Part IV. Analytical and Data Needs for Pest-Management Programs: Panel-Discussion Summaries

Introduction

Good data on pests and pest-management technologies are the prerequisites for building reliable models, performing accurate analyses, developing effective policies, and making good management decisions. The workshop and panel sessions grouped in this chapter discuss ways to improve the data that are collected in survey programs and other USDA programs that address pesticides and pest management.

USDA programs for data collection and analysis are designed to gather information on farming practices, farm and operator characteristics, and economic conditions to address broad issues in U.S. agriculture. The data are needed to determine the full benefits and costs associated with the use of chemical-based pest-management strategies and with the use of alternative strategies such as IPM. The benefits and costs include impacts to farm profits, environmental quality, human health, and the food supply. The data also are needed to assess the extent of adoption of alternative pest-management practices and to ascertain the factors that influence adoption.

The scope and breadth of the public data that are currently available at the national level and the innovations that are being experimented with in USDA and elsewhere are discussed in the opening session in this chapter on data needs for IPM assessment. Prior to the early 1990s, USDA's National Agricultural Statistics Service (NASS) and Economic Research Service (ERS) collected some pesticide-use data for major field crops in major producing States, but little data were collected for fruits and vegetables or for other pest-management practices. Beginning in the early 1990s, USDA began conducting a chemical use and practices survey for fruit and vegetable crops and expanded pest-management data collection for major field crops. In addition, a limited set of data was gathered from 1991 to 1993 on a location-specific basis, rather than by crop, to assess agricultural management practices and chemical use within 10 selected U.S. watersheds. In 1996, ERS and NASS combined several survey programs to collect data on farming practices, input use, yields, and economic characteristics with a single survey instrument. Questions were included on the adoption of several IPM practices. Although survey costs and respondent burdens preclude the use of this design for all commodities on an annual basis at this point, the basic design is scheduled for use with other field crops in subsequent years.

Analytical needs for further data improvement to perform more rigorous assessments of IPM are also discussed in the opening session. One panelist offered suggestions for improving IPM assessment through targeting a major data collection effort toward comparative research. Comparative research would help analysts understand why IPM is used intensively in one setting but not in others through examination of the pest management influences (e.g., State pesticide policies, cultural attributes in different farm settings, the availability of independent crop consultants, better communication technologies by Extension, and physical production-system attributes) that play a major role in IPM adoption. The improvements in national-level data collection that have just been implemented may also help catalyze a better understanding of how and why IPM practices and philosophy are adopted by farmers.

Changes in pesticide use have been used as a measure of environmental and human-heath impacts in the majority of IPM assessment studies conducted previously. More thorough evaluations of the environmental and health impacts of IPM would require systematic collection of water-quality monitoring data and the development of human-health-impact models. California was reported to have a pesticide-illness-surveillance program to track illnesses caused by acute occupational exposure to pesticides. Comparable data are unavailable at the national level, and few other States have similar programs. Comprehensive assessments of the effects of occupational pesticide exposure on the risks of contracting cancer, neurodegenerative disease, and other chronic health problems are rare. The Federal Agricultural Health Study, which was described in the previous chapter, is tracking pesticide use and other factors linked to chronic disease in approximately 75,000 operator/applicators and spouses in two States and will help fill the occupational-health-data gap.

Despite data limitations, environmental-assessment models are being developed and tested by university researchers and consultants for a variety of uses. Some of these models are described in the "Assessing Environmental Impacts" panel session summary. While most of these models make environmental-risk comparisons between pesticides, several also include at least a partial set of cultural and biological pest-management methods.

The benefits of agricultural pesticide use were addressed by three panel and workshop sessions. These sessions covered the data collection and modeling efforts in two USDA pesticide programs, the IR-4 program and the National Agricultural Pesticide Impact Assessment Program (NAPIAP). The IR-4 program collects pesticide-residue data for minor crop uses to help register pesticides for small markets that pesticide manufacturers find unprofitable. This program expects to make increasingly more biopesticides and other "ecosystem friendly" products available though its registration-streamlining program. The NAPIAP program provides information to EPA on the benefits of pesticide use in agriculture for regulatory decision making.

Data-availability issues were central issues in these panels. Data are nonexistent for some important variables (such as the frequency and distribution of many major crop pests) and are of poor quality for others. Better data would allow economists to estimate impacts associated with proposed regulatory actions on pesticides that currently are not calculated, such as costs by changes in pesticide resistance. And biologists could produce better estimates of the yield and quality effects of alternative pest-management technologies with better data.

A "one-stop-shopping" database for pest-management information is currently being built by USDA and Argonne National Laboratory and is described in the last session summary in this chapter. The purpose of the Pest Management Information Decision Support System (PMIDSS) is to facilitate the use of consistent standards for pest-management data collection, to integrate existing pesticide and pest-management databases (including databases on EPA pesticide registrations, resistant varieties, pesticide resistance, and the efficacy of alternative pest-management materials and techniques) and to develop a format that is easy to use and accessible on the Internet.

An early prototype of this system is being used by USDA's Cooperative State Research, Education, and Extension Service (CSREES) to help target the research areas covered by a recent competitive grants program examining pest-management alternatives for farmers. The developers of the PMIDSS hope to produce the most complete information system available and to provide a common resource for the wide range of communities interested in pest management, farmers, food processors and handlers, scientists, regulators, crop consultants, Extension educators, environmentalists, public-health specialists, and others.

Meeting Data Needs for IPM Assessment

Cathy Greene
Economic Research Service, USDA
Moderator

Continued public support for environmental protection along with recent industry interest in performance-based standards and government performance legislation has increased interest in the use of environmental databases for IPM assessment. The objectives for the "data needs" panel presentation were to describe: (1) the structure of current agricultural pesticide, pest-management alternatives, and other environmental databases; (2) current uses and limitations of these databases for IPM research and assessment; and (3) changes that are being made in these databases to improve their quality and usefulness. An additional objective was to solicit suggestions from the audience for additional ways to improve environmental-data-collection efforts.

Panel speakers described various pesticide-related databases and data-collection efforts, including those by USDA, EPA, National Center for Food and Agricultural Policy and the California Environmental Protection Agency. Panelists also discussed methods for measuring IPM adoption and tools for farmers to use for assessing pesticide risks.

In the opening session, panelists updated the audience on improvements that USDA is currently making in its data-collection program on pesticides. USDA has collected pesticide-use data in the past mostly for field crops (e.g., corn, soybeans, wheat, potatoes, and cotton) in major producing States and has sporadically collected pest-management-practices data on these crops since the early 1990s. Also during the early 1990s, USDA added a data-collection program for fruits and vegetables that has a link to socioeconomic farm characteristics for several of these crops. This year, NASS and ERS are implementing a new survey design that will tie input and practice data for one of the major field crops, corn, to the broader set of farm characteristics that includes production costs and returns and demographic data. Additionally, ERS and NASS are experimenting with an agroecosystem-specific design for the IPM practices section of the field corn survey. While these links are only being made for corn this year, additional major field crops will be examined in future years.

National Databases for IPM Assessment, Mary Ahearn, Economic Research Service, USDA, and Sam Rives, National Agricultural Statistics Service, USDA

Why do we care about IPM? What do we want to know about IPM? These questions lead us to the social goal of reducing chemical risks, which is a part of the larger question regarding reducing human health and environmental risks. To understand IPM, we must understand the whole farm setting, including the resource setting. This is also a necessity for addressing the primary social goals of reducing human health and environmental risks.

To collect data on IPM, we need a definition of IPM. This definition is likely to change over time, and any precise definition must be crop and region specific. Are there indicators of IPM that can be used across commodities? Although the policy goals of IPM adoption are to reduce risks from chemicals, science cannot currently tell us clearly what pest-management practices reduce chemical risks. In fact, cutting-edge science may never be clear on this issue because it is an ever-evolving process. In addition, the ability of a defined IPM technology to reduce risk to human health and the environment will vary over many variables, such as pest pressure level, weather, and soil properties. An important empirical question is to explore how IPM adoption affects chemical risk, and other human health and environmental risks, over these variables. That is, we care about the distribution of IPM adoption and IPM's relation to chemical use over several variables.

No matter what the answers are to the questions regarding a conceptual definition of IPM, any empirical definition will require knowledge of farm-level input use and production practices.

The number-one motivating force behind the decision of farmers to adopt pest-management practices is profitability. We need to be able to evaluate the economic implications of alternative farm technologies (inputs and practices) to provide useful information about the likelihood of adoption and to evaluate the social costs and benefits of adoption for purposes of considering policy options, including education, regulation, and incentive payments. Finally, we can only ask farmers for information that makes sense to them, is unambiguous across farmers, and will have the same meaning to them as the researchers intended. All of these goals must be accomplished with a clear recognition that respondent burden is our constraining variable.

The commodities included in most current farm-level data-collection programs related to pest-management practices are corn, flue-cured tobacco, burley tobacco, peanuts, sorghum, peaches, apples, oranges, grapes, strawberries, tomatoes, and sweet corn. Limited information exists for other fruits and vegetables; past information exists only on inputs and practices for soybeans, wheat, potatoes, and cotton. The pest-management-related data collected include:

- Outputs
- Input use, including characteristics of chemical applications, such as timing
- Who applies chemicals
- Practices
- Sources of information about pest management (e.g., crop consultants)
- Limited information on organic practices
- Costs and returns (paid): incomplete whole farm and commodity-specific
- Georeferencing (for linking to other spatial characteristics, such as resource base)
- Demographics of farmer and household
- Farm-structure characteristics

The additional farm-level data that are currently needed include: target pests associated with practices; costs and returns of IPM (or alternative) practices, paid and unpaid; attitudes about risk; external requirements for pest management (e.g., by lenders or contractors). The ancillary data/information sets that are needed include: pesticide prices; pesticide attributes: toxicities, persistence, mobility; resource characteristics, e.g., soil leachability; objective measure of pest pressure at spatially disaggregated level; expert assessment on recommended practices, including economic thresholds; and environmental values (i.e., for measuring social benefits and costs of alternatives). And to go beyond chemical-use changes as a measure of environmental and human health impacts, we would need objective monitoring [e.g., USGS water quality monitoring, environmental process (fate and transport) models, and human-health-impact models].

National Pesticide Database, James Earl Anderson, National Center for Food and Agricultural Policy

The National Center for Food and Agricultural Policy has developed a national pesticide-use database. This database builds on the NASS pesticide-use database and presents a more complete picture of total U.S. agricultural pesticide use by adding data from various State surveys and other sources. The Center is currently enhancing its pesticide-use reporting by constructing several new databases on pesticide prices, pesticide efficacy, and weed infestation, and it expects to release these products this year.

Databases Used in Pest-Management Evaluations by the California Department of Pesticide Regulation, David Supkoff, California Environmental Protection Agency

California maintains a complete database on agricultural pesticide use, as well as databases on pesticide illnesses and on residues in wells, and has recently developed a database on the availability of nonchemical alternatives.

With the implementation of full use reporting in California in 1990, all agricultural pesticide use must now be reported monthly to the county agricultural commissioner who reports the data to the California Department of Pesticide Regulation (DPR). The reports must include the date and location where the application was made and the kind and amount of pesticide used. Additional information may include acres treated, whether the material was ground or air applied, commodity or site information, and the field to which the pesticide was applied. There are more than 2 million records reported each year, including agricultural, structural, and other nonagricultural applications.

The infrastructure needed to carry out full-use reporting is considerable, with a cost of more than $2,000,000 at the county level alone. Efficiencies have been realized in the past several years through electronic reporting from the counties to DPR. A new program, starting in 1996, has been developed for full electronic reporting from applicators, through the counties, to DPR.

Pesticide-use report (PUR) information is critically important in pest-management evaluations at DPR. Data may be analyzed as pounds of active ingredient applied, acres treated, or number of applications. By linking the PUR to other databases, such as the label database, data can be summarized and evaluated in new ways.

The Label Database contains information on all products currently registered in California. In addition, historical information on past registrations are included. Information includes registration number, registrant information, crops and sites on which the product is registered, active ingredients, pesticide type (insecticide, herbicide, etc.), and formulation type.

Regulatory changes often restrict the availability of pesticides to California farmers. DPR, in cooperation with the University of California Cooperative Extension, developed the Pest Management Survey Database (PMSDB) to determine the availability of alternative products when pesticides become unavailable. This database is presently being expanded in cooperation with the University of California Statewide IPM Project to include both chemical and nonchemical alternatives. The PMSDB assists DPR in predicting the impact of regulatory decisions on the management of economic pests. It is made accessible to researchers and other interested parties through the University Impact system.

In the current, expanded version, which was recently mailed to more than 180 University of California Extension scientists and farm advisors, information is being collected for each of seven California growing regions, for specific pest-control methods and individual target pests, including whether a pest-control method is the only feasible alternative, limitations, resistance, primary and secondary methods of application, and information on quality and yield.

The Pesticide Sales Database contains information collected on all pesticide sales in California. Because home-use pesticide products are not captured in the PUR, the sales database provides an important overview of pesticides used in California. Information in the database is confidential, although general summaries may be available. The Pesticide Illness Surveillance Program (PISP) is the repository for reports on illnesses caused by pesticides, which must be reported in California. The Well Inventory Database contains information on wells sampled for the presence of pesticides. This database identifies positive detections, active ingredients found, and well locations, and it contains information from the DPR as well as outside agencies. The County Agricultural Statistics Database contains county-level statistics on crop acreage along with economic information, such as price and yield. This information is collected by the California Department of Food and Agriculture and is available in electronic form.

Tracking the Extent and Intensity of IPM Adoption, Steven Wolf, Institute for Environmental Studies, University of Wisconsin

Wolf challenged the IPM community to better estimate and track the extent and intensity of IPM in practice at specific points in time and to use these data to better understand and stimulate IPM adoption through policy, education, and research. He criticized much of the previous IPM-adoption research as largely ad hoc and politically motivated and suggested that measuring changes in IPM adoption within agricultural production systems requires rigorous assessment of both the context in which behaviors are examined and the behaviors themselves. One of his suggestions for improvement is to orient IPM assessment activities toward comparative research that looks at why IPM is used intensively in one setting and not another:

- Do State-level policies matter?
- Does priority watershed designation matter?
- Do cultural attributes matter?
- Are there economies of scale inherent in IPM?
- Are there barriers associated with large size?
- Do we see more intense IPM related to the services provided by agrichemical dealers or independent crop consultants?
- Does Extension matter?
- How does IPM practice differ from potatoes to corn?
- What is the role of commodity organizations?
- Does pesticide resistance drive IPM practice?
- Does soil quality affect IPM practice?

While the IPM surveys concentrate on field practices and, to a lesser degree, socioeconomic characteristics of farm firms and are not necessarily oriented toward these research questions, systematic sampling procedures and other tools can be used to collect data that support comparative research. Wolf also argues for more integration of primary and secondary data sets through development and application of spatially explicit sampling and inventorying techniques, and advocates the use of GIS technology to link agroecological and socioeconomic data. This integration allows the behavioral change of individuals as well as the adaptations in farming systems to be examined within the context of hypothesized IPM "drivers," such as modified pest-management regimes, resource-management conflicts, consumer preferences, technological and economic change, public investment, and development of a competitive crop-consulting industry.

An Environmental Yardstick for Pesticides, Joost Reus, Center for Agriculture and Environment, The Netherlands

The purposes for developing a "pesticide yardstick" for farmers are:

- to make the environmental impact of pesticide use visible to farmers and operators,
- to stimulate them to make a more sound selection of pesticides, and
- to evaluate the progress they make towards a more environmentally sound crop protection.

The risk of pesticide use for the environment is assessed by comparing the predicted environmental concentration (PEC) in a certain environmental compartment (soil, water, or groundwater) with the environmental quality standard (e.g., 0.1 x LC_{50} for aquatic organisms); this quotient of PEC and LC_{50} indicates the acute risk for organisms in the environment.

For each active ingredient, environmental impact points (EIP) are calculated, based on this risk quotient, in the following way: EIP = 100(PEC)/environmental quality standard. In other words, if the number of EIP equals 100, the PEC equals the environmental quality standard set by the Dutch government. EIPs are calculated for an application of 1 kg of active ingredient per hectare. The farmer should multiply the standard number of EIP with the actual dose rate if another dose rate is used. To calculate the PEC, differences in environmental characteristics are included, like organic matter content in the soil and distance to surface water. Furthermore, farmers can take into account the dose rate they actually use and the method of application (which determines the percentage of emission).

There are large differences in insecticides' impacts on the environment. Most insecticides are not mobile in soils, so they do not pose a risk to groundwater. An exception is propoxur, which is highly mobile. Cypermethrin is quite persistent in soil and therefore poses a risk to soil organisms. Most insecticides are very toxic to aquatic organisms and have many EIPs for the risk for water organisms.

The environmental yardstick was introduced in practice in 1994. Since then, it has been used by individual farmers, in study groups of farmers, by the extension service, in training courses for farmers and in agricultural schools. In most cases, farmers using the yardstick could reduce their score on the yardstick dramatically. Reductions of more than 90 percent are no exception. Most reductions in the short term were reached by changing from an environmentally harmful pesticide to a pesticide with less risk to the environment.

In the long term, we are trying to motivate farmers to change their crop-protection strategy more fundamentally: first, to use measures to prevent weeds, pests, and diseases; Second, to choose nonchemical crop-protection techniques (although these techniques may have an environmental impact as well); third, if a pesticide application is necessary, to choose the pesticide with the least environmental impact; finally, to choose the application method that causes the least emission of pesticides into the environment.

he Center for Agriculture and Environment (CLM) is a nonprofit, nongovernmental organization that aims to stimulate a more sustainable agriculture. Research in close cooperation with farmers is the core activity of CLM. This research is geared towards: (1) analyzing and quantifying environmental problems at the farm level; (2) developing solutions or measures that are suitable for individual farmers; (3) translating government objectives to specific objectives for individual farmers; and (4) developing proposals for a stimulating and motivating policy.

The philosophy of CLM is that environmental policy should focus on the objectives. Farmers have a personal responsibility, and should have the right, to choose the most cost-effective way of reaching these environmental objectives. Therefore, they should have suitable tools to measure the environmental impact related with their way of farming. CLM therefore developed farm-level indicators or "yardsticks" for nutrients (nutrient bookkeeping) and pesticides. Yardsticks for energy (greenhouse gases), biodiversity, and water (irrigation) are still in development. These yardsticks are used as an information and management tool, but are also used as basis for financial incentives (levies and premiums) and for green labeling of agricultural produce.

Tools for Assessing Environmental Impacts: Emerging Approaches for Different Objectives

Lois Levitan
Cornell University
Moderator

The goal of this session was for participants to become: (1) more knowledgeable about some environmental impacts of pest-control systems that are being developed, (2) a bit better versed about the issues at hand and the research challenges that remain, and (3) more familiar with some of the players in the field.

Presentations

Five panelists, each of whom has played a lead role in developing a model or conceptual tool for assessing impacts of plant-protection methods gave presentations that touched on the following points:

1. The purpose of the system: What or whose perceived need led to the development of the system?
2. Who is intended to use and make decisions based on the system: farmers, farming-system advisors, researchers, regulators, or the public?
3. Which environmental effects and variables have been taken into account? Are only inherent pesticide (and other pest-management products and methods) properties considered, or are site- and situation-specific conditions and farm management decisions also considered?
4. What are the principles behind the calculation(s).
5. What is the format of the output (i.e., computer screen, short handout, or scientific paper).
6. At what stage of development is the system? Is it still evolving? What would be involved in adapting the system for other user groups?

Most of the systems presented are "works in progress." Some focus on pest management, whereas others also assess other components of agricultural systems. Most are structured to enable comparisons of pest-control options. Some evaluate impacts of pesticides exclusively, whereas others also assess nonchemical pest-control methods. Each evaluates impacts on one or more environmental parameters or indicators; some of the systems focus on agroecosystem impacts and indicators, whereas others prioritize consumer and/or occupational risks (which are considered public-health impacts in the framework of these IPM meetings). The systems described here are methods for interpreting empirical field or laboratory (e.g., toxicity) data and data predicted by environmental fate models.

Participants

Joseph Bagdon, Natural Resources Conservation Service, Amherst, Mass., is the project leader for the National Agricultural Pesticide Risk Analysis (NAPRA), which is a water-quality model. Its output is in the form of a climate-based probability that pesticide loss from the field will exceed human health advisory levels. This risk can be compared for different pesticide options. Additional information can be obtained at jbagdon@fnr.umass.edu.

Charles Benbrook, Benbrook Consulting Services, consultant to the Policy Program of the World Wildlife Fund, Washington, D.C., developed a method for measuring progress toward the national adoption of IPM. This system places pest-control practices along a continuum to demonstrate a shifting reliance from treatment to prevention of pest problems. The continuum is divided into four zones on the basis of these farmer behaviors in pest management: no IPM, low and medium transitional IPM systems, and biointensive IPM. Additional information can be obtained at benbrook@hillnet.com.

Lynn Coody, Organic Agsystems Consulting, Eugene, Ore., designed a prototype computer expert system to assist the Technical Advisory Panel of the National Organic Standards Board in developing a list of materials appropriate to use on organic farms. Data about the characteristics of materials are compared with evaluation criteria with weighted values to produce a product rating (allowed, regulated, or prohibited). Results can be reported at three levels of detail. The system is intended to provide a structure for the evaluation process and to simplify the presentation of information needed to satisfy the requirements of the Organic Foods Production Act. Additional information can be obtained at 76305.3545@compuserve. com.

Kevin Klair, Center for Farm Financial Management, University of Minnesota, St. Paul, Minn., is a member of a team that has recently released an updated version of PLANETOR 2.0, which is a comprehensive environmental and economic farm-planning software program. The system combines site-specific environmental models with individual farm financial planning data to evaluate impacts of reducing or changing pesticide, nitrogen, phosphorus, and manure applications; tillage systems; and crop rotations. PLANETOR evaluates alternative management plans for individual farms and compares impacts on soil erosion, nitrate leaching, phosphorus runoff, pesticide movement, and whole-farm profitability. Additional information can be obtained at cffm@cffm.agecon.umn.edu.

Joost Reus, Center for Agriculture and the Environment, Utrecht, The Netherlands, developed the Pesticide Yardstick as a method for farmers to use in selecting pesticides and evaluating progress they make towards more environmentally sound crop protection. In this system, pesticide risk is assessed by comparing predicted environmental concentration (PEC) in a certain environmental compartment with the Dutch environmental quality standard for several indicators. Reus is currently working on a proposal for a joint European project in scoring or ranking pesticides. Additional information can be obtained at clm@gn.apc.org.

Discussion

Group discussion focused on the objectives, potentials, limitations, and research needs regarding environmental impact assessment tools. Discussion themes included:

- Knowledge and database gaps in general and particularly concerning nonsynthetic chemical pest-control methods; also difficulties in assessing impacts and efficacy of biological and cultural control methods.

- Extrapolating or adopting existing and prototype assessment tools to additional crop scenarios and site conditions.

- Methods and challenges in incorporating a broader range of environmental indicators into assessment systems, including indicators of community- and ecosystem-level environmental quality and indicators with longer time horizons (e.g., genetic and reproductive effects).

- Targeting audiences for different assessment tools; structuring assessment systems to meet the objectives and needs of user groups. How to make explicit the limited objectives of an assessment system so results are not misinterpreted or extrapolated beyond the intended purposes and audiences of the assessment tool. How to encourage target group adoption of an assessment procedure and results? What are the barriers to adoption of environmental assessment tools?

- Difficulties in collecting data from farmers and growers who are fearful that identification of an environmental impact will lead to greater regulation in the use of a pest-control method.

- Whether efficacy data belong in environmental-impact assessments.

- Facilitating communication and cooperation among people working to develop and implement environmental impact assessment methods for agriculture. A new, unmoderated e-mail discussion group (Ag-Impact) was announced; it will be administered by the Institute for Agriculture and Trade Policy (IATP) in Minneapolis, Minn., and hosted by Dr. Lois Levitan, Department of Fruit and Vegetable Science at Cornell University. Subscribe by sending e-mail to listproc@mtn.org with the message: subscribe Ag-Impact [your name].

Estimating Biological Benefits of Pesticides for Regulatory Decision Making

Ron Stinner
North Carolina State University
Moderator

Introduction

The National Agricultural Pesticide Impact Assessment Program (NAPIAP), a USDA/State program, was established in 1976 to promote informed regulatory decisions on agricultural pesticides. NAPIAP develops and distributes science-based information evaluating the benefits of pesticides in U.S. agricultural production. The information in NAPIAP assessment documents is provided to the U.S. Environmental Protection Agency (EPA) for use in its regulatory decision-making process. These documents also provide useful information to the USDA, agricultural scientists, and commodity groups. In February 1995, a panel reviewing NAPIAP criticized the program for using excessive “expert opinion” (scientific estimates) in lieu of documented biological data in these assessments. At the same time, the benefit-assessment process has suffered from a lack of protocols that could be used to guide the acquisition of such data. In an effort to better refine the benefit-assessment process, a Benefits Assessment Protocols Working Group was formed in 1995 to address these issues. The Working Group consists of representatives from USDA, EPA, and the American Crop Protection Association (ACPA). This workshop is the first result of the ongoing discussions on the development of assessment protocols.

The panel participants have all had experience with NAPIAP and the benefit-assessment process. Drs. Jenkins and Pike are the NAPIAP State liaison representatives for their respective States and have also participated in the assessment process. Dr. Bridges was a member of the panel that reviewed NAPIAP; he also has done an assessment, using an innovative approach, of the benefits of pesticide use in peanut production.

Panel Presentation

Dr. Jenkins discussed the Pesticide Benefits Assessment Model, developed at Ohio State University. This model attempts to assess the true economic impact of alternative control strategies and to provide information useful to regulatory decision making. The advantages of such an approach are: improved credibility and reliability, less expert opinion, consistent framework, and the development and use of formalized models. He also discussed the data needs and sources presently available.

Dr. Bridges pointed to the major problems with the present benefit-assessment process: imbalance in risk and benefits (with large sums spent on risks and little on benefits), credibility (risk well-defined with systematic approach to assessment; benefits more diffuse and difficult to define), little investment in benefits methodology, and an underestimation of the importance of biological components and their variability. This is true for agribusiness as well as government regulators and university cooperators. Dr. Bridges recommended that NAPIAP develop a common ground for assessments that includes: (1) multiuser databases of pest occurrence (and damage) and demographics of pest-management practices and (2) common, consensual, and systematic processes for assessments.

Dr. Pike addressed the history of assessments, noting that there has always been a balance of both expert opinion and empirical evidence, with the pendulum now moving away from expert opinion. He noted that in spite of regional variations and requirements, NAPIAP should be able to develop a set of protocols that include subjectivity; that is, both models and individuals to interpret the information (model, expert opinion, and empirical data).

Discussion and Conclusions

Numerous questions were raised, such as: How do you estimate the costs of practices (e.g., resistance management, new-product costs, and value of product alternatives)? This question led to a discussion of individual costs versus averaging and the value of prior knowledge (e.g., we know that curative methods always produce a higher return than prophylactic treatments when we average, but not necessarily when looking at individual years and fields).

Where are the data? Can we realistically estimate yield as related to damage indices? Are such models well known, and more important, are they transparent (is it obvious what they do)? This discussion led to a major conclusion that the concept of transparency was critical to the benefit-assessment process. A main concern with expert opinion is how interpretations are made from point A (data or estimates) to point B (recommendations). If the entire logical process from A to B is made clear (hence the term, transparent), then it stops being expert opinion and becomes empirical information. Because yield-quality effects are the most difficult to estimate, models become necessary tools. However, the inherent complexity and variability of our agricultural system demand that any model results be interpreted and analyzed in light of this variability.

The workshop concluded with the consensus that NAPIAP should develop protocol criteria that include the use of transparent models and careful analysis while not forgoing expert opinion. All affected parties should be a part of the development of these protocols. Benefit assessment should be an integral part of product development.

NAPIAP: Issues in Estimating Benefits of Pesticides

Craig Osteen
National Agricultural Pesticide Impact Assessment Program, USDA
Rob Esworthy
U.S. Environmental Protection Agency
Moderators

This session focused on issues of estimating economic impacts of pesticide regulations. These issues are important to IPM because pesticides are important tools in many IPM programs. Pesticide regulations can reduce the options available for some IPM programs with undesirable pest control, environmental, and resistance-management consequences. These concepts can also be applied to analyzing the economic impacts of IPM adoption.

EPA and USDA/NAPIAP have created a working group to review currently used economic methods of USDA and EPA pesticide benefit assessments because of questions raised about their quality. The ultimate purpose is to develop an improved set of guidelines for estimating the economic effects of pesticide regulatory actions. The primary questions of concern are:

1. Are we trying to measure the right things?
2. What methods to estimate economic effects are feasible, given restrictions on time, manpower, etc.?
3. Assuming that acceptable methods are being applied by USDA and EPA, are they being properly applied?
4. Are there new methods that should be employed?

Economic Analysis in the Pesticide Regulatory Process

Rob Esworthy discussed the role of economic analyses in risk-benefit comparisons under FIFRA Special Reviews and other registration decisions and in regulatory-impact analyses. In EPA, as well as NAPIAP, biologists and economists cooperate in the benefit-assessment process. The key elements in assessing the benefits of a pesticide used on a crop include: major pests controlled, chemical and/or nonchemical alternatives to the pesticide, and comparative performance of the alternatives in terms of pest control and crop yield or quality. Ultimately, the economic analyses require estimates of the use of the pesticide in question and changes in yield, quality, and/or production cost associated with changing to alternative control measures.

The Current Approach

Conceptually, the assessment of benefits by USDA and EPA is the same as estimating the annual net efficiency loss of removing the pesticide from the market and switching to the best alternative control option. Monetary values generally are not estimated for health and environmental effects of proposed regulatory actions, which are considered in EPA risk assessments. However, the economic-impact estimates can be used to estimate cost-effectiveness of risk-reducing options.

The standard framework for estimating the net economic effect is based on traditional Marshallian demand-and-supply curves. The supply curve is modified to reflect changes in yield and cost; price and quantity changes are estimated; and changes in consumer and producer surpluses are summed to estimate net effect.

Partial budgeting (change in value of production plus cost change) is used to estimate net effect when price changes are expected to be negligible or data to estimate price changes are not available. A variation on partial budgeting is often used when yield or quality losses are difficult to value: pest control experts are asked to develop equally effective control options, and the net effect is estimated as the cost of the new option minus the cost of the current approach.

Pesticide regulations can affect various groups differently. These so-called distributional effects are not obvious from the "net effect." Distributional effects estimated in assessments often include economic effects on purchasers of affected commodities, growers of affected commodities, users and nonusers of the regulated pesticide, regions where economic losses are particularly severe, and growers of other crops. Changes in commodity-program payments are also estimated, where appropriate, because they can shift the distribution of impacts.

Several methods are used to address price effects and associated welfare effects: demand-and-supply elasticities in simple static-equilibrium models; mathematical (quadratic) programming models; and econometric simulation models, such as AGSIM, that account for simultaneous price, acreage, consumer, and producer effects for several crops.

Comments by Panel

Fred Kuchler argued that the economic effects of pesticide regulations would ultimately affect rents and values of land, a primary fixed factor of production. This link may be an important distributional effect because approximately 40 percent of land in U.S. farms is rented. At one time, most farmers owned all the land they farmed, so separating this effect was not important. But a significant portion of farmland is now owned by people who do not farm. Share rents would be affected in the same years as effects of pesticide regulations on costs and yields occur. Potential renters would ultimately change their cash rent bids as changes in prices, yields, and costs became apparent.

Jerry Carlson focused on some important costs typically neglected in the benefit assessment process: phytotoxic effects of replacement pesticides, changes in drift damage to adjacent fields, changes in resistance development for remaining pesticides, and changes in the variability or risk of crop yield. In addition, there can be effects on the value of human capital: regulations could force growers to use new, unfamiliar techniques and receive lower financial returns until they gain experience with them. Carlson felt that there were difficult tasks where improvement was needed: (1) correctly estimating market shares of replacement controls and (2) estimating crop yield changes for different technologies in different regions by using experimental data. Two other important issues that need to be addressed are estimating changes in commodity-program payments and changes in unit prices of remaining pesticide products.

Erik Lichtenberg argued for a different approach to estimating the effects of regulations and focused on issues of data and data quality. He argued that crop science data fit poorly into the traditional economic framework, and better results could be obtained by collecting data capable of supporting estimation of economic relationships directly. Such data could be collected through USDA Farm Costs and Returns Surveys or pesticide-use surveys. The data currently collected are not sufficient by themselves, however, and would need to be augmented to include such items as: (1) output (yield) information; (2) quantities of individual pesticides used; (3) quantities of other inputs used, such as fertilizers, labor, cultivation methods, other nonchemical control methods, etc.; and (4) prices of all of the above. Panel data that included both cross-sectional and time-series information would support the use of dual methods and estimation of supply and input demand curves. Cross-section data alone would support estimation of production functions directly. The damage-control approach of Lichtenberg and Zilberman could be used to estimate damage; such estimates would be useful to cross-check damage estimates of crop scientists.

Erik Lichtenberg identified some other issues. First, assumptions of perfect competition (no individual buyer or seller can affect market price) may be invalid in some markets. Large buyers of agricultural commodities, such as grain marketers or food processors, could influence the prices that growers receive. In addition, national governments play an important role in marketing commodities in international markets. Second, it is not clear how effects on first-level purchasers of agricultural commodities transmit to effects on retail-level consumers, so that the "consumer effects" currently identified may relate to wholesalers but not retail-level consumers.

IR-4 Minor-Use Registrations

Dick Guest
Rutgers University
Moderator

Overview of the IR-4 Project, Christina L. Hartman, Rutgers University

Interregional Research Project No. 4 (IR-4) was established in 1963 by the Federal Government. The project helps producers obtain registered pesticides for "minor uses" on food crops. Minor uses include minor crops and limited uses on major crops. IR-4 also helps obtain labels for ornamentals. Most of IR-4's resources are directed toward the collection of field-residue data and the chemical analysis of those data. IR-4 receives the majority of its funding from USDA-CSREES, but also receives funding from USDA-ARS, commodity organizations, and pesticide registrants. Cooperating personnel on the project include Extension, ARS, private contractors, and IR-4 university employees. The IR-4 project is administrated from the Headquarters Office located at Rutgers, New Brunswick, New Jersey. Staff at Headquarters include the national director, associate director, national coordinator for research and registration, project planning coordinator, biopesticide coordinator, six study directors, quality-assurance coordinator, and database manager. Regional Offices at the University of California, Davis; Michigan State University; University of Florida; New York Agricultural Extension Service – Geneva; and USDA-ARS, Beltsville, handle the field trials and chemical analysis for the residue projects.

The majority of IR-4 research continues to support chemical registration; however, IR-4 also has an active biopesticide program. This program consists of two parts. The first part is the IR-4 Biopesticide Grants Program. In 1995, IR-4 funded the following projects: pepper-extract trials on minor crops in Washington State, bioherbicide for dodder control in cranberries, citrus root weevil larvae control with *Beauvaria bassiana*, disease-suppressive potting mix, fungi for the control of horticultural pests during shipping, soilborne disease control with *Pseudomonas fluorescens* and *Burkholderia cepacia*, recombinant viruses as a biological insecticide, *Entomophaga maimaiga* for gypsy moth control, and biocontrol of alfalfa disease with *Bacillus cereus*. The second part is petition preparation and submission to EPA. This past year, EPA granted tolerance exemptions for methyl anthranilate on blueberries, cherries, and grapes; for codling moth granulosis virus on apple, pear, walnut, and plum; and for cinnamaldehyde for mushrooms based on IR-4 petitions. In addition, an experimental-use permit was granted for the two organisms used in the microbial potting mix, and an experimental use permit is pending for use of a nonaflatoxin-producing isolate of *Aspergillus flavus* as a niche competitor in Arizona cotton.

The IR-4 program continues to bring pesticide tools of all types to the growers of minor crops. IPM is important to minor-crop production; and by providing more options (or in many cases the only option) for pest control, IPM is more easily implemented in these crops. As we move forward to the year 2000, IR-4 will continue to support IPM through pesticide registrations that will bring more ecologically compatible products to the market.

Pesticides for IPM Programs on Minor Crops: Insect Control, Kenneth S. Samoil, Rutgers University

IR-4 projects are initiated when a pesticide clearance request form detailing the needed pesticide use is received from a grower, an extension agent, or any other interested person besides the registrant. All projects are prioritized by extension agents, IR-4 State liaisons, and/or commodity representatives. In the fall, IR-4 coordinators schedule field trials and laboratory analyses for the following year, with high-priority projects scheduled first.

The IR-4 program is currently working with two new insecticides that fit particularly well into IPM programs: Imidacloprid and Tebufenozide. These compounds both have new modes of action and very low use rates as well as other favorable characteristics.

Imidacloprid is a Bayer product with a broad spectrum of activity against insects, although it is inactive against spider mites and nematodes. Although it affects the insect nervous system, its mode of action differs from organophosphates and carbamates in a way that is unlikely to result in cross-resistance. Typical use rates are 1 to 9 oz active ingredient (ai) per 100 lb seed, or 0.01 to 0.13 lb ai per acre for foliar applications. Imidacloprid is highly systemic, has good residual activity, and may control many insect pests with a single application. When applied as a soil or seed treatment, beneficials that would be harmed by a foliar application are spared. At a sublethal dose, it is still effective at preventing crop damage. IR-4 projects initiated prior to 1996 include uses on spinach, lima beans, succulent beans, greenhouse tomatoes, and cucurbits. In 1996, IR-4 will conduct trials on carrots, turnips, and dandelions. Already, IR-4 data have been used to obtain tolerances on hops and fruiting vegetables (except cucurbits).

Tebufenozide is a Rohm & Haas product that is active only against caterpillars (*Lepidoptera*). It imitates the molting hormone, causing the insect to stop feeding and to produce a new, malformed cuticle beneath the old cuticle. The caterpillar eventually dies of starvation and dehydration. Because it does not affect bees, tebufenozide may be applied during bloom at rates typically in the range of 0.03 to 0.3 lb ai per acre. Predators and parasites of nonlepidopterous pests are not harmed by Tebufenozide; thus, they are able to provide biological control, which in some cases will eliminate the need for other insecticide applications. Studies with this compound have been initiated at IR-4 for the first time in 1996, including work on turnips, blueberries, cranberries, raspberries, and mint.

Magnitude-of-Residue Data for the Establishment of Raw Agricultural Commodity 408 Tolerances for Fungicides, David C. Thompson, Rutgers University

I would like to describe three fungicide programs in which IR-4 has been involved that provide different examples of integrated disease-management strategies. The three examples include: eastern filbert blight, *Alternaria* blotch of apple, and metalaxyl insensitivity management.

IR-4 has been involved in the development of magnitude-of-residue data to support FIFRA Section 18 Specific Emergency Exemptions and ultimately Raw Agricultural Commodity 408 tolerances for Section 3 registrations of the use of chlorothalonil (Bravo®) and fenarimol (Rubigan®) on filberts for the control of eastern filbert blight (EFB) caused by *Anisogramma anomala*. EPA was initially somewhat reluctant to authorize two Section 18s for one disease/crop situation; however, after careful consideration of the situation, they realized that this was a good use of emergency exemptions in a developing IPM program, thereby reducing human exposure.

These two fungicides are used only in the early part of the growing season, which is the time of wet spring weather and maximum EFB infection. The preferred application time is from leaf-bud break through shoot elongation. That period is from late March until late May. Harvesting takes place in late September and October, and residues of both fungicides would be at nondetectable levels at harvest time.

Chlorothalonil is used early in the season, prior to or just as the leaf buds are opening. The excellent sticking activity of Bravo® allows adequate fungicide to be applied to leaf-bud tissue to provide excellent protection against infection.

Fenarimol is used later in the infection period as leaf buds open and new leaf tissue becomes exposed to EFB spores. This fungicide is locally systemic, and needs leaf tissue to be absorbed and translocated at levels necessary for good control of infection. This systemic activity is beneficial in that, once it is applied and absorbed by plant tissue, fenarimol is not washed off or diluted by the frequent rain showers that occur in spring weather, which is the time of maximum EFB infection. Fenarimol has shown "kickback activity" in that it controls fungal spore growth up to 48 hours after the spores have germinated and begun to infect plant tissue. This feature again proves to be valuable in Oregon during wet springtime conditions when growers cannot get into their orchards to spray immediately after a rain because of muddy or slippery conditions.

The percent control of EFB in the five years prior to 1991 has been estimated at 0 to 10 percent. The use of chlorothalonil through emergency exemptions in 1991 and beyond has increased the level of control to 50 percent. The addition of fenarimol is estimated by knowledgeable experts to increase control to greater than 80 percent.

IR-4 has been involved in the development of magnitude-of-residue data to support a Section 18 Specific Emergency Exemption and ultimately a Raw Agricultural Commodity 408 tolerance for Section 3 registrations of the use of iprodione (Rovral®) on apples for the control of *Alternaria* blotch. Iprodione application timing will be based on models. Two models are presently under evaluation. One model is based on a threshold of 65 percent of leaves with symptoms during the period of rapid disease increase (mid-June). The other model is based on accumulation of degree days and hours of leaf wetness. The models will be used to make a decision about the timing of the first fungicide application; subsequent applications will be made at 2- or 3-week intervals. Research has shown that where the first spray of iprodione (Rovral® 4F) was applied when recommended by the models, disease severity and defoliation were not significantly greater than in the preventive treatment where iprodione was applied on a 2-week schedule. The use of either model provided a savings of five fungicide sprays in each of the two orchards evaluated, thereby reducing the chemical load in the environment.

The fungicide metalaxyl has a very specific mode of action. Downy mildew fungi, of which there are many species and genera, have the ability to produce large numbers of spores that can be disseminated and cause new infections through many cycles within a single growing season. These two factors make it highly likely that insensitive strains of downy mildew fungi will develop. Ciba Crop Protection has employed fungicide mixtures to reduce this potential. They have packaged metalaxyl with Mancozeb, Chlorothalonil, or copper fungicides to prevent the development of metalaxyl-insensitive strains of downy mildew. IR-4 has been involved in the development of magnitude-of-residue data to support Raw Agricultural Commodity 408 tolerances for Section 3 registrations of the use of metalaxyl plus copper on many crops for the control of downy mildew. These crops include: arrugula, bok choy chinese cabbage, collards, kale, mustard greens, turnip, swiss chard, raspberry, grape, and papaya.

These three examples are only a few of the many ways that fungicides can be used in IPM/crop protection programs that enhance both food and environmental safety. IR-4 will continue to work cooperatively with growers, grower groups, state scientists, federal scientists, and registrants in obtaining clearances for fungicide uses that provide more optimal pest-management strategies.

Displacement of Aflatoxin-Producing Fungi from Cottonseed, Peter J. Cotty, *Agricultural Research Service, USDA*

There are no reliable and economic methods for preventing aflatoxin contamination of cottonseed, and no products are currently marketed to prevent preharvest contamination. Insect management, irrigation practices, harvest timing, planting date, and crop-handling procedures can be optimized to limit contamination. However, even after optimization, under severe environmental conditions, crops will frequently contain unacceptable levels of contamination. Controls must be effective during crop development and after crop maturation both in the field and in storage. Furthermore, most contamination occurs in damaged bolls; thus, controls must prevent contamination of plant parts compromised by either physiological stress or predation. Meeting these requirements is difficult for procedures that must prevent formation of the relatively rare, highly contaminated seeds that often contain the most contamination. A biopesticide that meets these requirements is being developed. This biopesticide uses naturally occurring atoxigenic strains (do not produce aflatoxins) of *Aspergillus flavus* to competitively exclude aflatoxin-producing fungi and, in so doing, to prevent aflatoxin contamination. The product is expected to provide economic benefit to cotton producers in severely affected portions of Arizona.

The IR-4 Project Biopesticide Program is facilitating the development of this product by assisting in the registration process.

Aflatoxins are toxic, carcinogenic chemicals that frequently occur in foods and feeds. Health concerns have led to regulatory limitations on the aflatoxin content of foods throughout most of the world (Stoloff, van Egmond, and Park 1991). The most toxic and highly regulated aflatoxin is B_1 (Park and Stoloff 1989; Stoloff, van Egmond, and Park 1991). The fungus *Aspergillus flavus* causes aflatoxin contamination of cottonseed. Contamination results in losses for producers, processors, and animal industries that depend on cottonseed for feed (Park and Stoloff 1989). Whole cottonseed and/or cottonseed products are an important dairy and cattle feed. Aflatoxins in cottonseed are transferred to milk in slightly modified form (Park and Stoloff 1989; Park and Stoloff 1989). U.S. regulations prohibit aflatoxin concentrations over 0.5 µg/kg in milk. Milk may be destroyed and entire operations temporarily shut down and quarantined in dairies producing milk tainted with unacceptable aflatoxin levels (Emnett 1989). To prevent unacceptable aflatoxin levels in milk, the regulatory threshold for aflatoxin B_1 in cottonseed fed to dairy cows is 20 µg/kg (Park, Lee, Price, and Pohland 1988; Park and Stoloff 1989). Aflatoxin contamination of cottonseed can be minimized by early harvest, prevention of insect damage, and proper storage (Cotty 1991a; Cotty 1991b). However, even under careful management, unacceptable aflatoxin levels may occur via either unpreventable insect damage to the developing crop (Cotty and Lee 1989) or exposure of the mature crop to moisture prior to harvest (Cotty 1992) or during storage (Russell and Lee 1985), handling, transportation, or even use (Cotty 1991a).

Aspergillus flavus populations are highly complex and are composed of strains that differ morphologically, physiologically, and genetically (Bayman and Cotty 1991; Bayman and Cotty 1993; Cotty 1989). Differences among strains in ability to produce aflatoxins is well known (Davis and Diener 1983), and aflatoxin-producing ability is not correlated with strain ability to colonize and infect developing cotton bolls (Cotty 1989). These observations led to the suggestion that atoxigenic strains of *A. flavus* might be used to exclude toxigenic strains through competition during infection of developing crops, thereby preventing aflatoxin contamination (Cotty 1989; Cotty 1994). In both greenhouse and field experiments, wound inoculation of developing cotton bolls and corn ears simultaneously with toxigenic and atoxigenic strains led to reductions in aflatoxin contamination of the developing crop parts as compared with controls inoculated with only the toxigenic strains (Brown, Cotty, and Cleveland 1991; Cotty 1990). Atoxigenic strains are effective at preventing post-harvest aflatoxin contamination both when the crop is infected naturally in the field and when it is inoculated after harvest (Brown, Cotty, and Cleveland 1991). Thus, competitive exclusion of aflatoxin-producing strains of *A. flavus* with atoxigenic strains of the same fungal species may provide a single method for preventing aflatoxin accumulation throughout crop production and utilization (Cole and Cotty 1990; Cotty 1989; Cotty 1990; Cotty 1994).

In the United States, aflatoxin contamination of cottonseed is most consistent and severe in the irrigated western desert valleys, where contamination is often associated with pink bollworm damage (Cotty 1991a; Cotty and Lee 1989). Cottonseed produced in these valleys has a relatively high value per acre because of high cotton yields and high demand for cottonseed within the area. Contamination levels are highly variable within fields, plants, and even bolls (Cotty 1991a; Cotty and Lee 1989; Lee, Wall, Cotty, and Bayman 1990). Contamination is often associated with seed exhibiting bright green-yellow florescence (BGYF) on the linters under ultraviolet light (1). BGYF cottonseed are typically those infected by *A. flavus* through insect wounds. Results of greenhouse studies suggest atoxigenic strains reduce aflatoxin contamination by competitively excluding aflatoxin-producing strains from the crop (Brown, Cotty, and Cleveland 1991; Cotty 1990; Cotty and Bayman 1993). During seasons when aflatoxin contamination is severe, *A. flavus* populations increase as the cotton crop is produced (Lee, Lee, and Russell 1986). For atoxigenic strains of *A. flavus* to be useful during crop production, they must be applied at a time and in a manner that allows them to compete successfully with aflatoxin-producing strains. In theory, application of an atoxigenic *A. flavus* strain early in the season should give the atoxigenic strain preferential exposure to the developing crop and thus the advantage in competing for crop resources during infection and during *A. flavus* population increases associated with cultivation (Robens and Richard 1992).

An aflatoxin-prevention technology based on atoxigenic strains of *Aspergillus flavus* is being developed for use in the region of Arizona with the most frequent and severe aflatoxin contamination of cottonseed. Strains are seeded into cotton fields at lay by (immediately prior to first bloom). The strains are applied to the soil surface under the crop canopy in the form of colonized sterile wheat seed. When the crop is subsequently irrigated, the atoxigenic strain uses the resources in the colonized wheat seed, sporulates, and disperses to the crop. Wheat seed colonized by atoxigenic strain *Aspergillus flavus* AF36 has been evaluated in small-scale test plots since 1989. Strain seeding caused large and significant changes in the *Aspergillus flavus* population on the crop and in the soil. Applications resulted in the applied atoxigenic strain becoming dominant in the field and aflatoxin-producing strains becoming less frequent. These changes in the *A. flavus* populations were associated with great reductions (75 percent to 99 percent) in aflatoxin contamination (Cotty 1991b). Further tests showed that atoxigenic strain applications have a long-term influence on *A. flavus* populations resident in agricultural fields, suggesting atoxigenic strain applications may have benefits over multiple seasons and that long-term, area-wide changes in the aflatoxin-producing potential of *A. flavus* populations may be achieved. Results of field plot tests indicate that atoxigenic-strain applications do not increase the amount of *A. flavus* on the crop at maturity and do not increase the percent of the cottonseed crop infected by *A. flavus*.

Aspergillus flavus typically becomes associated with crops in the field during crop development and remains associated with the crop during harvest, storage, and processing. Thus, crop vulnerability to aflatoxin contamination remains until the crop is ultimately used. Similarly, atoxigenic strains seeded into agricultural fields prior to crop development will remain associated with the crop until use and may provide long-term postharvest protection from contamination. Atoxigenic strains applied both prior to harvest and after harvest have been shown to provide protection from aflatoxin contamination of corn (Brown, Cotty, and Cleveland 1991), even when toxigenic strains are associated with the crop prior to application.

Economics of aflatoxin contamination will probably dictate the regions in which atoxigenic strains are used. We hope to produce materials for atoxigenic strain applications for $5.00 per acre or less. If treatments are 70-percent effective and an average of 40 percent to 70 percent of seed is above 20 ppb and the benefit of having aflatoxin-free seed is $20 to $40/ton, then growers will gain an average return above an initial $5/acre investment of $0.60/acre to $14.60/acre. Economics may be improved by both long-term and cumulative benefits resulting from strain ability to remain in fields until the next crops are planted. Benefits may also arise from the applied atoxigenic strains remaining with the crop until use and thus preventing increased contamination during transit and in storage at dairies.

Just as dust does not stay in the field in which it is raised, fungi do not stay in the field to which they are applied. Thus, over time, applications may reduce contamination in an area as a whole, facilitating the development of either gin-wide or community-wide management programs. In areas where multiple crops are affected by contamination (i.e., corn, cotton, and peanuts), treatments to one crop may benefit all crops. The economics of applications in such areas may be complex.

Development of a product based on atoxigenic strains and sold as an agrochemical would probably be the simplest course to producing an aflatoxin-control product. However, there are currently no products available for preventing aflatoxin contamination during crop development. Thus, the potential market for such products is unclear. Failure to demonstrate a reliable and ready market for atoxigenic-strain-based products has limited industrial involvement in their development. Alternatives to company development may include development of pest control districts. Advantages of such programs include tailoring the atoxigenic strains and formulations to specific regions, increased cost effectiveness, and development of mechanisms for funding the monitoring of fungal populations.

The next step in development and commercialization of atoxigenic strains is the performance of large-scale commercial tests. These tests will determine how to fit the technology into commercial practice and how to assess benefits of large-scale applications. Because atoxigenic strains are considered biopesticides, such evaluations require entry into the pesticide registration process and granting by the U.S. Environmental Protection Agency of an Experimental Use Permit and an Exemption from Tolerance. Interregional Research Project No. 4 is facilitating the further development of atoxigenic strains by assisting with the registration process. An application to treat a portion of the 1996 commercial cottonseed crop has been submitted.

Dead, weakened, and partially decayed plant tissues are readily available in agricultural environments, and it is not feasible to prevent the use of these resources by fungi. Thus, fungi grow as our crops are grown, and these fungi become associated with the edible portions of the crop. A level of control over which fungi become associated with crops may be provided by seeding select fungal strains into agricultural fields. This selection and seeding of fungal strains may reduce the vulnerability to aflatoxin contamination of all crops grown in a treated area.

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Pest Management Information Decision Support System

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What I have been hearing communicated from previous speakers at this symposium are two distinctly different philosophies and goals in regard to IPM. These two differing philosophies represent disparate concepts of, approaches to, and expectations from IPM.

One group views IPM as a program and a way to focus efforts on managing pesticides and their use. Those expressing this view have strong interests in environmental issues, public health, basic research, and pesticide regulation. Representatives expressing these goals and this philosophy see a need for rapid implementation of biologically based pest-management systems as the direction in which IPM should be moving.

Another group at this meeting views IPM as a way to better manage pests. Participants that expressed this philosophy were farmers, industry representatives, commodity-group representatives, and applied agricultural research and Extension scientists. People in this group view pests as the problem issue and that enhanced management tools are needed to address this problem. Those with this philosophy view the use of synthetic chemistries as one of the options in the pragmatic management solutions to pest problems, rather than the pesticide itself being the problem.

The exciting thing about this workshop is that both groups are using this format as a common meeting place to present their concepts and approaches and are seeking shared grounds to communicate their beliefs and differences. The Pest Management Information Decision Support System (PMIDSS) will be useful to all parties interested in pest-management issues, regardless of one's position, goals, issues, or philosophies.

Because the database is still in a formative phase, my concepts remain in the dream category. My dream is that PMIDSS can provide a totally new and more complete package of information re-garding pest-management topics than ever possible before. This information system will put these pieces of data at the fingertips of scientist, regu-lators, and policymakers, allowing users to make more-informed decisions. It must be kept in mind that a dream is a combination of one's reality, one's past, one's present, and one's imagination. Let me share with you now some of the parts of my dream of PMIDSS:

- I see this database as being an information-rich system accessible to government, State, and private organizations. Users will be able to rapidly search, download and identify sources of pest-management information in convenient, usable formats for use in rapid, concise, and documentable decision making.

- I see the database becoming a reality in FY96 through IPM and NAPIAP working as partners by sharing costs, information, personnel, and commitment to this effort.

- I see this as an information system with multiple owners, supporters, users, and contributors. Besides IPM and NAPIAP, other partners in the area of data contribution, development, maintenance, and use would be the State Land Grant Partners, EPA, IR-4, NASS, NCFAP, and AIS, to mention just the obvious.

- In the electronic environment of tomorrow, this database will have to be easy to access, contribute to, update, and use. It will be an information system that allows users to easily search for information, focus on topics or issues, retrieve information, and manage and format output to fit users' needs.

- My dream sees this database as a common decision-making information system on pest-management issues sharing common use by the agricultural, environmental, regulatory, scien-tific, industrial, crop-consultant, Extension, and public-health communities.

- A key link in the data gathering will be the land-grant scientists. Therefore, this information system will be of equivalent or greater use and value to the state scientist as it will be to the Federal partners. State scientists will have the ability to instantaneously bring together pest-management information that was previously either unavailable or difficult to find or handle. This database will be a one-stop shopping spot for pest-management information.

- It will be an information system with many layers of pest-management information, such as pesticide usage, regulatory history of active ingredients, pesticide labels, pesticide-resistance information, host plant resistance, cultural control, comparative performance of different management options, and much more.

Often a person can trace the source of a dream to a real time, place, or incident. My dream can be traced to my experiences with the three people who have collaborated with me on the Pest Management Information Decision Support System Project, Dr. Barry Jacobsen, Dr. Bob Riley, and Mr. Terry Janssen.