Pesticide Use and Produce Quality

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IMPACTS OF REDUCED PESTICIDE USE ON THE PRODUCE INDUSTRY

Ronald D. Knutson
Agricultural and Food Policy Center
Texas A&M University

Economic research on the fruit and vegetable industry is among the most neglected in agriculture. Yet this industry has become a focal point for policy decisions relating to agricultural pesticides. Of all agricultural segments, fruits and vegetables are being the most profoundly affected by court-mandated policy changes requiring interpretation of the zero tolerance provisions of the Delaney clause.

Background on Issues Analyzed

Most studies of reduced pesticide use deal with the implications of taking an individual chemical off the market. This orientation results from the requirement under Federal Insecticide Fungicide Rodenticide Act (FIFRA) that the costs of market be weighed against the benefits. The major benefit from pesticide use is the increased yield experienced by farmers, the improved ability to store produce, and the increased availability of domestic products to consumers throughout the year.

To date, substitutes have been available for most individual pesticides when and if they are withdrawn from the market. Therefore, the withdrawal of a pesticide has not, as a general rule, meant the product could not be produced. However, after years of winnowing down the number of registered pesticides, questions of the availability of any chemicals to control particular pests have become more real. Moreover, there are those who advocate policy changes that would further tighten the screws on pesticide availability as evidenced by presence of the Kennedy-Waxman Proposal. These advocates are supported by recent court decisions imposing the strict zero tolerance provisions of the Delaney Clause on the presence of minutely detectable carcinogenic residues in processed foods.

Nature of the Issues Analyzed

This paper explains what I have learned about the methodology for analyzing the impacts of reduced pesticide use on fruits and vegetables. Undoubtedly, most of you are aware that I supervised a study of the impacts of zero pesticide use for the major program crops. (Knutson, Taylor, Penson and Smith, 1990a and 1990b; Smith, Knutson, Taylor and Penson; Taylor, Penson, Smith and Penson; Richardson, Smith, Knutson and Outlaw). This study was the subject of considerable criticism (Ayer and Conklin, 1990 and 1991; Doering; Knutson, Taylor, Penson and Smith, 1990a; Knutson, Taylor, Penson and Smith, 1991). However, the specific yield reductions and cost increases reported in the study have not, to my knowledge, been refuted and have, to the contrary, been supported as being realistic (Schaub, Tweeten).

This initial study of the impacts of reduced pesticide use on the major program crops indicated substantial yield impacts (Figures 1 and 2). While costs per acre of growing some of these particular crops declined, their unit cost inevitably rose (Figures 3 and 4) because yields fell more than costs in percentage terms.

A separate dimension of this initial study utilized a macroeconomic and agriculture sector general equilibrium model (Ag-Gem) to determine the impacts of reduced pesticide use on prices, livestock producers, agribusiness, consumers, and macroeconomic variables such as inflation. A study of this type would not be possible in fruits and vegetables because, to my knowledge, none of the agriculture sector models include the supply and demand relationships for individual fruits and vegetables. However, at least one such model is supposed to be in developmental stages. The requirement for an agriculture sector model, as opposed to just a fruit and vegetable sector model, is particularly important for analyses of the price effects because of the need to consider both the substitution effects and the requirements for increased land as yields decline. Just as output-enhancing technology reduces the demand for land, taking that technology away has the opposite effect.

This study involves potatoes, oranges, tomatoes, grapes, apples, lettuce, onions, sweet corn and peaches. Because of the absence of individual fruit and vegetable product components in agriculture sector models, our study of the impacts of reduced pesticide use on fruits and vegetables will only address the issue of the yield and cost effects. While familiar with the above dialogue, you may not be aware that I am currently supervising a similar study of the impacts of pesticide-use reduction on nine fruit and vegetable crops utilizing the same basic methodology. I will not be reporting on the results of that study because the study is not yet complete as is the program crops study. However, I will utilize our experiences in both studies to explain some of the methodological issues related to studying reduced pesticide use and to draw implications for future research.

While studies of zero use of pesticides have been posited as being irrelevant to the policy issue of chemical use on major program crops (Ayer and Conklin, 1990), it quite clearly is not irrelevant to the minor use crops for which:

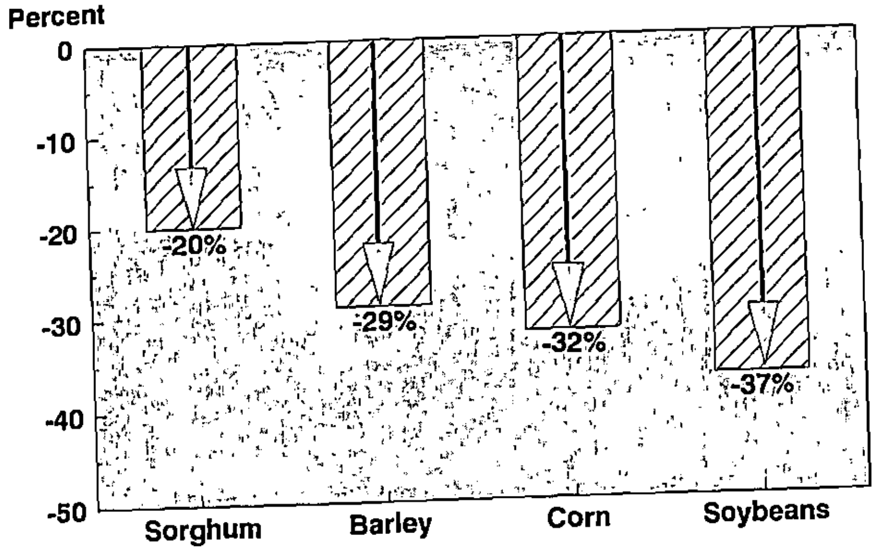

Figure 1. Percentage Yield Impacts of Reduced Pesiticide Use on Feed Grains and Oilseeds

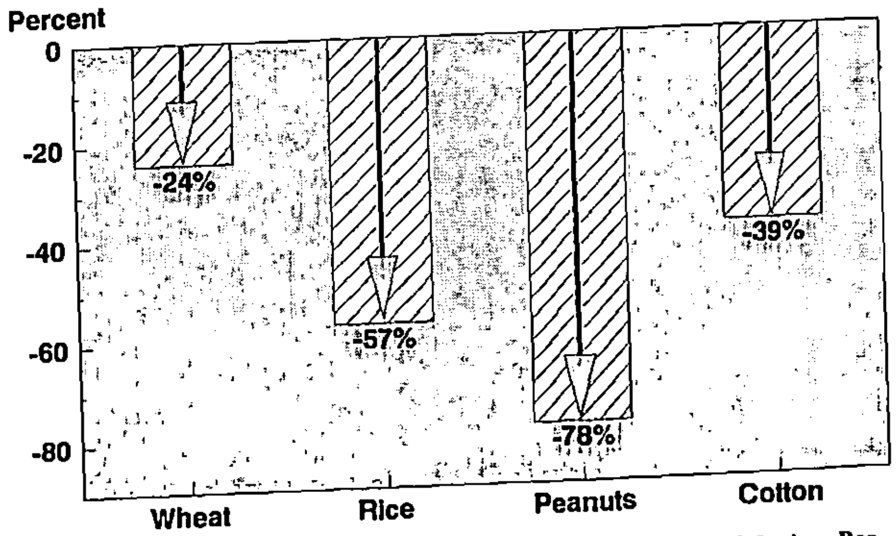

Figure 2. Percentage Yield Impacts of Zero Pesticide Use on Food Grains, Peanuts, and Cotton

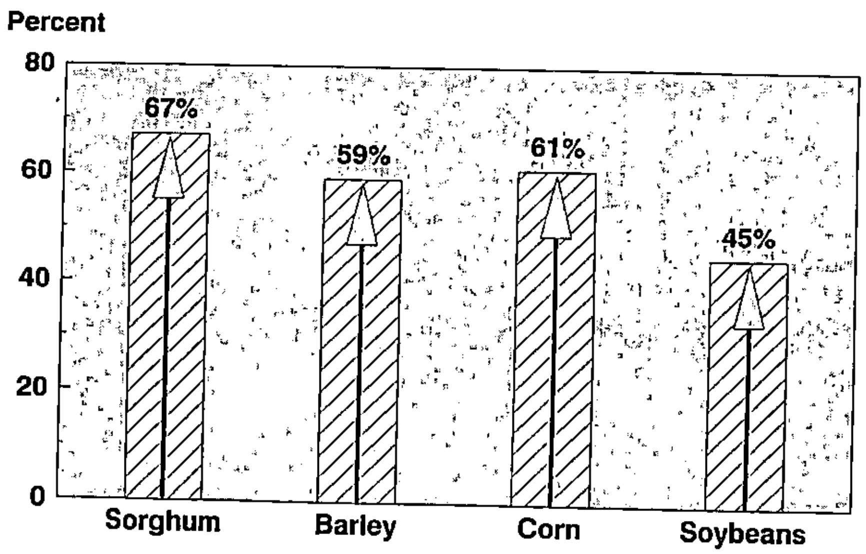

Figure 3. Percentage Impacts of Reduced Pesticide Use on Unit Costs of Producing Feed Grains and Oilseeds

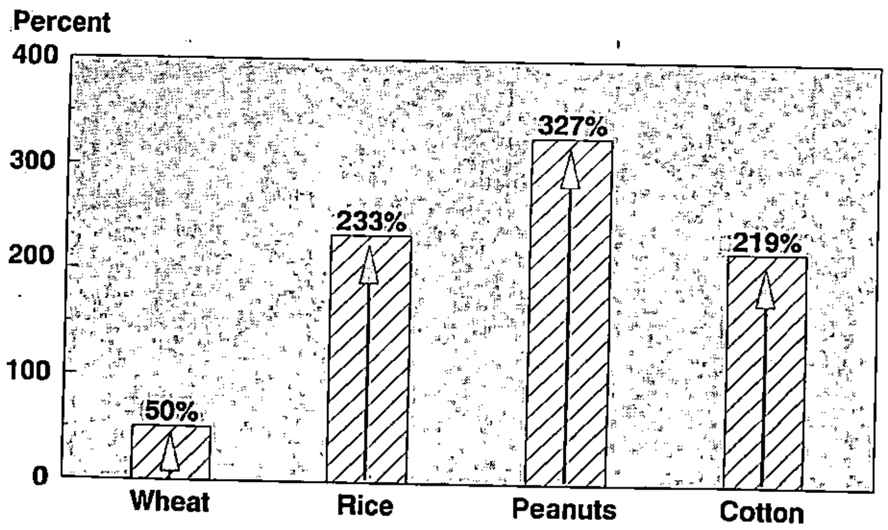

Figure 4. Percentage Impacts of Zero Pesiticide Use on Unit Costs of Producing Food Grains, Peanuts, and Cotton

- The options for control of particular pests have declined, with only one or two chemicals now available.
- The pesticide manufacturers, in effect, are limited procedurally on the number of crops for which a chemical can be registered for use if any carcinogenic effects are found.
- The existence of proposals that would approach the unworkable zero tolerance criterion contained in the Delaney Clause (EPA) threaten the use of pesticides on a wide array of crops.

However, as an innovation from the program crop study, the fruit and vegetable study includes yield and cost estimates for both the zero-use option and for a 50 percent reduction *in the number of pesticide applications*. Using this approach, the 50 percent option could be analyzed only if there were more than a single application of herbicides, fungicides or insecticides.

The interest in the 50 percent option results from the contention by Doering and others that the zero option is not only unrealistic but was chosen to have maximum impact—a contention apparently related to an allegation of biased results due to chemical company financial support for the program crops study. There is no chemical company money involved in the fruit and vegetable study.

Doering asserts that the yield response curve associated with reduced chemical use is concave, meaning there could be substantial reductions in pesticide use with little impact on yield as indicated by the right hypothetical graph in Figure 5. We desired to test the Doering hypothesis. While having one observation between zero use and commercial practice may not be definitive in determining the exact shape of the yield response curve, it should be decisive on whether the tendency is toward concavity as hypothesized by Doering.

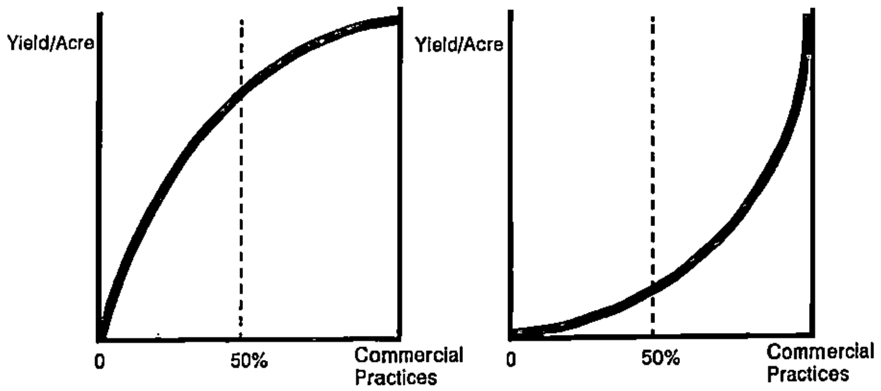

Figure 5. Alternative Hypothetical Nonlinear Shapes of the Pesticide Yield Response Curve

Procedure

With the exception of the introduction of the 50 percent option, the procedures followed in both studies are basically the same:

1) Lead plant and farm management scientists were selected for each crop and, in some instances, for each production area. The plant scientist was selected as the most knowledgeable person we could obtain for the crop. The plant scientist had to have a reasonably broad agronomic knowledge base covering weeds, fungi, mites, insects, growth regulators and sprout inhibitors. Ideally, he/she had to have expertise in each of the major production areas although, if this was not the case, he/she could consult with other scientists located in the other regions. Alternatively, we retained the services of more than one lead plant scientist. We found that, generally, the ideal farm management scientist is the person who prepares the crop budgets for the state in which the crop is produced.

2) The lead plant scientist specifies the baseline commercial production practices. In other words, he/she defines the cultural practices and inputs utilized to grow the crop. Among the cultural practices to be specified was the use of pesticides in the following categories: herbicides (including growth regulators and sprout inhibitors); fungicides; and insecticides (including miticides). However, all other cultural practices involving the use and timing of machinery, labor, irrigation and crop rotation were obtained. The farm management scientist then developed the per acre cash cost budget that was consistent with the baseline. Fixed costs were not included because of the problems of valuing fixed assets. Since fixed costs were not considered, the results tend to be on the conservative side because, at a minimum, more management is required under reduced pesticide conditions and more and different machinery may be required.

3) The lead plant scientist specifies the cultural practices and yields associated with eight pesticide-use reduction scenarios for each region analyzed.[1]

▪ No herbicide	▪ 50 percent herbicide
▪ No fungicide	▪ 50 percent fungicide
▪ No insecticide	▪ 50 percent insecticide
▪ No pesticide	▪ 50 percent pesticide

Cultural specifications may include changes in the frequency of cultivation, increased use of hand labor, adjustments in crop rotation patterns, changes in timing of applications. Yield effects could be determined with the assistance of previous studies, from demonstration plots, or from observations on farms, but the lead scientists were cautioned that the results must be practicable on a commercial farm basis. Organic farm results were useful to some scientists, although they had to be adjusted for

pesticides used, such as sulfur or pyrethrins, which must now also go through the re-registration process mandated under FIFRA. While each lead plant scientist weighed the substance of relevant research, there were ultimately elements of expert judgment involved. Once the cultural practices and yields were specified for each reduced-pesticide scenario, the farm management scientist modified the baseline budget for each scenario. The unit cost for inputs was not adjusted. Despite potentially large increases in demand for inputs such as labor when herbicides are eliminated, it was assumed these inputs would be available at the current price—a very conservative assumption.

4) The cost per unit of product produced under each scenario was calculated by dividing the cash cost per acre by the yield per acre. In cases in which a larger proportion of land was fallowed to control pests, the yield per acre had to be properly adjusted to reflect the reduced productivity of the land utilized to produce the crop. If the farm management economist or plant scientist failed to account for changes in cropping patterns, the inevitable result was an underestimation of the magnitude of the yield reduction. For example, if under baseline commercial practices fallowing is now used, but under the without-herbicides option it becomes necessary to fallow every other year, the yield per acre is automatically cut in half. Thus, while the scientist may perceive the farmer as receiving the same yield *on the acres cropped*, the effective percent yield reduction is 50 percent! Changes in crop rotation patterns appear to be more important in the major program crops than in the case for fruits and vegetables.

Definition of Pesticide Categories

Pesticide-use reduction on fruits and vegetables is more difficult to study than on program crops. One reason lies in the differing objectives for which chemicals are applied to fruits and vegetables. For example, the chemicals used as herbicides also serve to reduce the number of blossoms on trees in orchards, thereby resulting in larger fruit and higher yields. Chemicals such as gibberellin used on grapes serve a similar growth regulating function in terms of the effect on fruit size. Sprout inhibitors used on onions and potatoes likewise are used to regulate growth.

Biologicals are proliferating as methods of insect control. Conceptually, these substances are subject to the same registration and testing procedures as other agricultural chemicals. In a no-pesticide world, biologicals would likewise be banned from use. Pheromones are among a group of chemicals that disrupt the mating habits of insects.

Several chemicals have a natural or organic origin that make them "acceptable" for growing crops organically. Under the re-registration requirements, organic chemicals such as sulfur and pyrethrins are presumably subject to the same requirements as inorganic chemicals. Interestingly, these chemicals have not been subject to the same level of scrutiny as the inorganics.

Concept of Marketable Yield

One of the major issues encountered in the fruit and vegetable project has involved the definition of what constitutes marketable yield. The issue is probably best understood by considering two questions:

- Will the U.S. consumers buy wormy sweet corn? Commercially, buyers/brokers have determined that the problem of selling wormy sweet corn is sufficiently severe that the existence of two worm-infested crates per truck results in rejection of the load. Moreover, clipped corn, on which the wormy end of the cob is cut off, is not saleable in supermarkets. One might speculate that if only wormy sweet corn were available, consumers would eat it. However, the market niche of people who would eat wormy corn may be considerably smaller than the current market. In addition to sweet corn, worms are a major problem in apples, peaches, plums and tomatoes.

- Would/should domestic and international standards for insect parts in processed foods be raised to allow for marketing of products produced from worm- or insect-infested products? While this issue applies to both domestic and foreign markets, the international issue may be more problematic because of the potential loss of substantial market shares.

The issue of marketable yield is more complex than insect parts. Determining the marketable yield involves consideration of at least three additional problems:

- External appearance of fruits and vegetables frequently is referred to as a cosmetic issue. This is only partially the case. Plant diseases, which are only one cause of external appearance problems, create storage and internal quality problems. Therefore, considerable care needs to be exercised in defining the term cosmetic.

- Size of fruits and vegetables decline with more weed, insect and disease problems. Moreover, as indicated previously, growth regulators are utilized to generate larger fruit preferred by consumers. Consumers could do without large fruit, but would also have to be satisfied with lower yields and higher prices.

- Sprout inhibitors foster storability of vegetables such as onion and potatoes. Were it not for sprout inhibitors, such vegetables would be available from domestic sources for a shorter time period. Accordingly, U.S. consumers would be more import dependent.

Implications for Future Research

The concept of marketable yield requires considerable research of an experimental as well as a survey nature. What quality of products will consumers buy in the presence or absence of alternatives? In what quantity will they be purchased and at what price? Will consumers switch to alternative fruits and/or vegetables in the presence of defects resulting from reduced pesticide use? What are the impacts of such switches? Will imported products, on which pesticides are used, be preferred to domestic products? All of these are questions that require answers to evaluate the costs and benefits of reduced pesticide use.

There have been a number of proposals to tax the use of pesticides. Evaluating the impacts of these proposals requires a knowledge of the elasticity of demand for pesticides in specific uses as well as in the aggregate. Economic theory suggests that if the demand for the products (fruits and vegetables) is inelastic, the demand for the input ought to be inelastic. Moreover, the consequences of not applying pesticides in the presence of a pest problem suggests that the demand for pesticides should be quite inelastic. If that is the case, the tax on pesticides would need to be large.

Prior to making policy decisions on reduced pesticide use, a general equilibrium model needs to be developed that makes it possible to evaluate the price effects. We are dealing with a set of commodities that are good substitutes for one another. Accordingly, the magnitude of the price impacts are difficult to determine.

NOTES

1. In the program crop study, fungicides and insecticides were combined in a single category. Then estimates were made for possible pesticide group combinations with nitrogen fertilizer.

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WHO MAKES PESTICIDE USE DECISIONS: IMPLICATIONS FOR POLICYMAKERS

David Zilberman, David Sunding, Michael Dobler
University of California, Berkeley

Mark Campbell
University of California, Davis

Andrew Manale
U.S. Environmental Protection Agency

Concern about the impacts of pesticide use on food safety, worker safety, water quality and the environment has motivated establishment of a complex set of pesticide-use regulations. However, these policies are far from perfect and research continues on how to improve control of pesticide use. Identifying efficient and effective policies requires understanding both who makes decisions regarding pesticide use and how these decisions are reached.

Most quantitative models of pest management choices assume, either implicitly or explicitly, that decisions are made by farmers. While there is some literature addressing the importance of pesticide advisors, not much attention has been given to the role of other elements in the agricultural production chain in decisions regarding how to manage pest problems. On the other hand, there is growing recognition that the production of food and fiber represents a process that involves many entities. Since decisions at each stage of the production chain are interrelated, pest management choices are likely to be affected not only by farmers and advisors but also by other agents.

This paper presents the findings of a recent survey investigating the contributions of various agents at different stages in the food production chain to decisions on pest management and pesticide use. It identifies those links that affect pest management practices and describes the types of impacts they have. It also investigates how the pattern of pesticide decision making varies across agricultural industries and regions. The analysis is mostly limited to Calfiornia fruits and vegetables. Since California is the largest agricultural state and the major producer of many of the fruits and vegetables sold nationally, pest management choices in California have significant impact outside the state. Furthermore, we postulate that some of the generalizations derived from California data apply to other regions.

The first section of the paper identifies different types of agents