Computer-Assisted Evaluation of the Economic Impact of Cancellation of Pesticide Registrations

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ABSTRACT

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Risk/benefit analyses, used by the U.S. Environmental Protection Agency (EPA) in the special review process, are central to decisions regarding continued use or cancellation of certain or all uses of pesticides under review. Because the benefit of a pesticide is, in part, a function of available alternatives to its use, information should be collected on the whole spectrum of plant protection chemicals for each crop-pest combination. A method of analyzing the prospective monetary and agronomic impact of losing selected crop protection chemicals indicated that the removal of carbofuran alone from the market would not have adverse effects on peanut production in North Carolina, as the use of available alternatives would result in small net gains in yield and revenue. However, carbofuran became much more beneficial when alternative nematicides were deleted first. We concluded that the EPA must be visionary when selecting pesticides for special review because the benefit/risk ratio increases as alternatives are eliminated.

Pesticides are registered for use in the United States by the U.S. Environmental Protection Agency (EPA) under the authority of the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) as amended (16). Many pesticides registered prior to the development of current standards for chemical residues, toxicity, and environmental fate must be reregistered with the EPA. Reregistration must consider both the risks and the benefits of each pesticide, including economic benefits (2,4,6,14,16). Recent legislation has increased the rate at which plant protection chemicals are reregistered (16). The reregistration of older chemicals can trigger a "special review" by the EPA for those chemicals that, under reevaluation, appear to pose an unreasonable risk of adverse effects to humans or the environment. Special review can result in the cancellation of some or all of the registered uses of a pesticide, in limitations on its use, or in its return to complete registration. The EPA looks to the U.S. Department of Agriculture (USDA) and other federal agencies for information on which to base risk/benefit analyses for these special reviews. These analyses should be based on the most reliable data available regarding current use patterns and the economic and agronomic impact of using alternative chemical and nonchemical methods to control plant pests. Acquisition of these data can be a difficult task, particularly for compounds with multiple activity (e.g., insecticidal and nematicidal) (1).

The economic impact of canceling a crop protection chemical depends on the alternatives remaining. Deletion of a pesticide can have a positive economic impact if it encourages the use of more efficacious alternatives, but the loss of the same compound may have significant negative economic consequences if no alternatives are available. Therefore, it is important to have a systematic method of evaluating several alternative deletion scenarios to describe the benefit of a compound. Because the EPA has been unable to fully interpret the efficacy of pesticides under special review (5), a pilot model was constructed to aid in the collection and analysis of data for the benefits assessment process (3). This was done, in part, to expedite special reviews where the USDA/EPA/university team approach is required. This model continues to be developed and is designed to interface with preexisting economic analysis programs (3).

In 1989, the EPA conducted a special review of the granular formulation of carbofuran (USDA/NAPIAP Carbofuran Assessment Team. 1989. Report to EPA: Benefits Statement for the Granular Formulation of Carbofuran [*unpublished*]). The USDA selected a committee of scientists to develop a benefits assessment of carbofuran to submit to the EPA. The purpose of the assessment was to estimate the impacts if registration of this material were canceled, with and without the cancellation of all alternative chemicals. The purpose of this paper is to report on the use of a computer program, Furadan Assessment (15), to organize, compile, and analyze the survey information collected for this review. The analysis program is not intended to be a comprehensive, whole-farm, enterprise budget; rather, it is designed to describe the direct economic impacts of treating a crop with alternative pesticides or of deleting these pesticides on value of a crop. The impact of various deletion scenarios on the benefit of carbofuran use for nematode control in peanut fields is reported.

Collection of data

A mail survey of 503 peanut producers in the 10 peanut-producing counties in North Carolina was conducted in May 1989 to collect information on pesticide

Table 1. Content of a data entry screen for price (dollars per kilogram of active ingredient) and deletion order of plant protection chemicals used for peanut nematode control in North Carolina[a]

Chemical	Price per unit active ($/kg)	Deletion order
Ethoprop 15G	18.36	4
Aldicarb 15G	38.45	2
Fenamiphos 15G	35.91	3
Carbofuran 15G	20.94	1

[a] Data on prices were obtained from agrichemical dealers. Deletion order refers to the order in which products might be removed from the marketplace. Carbofuran was deleted first because the study was designed to measure the impact of its loss. Thereafter, a worst-case deletion sequence was used, whereby the products that gave the greatest return per hectare were eliminated first.

The use of trade names in this article does not imply endorsement of any product named or criticism of similar ones not mentioned.

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use on the 1988 peanut crop. In those counties, 167,883 t of peanuts were harvested from 61,513 ha (7). The survey was designed as a stratified random sample of producers with the county as the stratum. The size of the sample taken in each county was proportional to the area of peanut production and the number of producers. Producers were randomly selected from mailing lists provided by county offices of the Agricultural Stabilization and Conservation Service.

Each producer received from the local county extension office a cover letter signed by the county agricultural agent, a questionnaire, and a business reply envelope in which to return the completed questionnaire. After 1 week, a second letter was mailed to each producer as a reminder to complete and return the questionnaire. After an additional 2 weeks, another letter, questionnaire, and business reply envelope were mailed to producers who had not returned a questionnaire. Data on the nematicides used and area treated with each nematicide were obtained from the questionnaires.

Data on area planted to peanut, state average yield, and prices received by peanut growers were obtained from the Agricultural Conservation and Stabilization Office. Price per kilogram of active ingredient of nematicide was estimated by a semiannual phone survey of pesticide dealers conducted by the Department of Agricultural Economics at North Carolina State University. State extension recommendations for application rate of chemical and number of applications were used to estimate amounts applied (1).

Yield and quality responses to various nematicide treatments in the Virginia/Carolina peanut region were computed from on-farm test results (8–13). Only years in which all treatments under consideration were tested were used. Carbofuran was used in combination with aldicarb in these tests. The effects of carbofuran were estimated by subtracting treatment effects of aldicarb alone, using the same rate and application method as the combination treatment. Data were obtained primarily in fields with damaging levels of the northern root-knot nematode (*Meloidogyne hapla* Chitwood), the predominant nematode pest of peanuts in North Carolina (6).

The computer program Furadan Assessment was designed to analyze the impact of the loss of carbofuran and the sequential deletion of all pesticides used as substitutes for carbofuran. The program was written in compiled BASIC and was designed to run on an IBM PC or fully compatible computer running PC/MS-DOS 2.0 or higher. This program is available for those who wish to use it (15).

Table 2. Content of a data entry screen for calculation of crop yield and quality adjustments associated with pesticide use[a]

	Current program				
Chemical	**% Ha treated**	**Total kg a.i./ha**	**Total treat/yr**	**Quality adjust (%)**	**Yield adjust (kg/ha)**
Ethoprop 15G	3.0	1.9	1	0.7	24
Aldicarb 15G	75.0	1.78	1	1.7	742
Fenamiphos 15G	15.0	1.78	1	0.7	679
Carbofuran 15G	4.0	1.78	1	0.6	259

[a] Input variables are percentage of treated area on which the various peanut nematicides were applied, amount of active ingredient used (kg a.i./ha), and number of applications per year. Quality adjustment is percentage decrease in value of crop due to pest damage. Yield adjustment is an estimate of loss that would occur if no nematicide was used. Data were obtained from a grower survey, extension recommendations, and information found in *Fungicide and Nematicide Tests.*

Table 3. Contents of four data entry screens for redistributing the percentages of the total treated area on which alternative pesticides are applied as each pesticide is deleted in order[a]

		Redistribution[b]			
Chemical	**Current % ha treated**	**Chem 1 removed**	**Chem 2 removed**	**Chem 3 removed**	**Chem 4 removed**
Carbofuran lost first					
Carbofuran 15G	4	0			
Aldicarb 15G	75	78.0	0		
Fenamiphos 15G	15	15.6	80.9	0	
Ethoprop 15G	3	3.1	16.2	97	0
Carbofuran lost second					
Aldicarb 15G	75	0			
Carbofuran 15G	4	17.6	0		
Fenamiphos 15G	15	66.1	80.8	0	
Ethoprop 15G	3	13.2	16.2	97	0
Carbofuran lost third					
Aldicarb 15G	75	0			
Fenamiphos 15G	15	66.0	0		
Carbofuran 15G	4	17.6	55.4	0	
Ethoprop 15G	3	13.2	41.6	97	0
Carbofuran lost last					
Aldicarb 15G	75	0			
Fenamiphos 15G	15	66.0	0		
Ethoprop 15G	3	13.2	41.6	0	
Carbofuran 15G	4	17.6	55.4	97	0

[a] Numbers are based on a survey of growers.
[b] Redistribution of use patterns (market share) proportional to original use percentages.

Results of survey

Of the 503 peanut producers surveyed, 278 responded (55%); 251 had produced peanuts in 1988. The respondents had planted a total of 6,932 ha, which was approximately 11% of the area planted to peanuts in 1988. Of the planted area reported in the survey, 37% had been treated at planting time with a granular nematicide; 4% of the total amount applied was carbofuran, 75% was aldicarb, 15% was fenamiphos, and 3% was ethoprop.

The computer program used seven video displays, or "screens." A disclaimer on the first screen stated that the results were only approximations. The second screen aided in file maintenance by allowing the retrieval of previously entered information. If data had been previously entered and saved, these files could be retrieved for editing or printing by typing in the name of the saved file.

The main program was executed through a series of four input screens and one output screen. A new analysis could be started by entering information on the state, crop, crop yield, harvest units, price per unit, area planted to the crop in the state, pest and/or pest complex, and area treated with pesticides of interest.

According to our survey, four primary pesticides were used by peanut growers to control nematodes (Table 1). Pesticides used primarily for other purposes or on less than 1% of the state's peanut crop were not included. For example, aldicarb was widely used as an in-furrow insecticide, but only the portion of it used for banded (high-rate) applications (27% of the growers) was considered to be intended for nematode control.

The last two items entered on this screen were price per unit of active ingredient of chemical and deletion order. Deletion order was the order in which compounds would be eliminated (i.e., lost from market) to create a new list of alternative compounds. The order was specified by the user of the program and could be used to make best-case or worst-case scenarios or to represent the most likely order in which the alternatives might be lost.

The second data entry screen (Table 2) was for current pesticide use patterns on the areas treated for the selected pest. Data in the column "% Ha treated" should total 100% unless some areas were treated with chemicals or methods other than those listed. In this example, 3% of the area treated did not fit the criteria for inclusion in the analysis.

The column "Total kg a.i./ha" allowed entry of the total amount of active ingredient in all applications for this pest (recommended rate of application × number of applications). This value was multiplied by the price per unit from the previous screen and stored as a negative number to represent a cost. The product of the number of treatments per year × the cost of application was added to the cost of the chemical to get the total cost of a chemical application. "Total treat/yr" indicated how many applications were made in one season. "Applic $/ha" (not shown in Table 2) was the estimate of overhead, labor, and equipment associated with each application. Application costs for aldicarb were considered to be zero, as this expense was allocated to planting costs.

When pest injury to an untreated crop resulted in a decrease in quality of the commodity, a quality adjustment value was entered as a whole number between 0 (no loss) and 100 (total loss) in the "Quality adjust (%)" column. The program converted this value to a percentage and multiplied that by the average yield to estimate benefit (kg/ha) from the use of the pesticide. Quality adjustment was based on either value or yield lost due to a decrease in marketability of the harvested crop. If pest injury to the crop resulted in a yield loss, that number was entered in the "Yield adjust (kg/ha)" column. The value of this adjustment reflected the yield and/or quality that was preserved by the use of this pesticide (Table 2).

As pesticides were deleted, pesticide use patterns were redistributed (Table 3). Four different deletion scenarios were examined, where carbofuran was eliminated first, second, third, or last. The alternative nematicides were always eliminated in the following priority: aldicarb, fenamiphos, and ethoprop. Once a nematicide was lost, the percentage of treated area to which it had been applied (market share) was redistributed to the remaining nematicides based on the proportion of total treated area to which each had been applied, according to the survey. For example, when carbofuran was deleted first, the 4% market share it had was redistributed to aldicarb, fenamiphos, and ethoprop in a 75:15:3 ratio (Table 3). Original use proportions found in the column "Current % ha treated" were obtained from the survey of North Carolina peanut producers. For this presentation, the total percentage treated was left at 97% until all nematicides were deleted, since the four nematicides were used on 97% of the 2,564 ha treated for nematodes.

Economic analysis

Systematically deleting nematicides and redistributing their market share to those remaining had a substantial effect on peanut production and revenue for North Carolina (Table 4). Elimination of all nematicides resulted in a loss equivalent to 13,837,000 kg of peanuts due to unchecked nematode damage. Revenue losses, which included yield and quality losses, adjusted for reduced pesticide input and application costs, amounted to $3,451,000. These losses were the same regardless of the order of deletion leading to total elimination.

The order in which carbofuran was deleted had a profound effect on its benefit. Loss of this nematicide produced changes in production from a 1,073,000-kg increase to a 5,221,000-kg decrease, depending on the nematicides remaining as alternatives. Likewise, revenue changes ranged from an increase of $279,000 to a decrease of $1,168,000. The other nematicides were similarly affected (Table 4).

Evaluation of analysis

Agricultural experts are increasingly called on to supply information regarding the use patterns and benefits of pesticides. The benefit of a pesticide depends on its biological activity, the destructiveness and prevalence of target pest(s), cost of application, and alternatives available. Benefit analyses should include the whole spectrum of pest control alternatives. These analyses are important, because many alternatives can be less effective, in danger of being removed from the market, or unsuitable for a particular pest or pest complex. The procedure described in this paper is a method by which the benefit of a pesticide can be evaluated in the presence or absence of various alternatives. This paper shows that the availability of efficacious alternative compounds has a profound effect on the "benefit" of the compound under special review. Although this paper focuses on synthetic pesticides, cultural controls can also be compared in associated costs and effectiveness. Moreover, this analysis program is not limited to nematicides. The format of this program can be used for most types of pesticides and/or biological or cultural controls.

Table 4. Effect of cumulative deletion of nematicides on peanut production and revenue for North Carolina

Initial selections[a]	New selections	Changes for state production revenue[b] kg × 1,000	$ × 1,000
Carbofuran lost first			
C+A+F+E	C+A+F+E	0	0
C+A+F+E	A+F+E	330	88
A+F+E	F+E	−3,049	−836
F+E	E	−10,243	−2,813
E		−875	110
		Total −13,837	−3,451
Carbofuran lost second			
A+C+F+E	A+C+F+E	0	0
A+C+F+E	C+F+E	−3,806	−1,031
C+F+E	F+E	1,073	279
F+E	E	−10,229	−2,809
E		−875	110
		Total −13,837	−3,451
Carbofuran lost third			
A+F+C+E	A+F+C+E	0	0
A+F+C+E	F+C+E	−3,820	−1,034
F+C+E	C+E	−6,660	−1,797
C+E	E	−2,482	−730
E		−875	110
		Total −13,837	−3,451
Carbofuran lost last			
A+F+E+C	A+F+E+C	0	0
A+F+E+C	F+E+C	−3,820	−1,034
F+E+C	E+C	−6,660	−1,797
E+C	C	1,864	548
C		−5,221	−1,168
		Total −13,837	−3,451

[a] C = carbofuran, A = aldicarb, F = fenamiphos, E = ethoprop.

[b] Predicted changes in peanut production and value of production due to the loss of carbofuran under the four scenarios shown in Table 3. Negative values indicate that the loss of a pesticide resulted in reduced production or revenue.

Table 5. Sources and accuracy of information used for the economic impact assessment program

Input	Source	Estimated effect on accuracy of assessment
Area planted, yield, price per kilogram of peanut	USDA-ASCS,[a] Raleigh, NC	Minor
Price per unit active ingredient of nematicide	Dealer survey	Minor
Area treated with available nematicide	Grower survey	Minor
Rate of application, number of applications	Extension literature	Moderate
Deletion order, redistribution of pesticide use	Opinion of state agricultural specialists	Major
Yield and quality adjustment	Research (*Fungicide and Nematicide Tests*)	Major

[a] U.S. Department of Agriculture Agricultural Stabilization and Conservation Service.

There are several sources of error in the data used for this model. The level of accuracy needed is defined by the goals of the study and how clear-cut the case is for or against the compound in question. Table 5 shows, on a relative scale, the amount of error for each type of measurement. Data from the USDA Agricultural Stabilization and Conservation Service and dealer and grower surveys were considered to be reliable. Data for chemical rates and numbers of applications, extracted from extension literature, are moderately reliable, as these data change with the grower and the season.

Deletion order and redistribution of pesticide use patterns were seen as major sources of variability in making an accurate estimate of the impact of nematicide loss, as values in these categories were based largely on conjecture of agricultural specialists. Yield and quality adjustments also represent a large source of variation, as these parameters change significantly with rotation, weather, nematode species, soil type, etc.

Values used in these analyses can represent measured values or estimates. Estimates can reflect the best-guess value. The type of value should reflect the purpose of the analysis. For example, separate analyses can be derived using maximum and minimum values to establish the upper and lower economic extremes resulting from the loss of one or more pesticides. Measured, average, or best-guess values could be used to estimate the most likely outcome of deletions.

The objective of the analysis presented in this paper was to estimate the most likely outcome of the loss of carbofuran. Measured values were used where available (i.e., area planted, yield, prices for peanut and chemicals, and area treated). Values for rate and number of applications and yield and quality adjustments were best guesses and estimates of the real values. Deletion order represented a special case. Only one sequence of deletion of carbofuran alternatives was used: aldicarb first, then fenamiphos, then ethoprop. We selected this order as the most likely one in which these materials might be lost from use. Other deletion combinations could have been used. Other assumptions were that as compounds were lost, their market share would be redistributed in proportion to the original market share and that all treated hectares would continue to be treated. These assumptions lack supportive data. However, the program is designed to allow quick reanalysis to investigate other probable redistribution sequences and to explore the impact of various redistribution scenarios. Alternative sequences were not presented in this paper.

The possible loss of carbofuran as a nematicide in North Carolina would have an economic impact on peanut farmers in that state. This impact may be positive or negative, however, depending on the alternatives available. This example shows that benefit assessments based on available alternatives lose their value when the alternatives change. Therefore, the useful life span of a benefits assessment can be quite short. In the future, benefit assessments should utilize computerized models, such as this one or others under development (3), so that the data can be quickly reanalyzed in a new context. In addition, pesticide-regulating agencies should keep in mind that elimination of pesticides can increase the benefit of remaining products regardless of their environmental and/or toxicological characteristics.

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This section is designed to help APS members understand more about APS Sustaining Associates. Information was supplied by company representatives. Each month features different companies. A complete listing appears in each issue of *Phytopathology*.

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