ESTIMATED IMPACT OF WITHDRAWING SPECIFIED PECTICIDES FROM COTTON PRODUCTION*

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Pesticides have become a major input for commercial agriculture. The quantity of pesticides applied annually is approximately 140 million pounds [2]. Even with this level of pesticide use, research indicates that per an additional dollar of pesticide use, returns are increased two to four dollars [5, 9]. However, recent emphasis on environmental quality has caused considerable pressure to discontinue use of some pesticides. This raises important questions regarding the impact of withdrawing specific pesticides from commercial agriculture.[1]

In response to possible cancellations, research has been directed toward establishing expected effects. However, much of the completed research is directed principally at the producer level and associated economic consequences of restricting the use of a pesticide. Some of the pesticides evaluated are phenoxy herbicides, organochlorines and chlordane [1, 3, 4, 7]. Other studies have considered the effect of a tax and change in government farm policy on level of pesticide use [8].

Common limitations of most of these studies have not considered cropping pattern adjustment or crop price response due to output changes. The purpose of this study is to overcome some of these limitations. Basically, the research and model development are directed to evaluating the effect of specified pesticide cancellations on cotton production.

Cotton was selected for emphasis in this study since most pesticides are used in cotton production and it is reasonable to expect pesticide withdrawals to have a significant effect on cotton yields, costs of production and total output. A comprehensive study is complicated because several regions are involved and the characteristics of each are different.

Due to regional production differences, this study was developed to estimate regional as well as national effects on cotton production that might evolve due to particular pesticide bans. For this work, five families for herbicides including anilines, triazines, arsenic, urea and oil solvents were used along with three families of insecticides including organochlorines, organophosphates and carbamates.

STUDY AREA

All of the cotton producing states were included in the evaluation. To appropriately consider regional differences, the cotton producing area of the United States were divided into regions with fairly homogenous production characteristics. A small work group of economists, entomologists and agronomists worked out the regional divisions as shown in Figure 1. Each of the eight regions was then subdivided into dryland and irrigated cotton since associated yields and costs were significantly different. However, only dryland cotton proved relevant in the first two regions and only irrigated cotton was relevant in the last two regions.

PROCEDURE

The methodology of this study was comprised of two distinct parts: (1) developing regional data and (2) developing a framework for analysis. A relatively new technique of collecting data was used in developing information on the expected cotton yield and cost response due to selected pesticide cancellations. The second part was development and

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[1] There was a Symposium in 1970 to examine the state of the arts with respect to economic analysis and pesticide use in agriculture[12].This Symposium included a discussion of the theoretical framework for analysis as well as research results from several pesticide related economic studies.

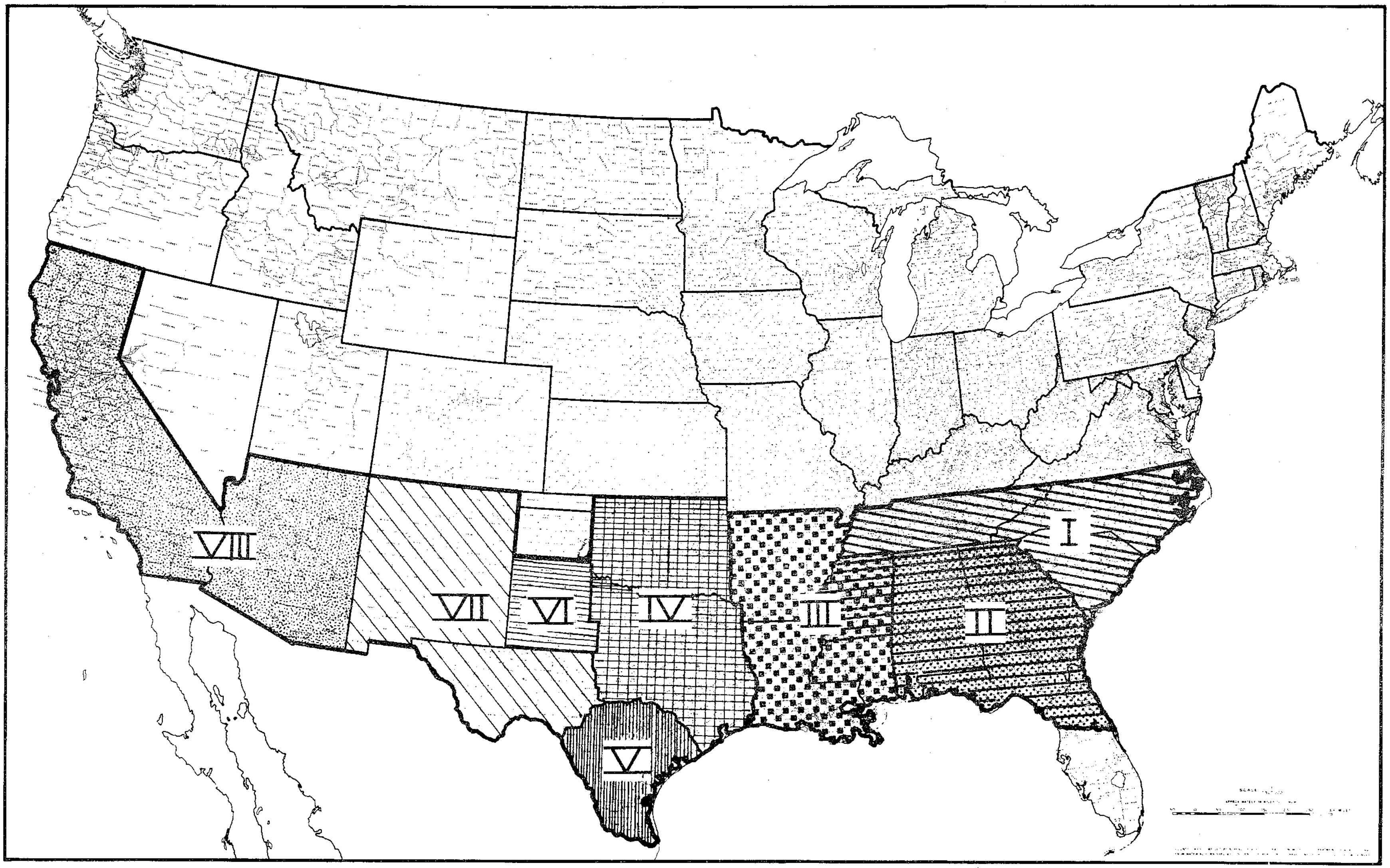

Figure 1. REGIONAL DELINEATION OF COTTON PRODUCTION REGIONS IN THE U.S.

application of a simulation model to determine the effects of specified cancellations of pesticide families.

Input Data Development

The data necessary for this study included regional estimates of the yield and cost changes due to pesticide cancellations. These data had not been previously generated. Therefore, a relatively new method called the "Delphi Technique," developed by Rand Corporation, was selected for developing this information [6]. The Delphi method integrates the opinion of experts in a logical, consistent, manner such that their knowledge and best judgment are reflected. Each contributing expert is asked to consider the estimates of other experts via a multi-round questionnaire system. The first round of questionnaires are collected, tabulated with a mean and percentile range determined for each response. Each additional round shows the respondent the results of the previous round and he is asked to adjust his responses based on a percentile range. If the respondent decides not to adjust into the range, he is asked to justify his position. The primary purpose of this type of adjustment process is to eliminate interferences of psychological factors caused by personalities.

For this particular study, three sets of questionnaires were developed and about 120 scientists participated. A separate questionnaire was developed for entomologists and for agronomists regarding per acre effects of specific pesticides family bans. The scientists were asked to estimate expected yield reductions and production cost increases due to the given ban. A third questionnaire was developed to obtain crop price and other economic information. Normally the Delphi method continues for four rounds, but this survey required only three rounds to bring the estimates into a very narrow range. After the three rounds, a complete tableau was developed including the estimated regional reduction in yield and production cost increase associated with the cancellation of alternative pesticide families (five families and three insecticides).

Other input data, such as regional acres of cotton, were taken from published statistics [10, 11, 13]. The economists questionnaire was used to establish per acre cost of production and cotton price elasticity of demand.

The Model

A general simulation model was developed to evaluate regional and aggregate effect of designated pesticide bans on cotton production.[2] The model is facilitated through a computer program that includes several sub-routines with alternative criteria that provide the basis for regional cotton production adjustments.[3]

Operation of the model involves designating by region, initial per acre costs of production, yield, price per pound and acres of cotton as well as regional acres and per acre net returns of the alternative crop to cotton. For this study, 1970 was used to establish these initial input data. Pesticide bans are then specified for none, one or two families of herbicides and none, one or two families of insecticides. For the first analysis, cotton acres are held constant in each region and the effects of the specified cancellations estimated with regard to national cotton output and regional cotton output, yield per acre, price and net revenue considering cotton and the major alternative crop. This establishes the cotton situation by region with a specified pesticide ban or bans preceding imposition of any acreage adjustment criteria.

Adjustments in cropping patterns are based on the relationship between per acre cotton net returns and per acre net returns for the alternative crop, by region.[4] The net returns of the alternative crop do not adjust with cropping pattern changes and only those acres that are initially designated as allocated to cotton and its alternative crop are subject to adjustments. In selecting appropriate land use, basically the crop (cotton or the alternative) with the highest net returns will be produced. This generally results in some regions using all available acres (initial acres of cotton and the alternative crop) for cotton, one region producing some acres of both crops where net returns per acre are equal for the two crops and all other regions shifting total available acres to the alternative crop. This adjustment process can be described as an unrestricted routine, as it allows for

[2] Although the model is specifically designed to evaluate pesticide cancellations, some policy alternatives other than pesticide cancellations can also be evaluated.

[3] Detailed methodology discussion and application of the model will be presented in a forthcoming Texas Agricultural Experiment Station publication.

[4] In the original model are four options whereby cropping pattern adjustments are estimated. Each option uses the relationship between net returns of cotton and the alternative crop as the basis for cropping pattern adjustments.

unlimited shifts in the acres of cotton and the alternative on the available acres.[5]

A limitation of this study is that a pesticide ban does not affect the yield or production cost for the crop chosen as the first alternative to cotton. Also, cropping patterns are adjusted assuming there are no governmental farm policies or other institutional restraints that would restrict regional changes in acres planted to each crop.

INPUT DATA

A rather large quantity of input data is required by the model and for this study was developed as previously discussed. The presentation of input data includes only a few examples and provides basically an indication of input data used rather than a complete listing.

An example of yield response data due to specific insecticide cancellations for dryland cotton in Louisiana, Arkansas and Mississippi is presented in Table 1. The values in Table 1 indicated the percentage reduction in expected yield and increase in production costs due to withdrawal of the insecticide family or families listed on the row and column. The estimated increase in production costs is given in parenthesis. For example, in row 2, column 2, a 15 percent reduction in per acre yield and $10.00 increase in production costs is indicated if organophosphorus is not used. Row 1, column 3, indicates a 15 percent reduction in yield and $8.00 increase in production costs if organochlorines and carbamates are not used.

Table 1. EXPECTED PERCENTAGE REDUCTION IN PER ACRE DRYLAND YIELD AND INCREASE IN PRODUCTION COSTS ASSOCIATED WITH WITHDRAWAL OF SPECIFIED INSECTICIDE FAMILIES FOR LOUISIANA, ARKANSAS AND MISSISSIPPI

Insecticides	Organochlorine		Organophosphorus		Carbamate	
	Percent	Dollars	Percent	Dollars	Percent	Dollars
Organochlorine	10	(4.00)[a]	15	(12.00)[a]	15	(8.00)[a]
Organophosphorus	15	(12.00)[a]	15	(10.00)[a]	20	(8.00)[a]
Carbamate	15	(8.00)[a]	20	(8.00)[a]	2	(2.00)[a]

[a]Estimated increase in per acre production costs are given in parenthesis.

As the quantity of cotton produced changes, the model allows for price change; in this study the total price elasticity of demand was established as -0.5 through the Delphi procedure. Considering the initial situation, which for this study was 1970, 10,156,100 acres of cotton produced 10,290,880 bales. Other input data used in this study include 1970 regional acres of cotton, yield per acre, production costs, acres of alternative crop and associated per acre net returns.[6] The initial average price per pound of cotton lint ranged from 19 to 25 cents depending upon the region.

RESULTS

With these and other data, the effects of specified pesticide cancellations were estimated. The expected effect of specific pesticide cancellations is presented with no cropping pattern adjustments first and then compared to the results derived assuming unrestricted movement of cotton acres among regions.

Without Acreage Adjustments

With initial (1970) cotton acres held constant in each region, the decline in regional and national output of cotton and associated net returns for cotton and the alternative crop were estimated for a withdrawal of organochlorines, organophosphorus, anilines and both organochlorines and organophosphorus (See Table 2). In 1970, cotton output was 10,290,880 bales and net returns to cotton and the alternative crop was estimated to be $623 million.

[5]Across all regions the "available acres" are 1970 acres of cotton and its alternative crop and consists of 31 million acres.

[6]The secondary or alternative crop to cotton, in each region, as established with the questionnaire, was soybeans in Regions I thru IV and grain sorghum in Regions IV thru VIII.

Table 2. **ESTIMATED REGIONAL AND NATIONAL EFFECT OF SPECIFIC PESTICIDE CANCELLATIONS ON COTTON OUTPUT, NET RETURNS AND COTTON PRICE**

		Pesticide Assumed Cancelled								
		Reduction in Cotton Output				Net Returns[a]				
	1970 Ouptut	Organo-chlorines	Organo-phosphorus	Organochlorines and Organophosphorus	Anilines	1970	Organo-chlorines	Organo-phosphorus	Organochlorines and Organophosphorus	Anilines
	(bales)	percent				Million Dollars				
I. Carolinas-Tennessee	732,763	10	8	40	5	104	104	111	77	97
II. Georgia-Alabama-Florida	854,622	10	10	19	0	44	44	46	45	46
III. Mississippi-Arkansas-Louisiana	3,066,479	9	14	14	9	338	333	330	348	296
IV. Central Oklahoma-North and East Texas	1,227,158	11	23	23	14	49	58	45	59	40
V. South Texas	409,700	7	22	23	34	16	16	10	7	1
VI. Texas High Plains	1,986,944	6	10	10	9	60	61	69	79	57
VII. West Texas-New Mexico	303,190	2	4	18	15	9	13	15	11	5
VIII. Arizona-California	1,810,030	1	4	9	0	4	23	36	32	12
TOTAL U.S.	10,290,880	6	11	14	7	623	648	663	658	553
Price Increase Per Pound of Lint (cents)		(9,667)[b] 2.7	(9,166)[b] 4.8	(8,758)[b] 7.7	(9,567)[b] 3.1					

[a]Net returns are producer net returns for cotton and the alternative crop to cotton.
[b]Total U.S. bales in thousands.

Model application indicated cotton output would decline 6 percent (624 thousand bales) and net returns would increase $25 million if organochlorines were withdrawn. The estimated increase in cotton price (2.7 costs per pound) would more than offset the yield and increased cost associated with withdrawal of organochlorines. The yield effect was greatest within Regions I through VI. Net returns to cotton and the alternative crop would be significantly increased in Regions IV, VII and VIII and change very little, if any, in the other regions.

Withdrawal of organophosphorus indicated similar results to organochlorines except output would decline 11 percent (1,125,000 bales), cotton price would increase 4.8 cents per pound and net returns to cotton and the alternative crop would increase from $623 to $663 million, compared to the 1970 situation. Withdrawal of organochlorines and organophosphorus would cause a 14 percent reduction in output. This yield impact would be most severe in Regions I, II, IV, V and VII. However, compared to the 1970 situation, net returns would decline only in Regions I and V, if organochlorines and organophosphorus were withdrawn. This indicates the complexity and surprises of evaluating pesticide withdrawal; i.e., of the five regions with a yield reduction of 18 percent or more, only two would experience a reduction in net returns. In aggregate, net returns would exceed the 1970 situation.

Withdrawal of anilines presents an example of lower aggregate net returns than in 1970. Output would decline 7 percent and net returns would decline in Regions I, III, IV, V, VI and VII. The increase in production costs caused by the pesticide withdrawal explain why net returns are not consistent with output and yield changes.

These results suggest that the aggregate effect of several pesticide cancellations would be similar. At the same time, the regional impacts fluctuate widely for different pesticide withdrawals. Only in Region VIII was there a consistent response in net returns to pesticide withdrawals (regional net returns increased above 1970 net returns). Even though these results provide insight into expected regional output response with specified pesticide cancellations, it should be emphasized that no acre adjustments were allowed. This leaves an important gap in estimates of the impact of pesticide withdrawals.

Unrestricted Acreage Adjustments

To extend the analysis to include expected cropping pattern adjustments, adjustments in regional acres were estimated with no pesticide withdrawn, organochlorines withdrawn and finally anilines withdrawn. Table 3 presents 1970 acres of cotton and net returns to cotton and the alternative crop in each region along with the acreage and net returns estimates developed with acreage shifts permitted.

Adjustments with no pesticides withdrawn, indicates cotton would shift completely out of Regions I and II, be reduced in Regions III, V and VIII and increase in the other regions. Net returns to cotton and the alternative crop would increase in each region with the adjustment and over all regions would increase from $623 million in 1970 to $999 million with adjustment. Total cotton acres would increase 240,000 while output would decrease over a million bales (from 10.3 to 9.2 million). Without further consideration of pesticides withdrawal, these estimates have strong implications relative to current cropping patterns and efficiency of production.

In discussing expected effect of a withdrawal of organochlorines and then anilines, it is convenient to relate to the results derived assuming no cancellations but free acreage adjustment. A withdrawal of organochlorines would not have much effect on total acreage of cotton, output would decline about 150 thousand bales and aggregate net returns to cotton and the alternative crop would decline $36 million (from $999 to $963 million). Within regions, the 464 thousand acres of cotton in Region V would shift out and cotton acres in Region VIII would increase from 663 thousand to 1.015 million. The major regional change in net returns would be a substantial reduction in Region VI.

Withdrawal of anilines would cause cotton acres to decline to about 8.446 million and output to decline to 8.546 million bales (683 thousand bale reduction). Some 196 thousand acres of cotton would shift out of Region IV, 2.156 million cotton acres would shift out of Region VI while 515 thousand cotton acres would shift into Region VIII. Aggregate net returns would decline from $999 million to $967 million with the largest reduction in Regions IV, VI and VII.

Since Region V would shift out of cotton production completely with both an organochlorine (insecticide) withdrawal and an aniline (pesticide) withdrawal, it appears the region is heavily dependent on pesticides. The organochlorine withdrawal did not affect Region VI particularly, but the withdrawal of anilines caused a 50 percent reduction in cotton acres. This suggests Region VI does not have a significant insect problem but that chemical weed control is very important to their cotton production.

Estimated effect of the organochlorine withdrawal indicates that with free acreage adjustments among regions, cotton output would be 596 thousand bales less that with the withdrawal on

Table 3. REGIONAL COTTON ACRES AND NET RETURNS FOR COTTON AND THE ALTERNATIVE CROP TO COTTON[a]

Region	Acres				Net Returns			
		Adjusted				Adjusted		
	1970	No Cancellations	Organochlorines	Anilines	1970	No Cancellations	Organochlorines	Anilines
	1000				1,000,000			
I	788	0	0	0	104	142	142	142
II	900	0	0	0	44	82	82	82
III	2,603	662	662	662	338	432	429	446
IV	1,839	3,420	3,420	3,224	49	95	94	75
V	509	464	0	0	16	31	29	29
VI	2,348	4,605	4,605	2,449	60	134	104	115
VII	217	581	581	581	9	35	36	20
VIII	953	663	1,015	1,530	4	47	47	57
U.S.[c]	10,156 (10,291)[b]	10,396 (9,229)[b]	10,284 (9,071)[b]	8,446 (8,546)[b]	623	999	963	967

[a]Acreage adjustments were estimated using the unrestricted routine of the simulation model; i.e., cotton produced in regions where per acre cotton net returns exceed that of the alternative crop to cotton and vice versa.

[b]Total U.S. bales in thousands.

[c]Due to rounding the totals may not agree with a summation of the column.

the 1970 cropping pattern but that net returns would be $315 million greater. Withdrawal of anilines caused large acreage shifts, hence, output with acreage adjustments would be 1.021 million bales less than if the withdrawal were imposed on the 1970 cropping patterns while net returns to cotton and the alternative crop would be $414 million more.

Usefulness of these results may be to indicate to policy makers the expected results of a particular action. By removing specific pesticides from use, cropping patterns and regional returns are affected. For example, without organochlorines, Region V would be expected to shift completely out of the production of cotton. In Region VI, removal of anilines would cause over two million acres to be shifted out of cotton. Without anilines for cotton production in Regions IV and VII, net returns would be reduced $35 million. Conversely, in many of these cases where rather large shifts occur, the effect on producer net revenue is relatively small. However, with significant shifts in output among regions, some consideration must be given to the effect on investment, people and local economies that are based on the product that is shifting out of the region. The overall implication of the results presented in this paper is that most pesticide cancellations, in aggregate, would not be associated with a major change in net revenue but that local effects may be very important and require the most consideration.

These results provide an indication of output available through application of the model developed. It is interesting to note that estimated national cotton acres would increase if free adjustment were permitted without pesticide cancellations. However, national cotton output would decrease. With pesticide cancellations, national cotton acres and output would decline as would net returns to cotton and the alternative crop. Perhaps more important than the national estimates are the regional shifts and effects. With the model, a region's dependence on a specific pesticide can be identified.

This study does not consider emerging pest management strategies or the externalities associated with pesticides. It must also be emphasized that the model is in need of refinements relative to alternative crop response to acreage change or pesticide cancellations. Nevertheless, model application does provide insight into expected primary effects of policy changes and/or pesticide cancellations.

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