payments improve their financial position over nonparticipation, despite the greater per-acre losses.

CONCLUSIONS

Losing chlordimeform could have an average annual net domestic loss of $148 million because of lower cotton yields and higher production costs, excluding the changes in environmental risk. Losses will decrease if effective alternatives to chlordimeform are found. Cotton production and acreage will fall, thereby raising cotton prices. In response to those changes, corn, sorghum, and soybean prices will fall.

The possibility that losing chlordimeform would accelerate the development of Heliothis resistance to pyrethroids significantly alters the estimates. If chlordimeform's loss caused pyrethroid ineffectiveness, the net domestic loss would be $832 million. That loss would be almost six times greater than if the ban did not affect pyrethroids. Again, losses would decrease if effective alternatives to pyrethroids were discovered. Estimating the economic value of chlordimeform for resistance management requires information not provided by the assessment team: 1) the likelihood that chlordimeform's loss will affect pyrethroid effectiveness, and 2) by how much the useful life of pyrethroids will decrease.

Traditional measures indicate that, under both pesticide scenarios, income transfers from consumers to producers of cotton, and from producers to consumers of other major crops. Cotton producers not using the affected pesticides would gain, while current users would either lose or gain less than nonusers.

The loss of chlordimeform and pyrethroids could reduce commodity program payments by raising cotton prices. Cotton program participants who use the affected pesticides would lose more and nonusers would gain less than comparable nonparticipants. Program parameters, such as the allocation factor, would affect the magnitude of those gains and losses. Given this report's specification of deficiency payment, if the allocation factor were 1 and the target price exceeded the market price, nonusers would not gain, but users would suffer yield losses valued at the target price rather than the market price. (See the caveats in the last paragraph of Policy Implications.)

The presence of participants and nonparticipants creates an interesting pattern of distributional effects when income transfers from cotton consumers and producer-users to producer-nonusers (especially nonparticipants) and taxpayers. Income would also transfer from producers of corn, sorghum, and soybeans to consumers. The loss of pyrethroid effectiveness would increase the magnitude of the transfers.

Acreage would shift the most in the Southeastern, Appalachian, Mountain, and Delta States, where Heliothis is a major pest. Cotton production in the Southeast could drop about 60 percent once chlordimeform is lost and 100 percent if pyrethroids also became ineffective.

The use of alternative control methods, the relative effectiveness of the alternatives, and change in pest control expenditures are difficult to estimate accurately. Study estimates and reported effects seem reasonably accurate but not perfect. The NAPIAP chlordimeform assessment team's estimates for Scenario 1 compare favorably with industry estimates. There are no estimates for comparison with Scenario 2. The estimates for Scenario 1 are likely to be more accurate than those for Scenario 2. The estimates presented in this study may deviate from true values, and results may differ if an alternative analytical tool is employed. Such limitations, however, do not nullify the conclusions of this study.

POLICY IMPLICATIONS

This analysis of pesticide loss scenarios illustrates the complexity of estimating the interrelated effects of pesticide policy and biological factors on agricultural production. The chemicals evaluated, chlordimeform and pyrethroids, are important Heliothis control inputs in cotton production. Excessive damage or expenditures caused by these pests affect the viability of cotton production in many areas. If we accept the premise that chlordimeform synergizes pyrethroids and acts as a pest resistance management tool, then a regulatory decision on chlordimeform use should also consider the possible loss of pyrethroid effectiveness.

Pesticides with a resistance management role create an interdependence among regulatory decisions. Ignoring that interdependence could lead to lower production efficiency or higher health risks. The need to consider resistance management reinforces Osteen's and Kuchler's argument (15, 16) that some EPA special reviews should be structured around alternative pesticides for important pest problems or groups of chemicals with similar uses.

Including farm program payment effects raises important policy questions. Removing pesticides from the market by EPA ban or manufacturer withdrawal could reduce program payments and the associated deadweight social loss by increasing commodity prices and reducing yields, but the removals would concentrate financial losses on the users of affected pesticides. An important policy question is whether the reduced income support associated with the reduced deadweight loss is desirable. Gardner (9) characterizes the deadweight loss of commodity programs as the social cost of transferring income from consumer-taxpayers to producers. If the income support is desirable, a pesticide removal could reduce the attainment of commodity program objectives by reducing income after payments for a group of producers. But even if reducing income support is desirable, a second question arises: is it fair to concentrate that payment reduction on the users of the affected pesticides? Society might conceivably find a more equitable allocation of payment reductions. These equity concerns might justify not banning the pesticide or compensating the losers if the pesticide were banned.

Also, consumer and program payment effects are important distributional effects that should be separated in an analysis of distributional effects. Consumers that lose from higher prices are not compensated, and consumers that gain from lower prices are not taxed. If lower program payments caused a tax decrease, the decrease might not be targeted to those experiencing price changes. Alternatively, the funds might simply be allocated to other purposes with no effect on Government expenditures.

Analysts must be aware of program participation rates and of such program parameters as the allocation factor and nonrecourse loan rate. The rules for computing farm program payment yields and crop acreage bases defined under current farm legislation are particularly important. Yield decreases might not affect program yields. So, the magnitude of payments would be affected only by price changes, and participant-users would suffer yield losses valued at the market price rather than the target price. Alternatively, the full effect on program yields and payments might not be felt for 5 years or more after a pesticide ban. In addition, although payments to cotton producers would decrease, payments to other crop producers and the associated deadweight loss could increase. Because of those program parameters, the potential exists for overestimating the reduction in deadweight loss and underestimating the net effect of a pesticide ban. The last result could provide an economic justification for a pesticide ban.

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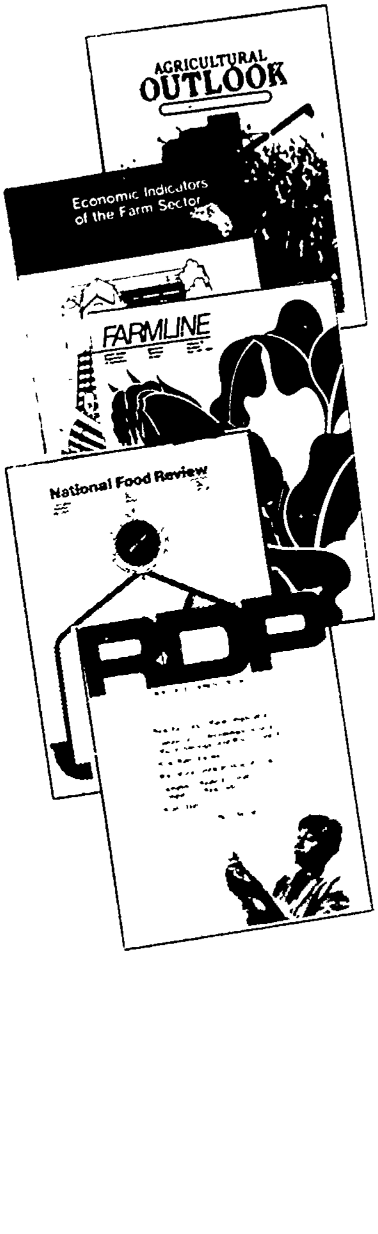

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