Part V. Policies for Promoting Biological and Reduced-Risk Alternatives: Panel-Discussion Summaries

Introduction

A myriad of policy tools (regulations and market incentives) could be used to reduce the negative environmental and health effects of pesticides. The sessions summarized in Part V focused on nonregulatory methods used by USDA to reduce pesticide risks, especially funding for research on alternatives, as well as policy tools used by EPA.

In the first session, eight policy approaches that could be used to reduce pesticide risks were outlined and discussed: (1) regulations on pesticide use, (2) regulations on the conditions of use, (3) taxing pesticides, (4) public funding for alternatives, (5) subsidizing the use of alternatives, (6) quota-based market incentives, (7) providing market information, and (8) moral suasion. One panelist cited successful European programs that use a variety of these approaches (the taxation program in Denmark, Norway, and Sweden; demonstration programs in Germany and the UK; Australia's voluntary agreements between farmer and consumer; and "green labeling" throughout Europe). California's multiple approaches, from mandatory training on biological control for pesticide applicators to an "IPM innovator" public recognition program, were also highlighted.

Does IPM certification help make farming more profitable to growers or does it make mandatory standards more likely? This issue is discussed in a session focusing on consumer concerns about pesticides. IPM certification is the policy approach of providing information to consumers about the environmentally friendly pest-management practices used under IPM production systems so that they can make more informed choices. In a recent survey, customers at farmers' markets and farmstands in Massachusetts, the only State with IPM certification, were generally unaware of IPM, but most said they would prefer it after hearing a definition that stressed environmental benefits. Numerous surveys indicate that consumer concern about pesticides is broader than food residues and includes environmental and farm worker concerns.

Research to develop pesticide alternatives is gaining ground as a major focus of USDA's nonregulatory approach for reducing the risks associated with pesticides, and several sessions in Part V were devoted to biological pest control. These sessions revealed some current successes with the use of biological control in some pest-management areas as well as the need for further research in others. The session on areawide IPM describes five, ongoing, biologically based Agricultural Research Service projects that are gaining support through partnerships with other Federal agencies, universities, commodity associations, and other stakeholder groups. The funding and acreage devoted to most of these projects, which are targeting major insect pests like the codling moth in the Pacific Northwest, have been increasing since their development in the early 1990's.

While the areawide IPM projects all target insect pests, the traditional biocontrol target, the two other sessions, "Limitations to Implementation" and "Exotic Pest Plants" describe some early successes with biocontrol of weeds. Most of the early successes with biocontrol have been for weeds in pastures and on ranges, where herbicides have been too expensive to apply. The need for research on biological management of weeds in cropping systems was underscored in both of these sessions. Robert Luck made a strong argument that the payoff for carefully designed, long-term, fundamental research on a specific ecological interaction, such as the interaction between a specific host plant and its biocontrol agent would be a better understanding of the fundamental mechanisms of similar interactions. He noted that the lack of this type of research has impeded biological and ecological pest management and will require teams and long-term commitment of funding to be successful.

EPA's Pesticide Environmental Stewardship Program is a new program through which pesticide users form a partnership with EPA, and make a voluntary commitment to reduce pesticide risk. This program and California's similar IPM Inno-vator Program use a "moral suasion" policy approach for encouraging the farmers and other pesticide users to reduce their use of risky products. Dozens of organizations have become partners with EPA since the program was launched in December 1994: the American Corn Growers Association, the California Tomato Board, other commodity groups, the Professional Lawn Care Association of America, the Tennessee Valley Authority, and other land managers. Some of EPA's partners have set numerical goals and tar-gets for reducing pesticide risks. The U.S. Depart-ment of Defense, for example, is aiming for a 50-percent reduction in pesticide use by the year 2000.

Finally, several new computer-based technologies [e.g., geographic information systems (GIS) and precision farming] are discussed in terms of their potential influence on IPM. The potential for GIS to "vastly improve" pest-sampling efficiency is described, and examples of its usefulness in characterizing habitat susceptibility (locating, for example, the egg beds of the Australian plague locust through satellite data) were cited. Panelists noted that precision farming will greatly enhance site-specific management capabilities but that mechanical capabilities may not be matched with economic thresholds. Precision farming can increase the efficency of pesticide applications but may not perform as well with other cultural and biological methods. Finally, the recent rapid growth in the U.S. organic industry is described along with the benefits that are anticipated from implementation of national organic certification, such as enhanced consumer confidence in products labeled organic.

Reducing Environmental and Health Risks from Agricultural Chemicals: Policy Considerations

Katherine (Kitty) Smith
Henry A. Wallace Institute
Moderator

When many hear the phrase "pesticide policy," they automatically assume that it applies to pesticides' regulation either in general or with specific reference to the U.S. pesticide registration process through which some pesticide uses are prohibited and others can be (and have been) canceled or restricted. Surely, restrictive regulation is one pesticide-reduction alternative. But there is an array of other policy approaches that have been or could be taken to reduce the use of and/or risk associated with pesticides. This overview of generic policy options identifies the alternatives.

Conceptually, the regulated restriction of some pesticides or pesticide uses has some policy advantages. The approach is direct and transparent. And restriction has been demonstrated to induce and stimulate technological change that can lead to development of new, less risky alternatives to the regulated class of materials. However, depending upon the manner in which restrictive regulation is implemented (particularly in the way that regulatory decisions are made), the approach can also have some distinct disadvantages. The U.S. experience points to the high administrative burden (and associated public costs) of pesticide regulation. Furthermore, the uncertainty associated with measures (of pesticide benefits and risks) used to make regulatory decisions can lead to poor decision rules and inappropriate incentives. For instance, registration costs may provide incentives for manufacturers to withdraw safe materials from the market.

The regulatory approach can also be (and has been) employed to restrict the conditions under which pesticides may be used, rather than restricting the materials themselves. Examples include worker-protection programs and water quality regulations that specify pesticide use conditions to minimize health or environmental risk. This approach, too, is direct and transparent. While less costly, to both policy administrators and pesticide users, than pesticide restriction, risk-reduction regulation can, in general, be harder to monitor and enforce.

Rates of tax sufficient to modify pesticide-use behavior are shown to be very high (more than 50 percent), so there is little room to calibrate tax rates with pesticide risk. Despite technical problems with taxation as a way to reduce pesticide use, it is an effective approach for generating revenues that may then be applied to remediation or prevention of adverse effects of pesticides.

USDA's expanded in-house research and competitive grants programs for IPM and biological pest control are examples of R&D investment. It needs to be noted, however, that the mere *availability* of new technologies and techniques does not guarantee their adoption. There are already a lot of alternative techniques "on the shelf." Appropriate economic conditions and/or incentives must exist before their adoption will displace pesticides.

Short-term subsidies can be used to introduce farmers or other pesticide users to alternatives that are likely to be profitable to the user. Longer-term subsidies are required for sustained adoption of alternatives that are not profitable relative to pesticide use under existing economic conditions without the addition of a subsidy.

A market-based system can be created to allocate reasonable levels of pesticide use. For example, quotas for a maximum level of pesticide risk could be allocated to users who could choose to employ or sell their rights to pesticide use. Quota-based markets have been created for the purpose of limiting air pollution within airsheds and point-source pollution within watersheds. However, the large number of pesticide users and the variance of nonpoint effects of pesticide use across numerous sites complicate the application of this approach to pesticide risk reduction. These large and practical problems probably explain why no simulated market has been tried for pesticide risk.

The preferences expressed by consumers in the marketplace can have a profound impact on the effective demand for pesticides at the producer level, but only if consumers have the information base on which to express preferences through purchasing behavior. Government provision of information, such as through certification of organic production or "green labeling" programs, can fill existing gaps. This approach allows the market to work more effectively through the availability of a fuller information set.

Successful Cooperative Extension System IPM programs demonstrate the potential for farmer education to reduce pesticide use and/or risk. Public-education programs might additionally improve the information base on which both economic and political markets operate.

Government could appeal, through advertisement and public relations campaigns, to individual pesticide manufacturers', distributors', or users' sense of responsibility in minimizing risk to people and the environment. This approach worked for antilittering. But then, there are no proponents for littering.

This set is basically the universe of different policy approaches that *could* be employed to reduce pesticide use or pesticide risk, arrayed according to the degree of intervention each applies to existing systems.

Our panel speakers reviewed what policy avenues have been pursued and what policies are actually being practiced in several venues. From there, we explore what experience has shown to be the problems and successes associated with different policy approaches to pesticide risk reduction.

Survey of OECD Countries' Activities to Reduce Pesticide Risks, Jeanne Richards, Organization for Economic Cooperation and Development

As a part of its pesticide-risk-reduction project, the Organization for Economic Cooperation and Development (OECD) surveyed 19 OECD (developed) countries, 9 Food and Agriculture Organization (less developed) countries, and the European Community to determine what policies and programs are in place to reduce pesticide risk. The surveyed countries' policies varied in three important respects: (1) whether policy goals focused on reducing pesticide use, reducing pesticide risk, or increasing IPM usage; (2) whether programs were implemented at a national scale or addressed by subnational political units; and (3) whether participation was mandatory or voluntary. Despite these differences in approach, many common elements of countries' policies were also identified. For example, all OECD respondents have policies or programs to enhance IPM, including IPM research and development programs and programs to increase the use of biological controls.

The survey and its analysis identified the following as among the more successful programs (in OECD countries other than the U.S. and Canada): pesticide-use-reduction programs in Nordic countries; Australia's voluntary agreements among farmers and consumer associations to reduce pesticide use; European subsidies for environmentally friendly farming; the European Union's "Fifth Environmental Action Plan"; green labeling programs throughout Europe; model-farm demonstrations in Germany and the United Kingdom; and pesticide taxation in Denmark, Norway, and Sweden. Survey respondents' views on what works best and what is needed for effective pesticide-risk-reduction policy identified sound data on pesticide use and systematic methods for measuring programs' progress toward reduction goals as critical needs. Identified ingredients for program success were: farmer participation in programs; farmers' commitment to reducing agriculture's impact on the environment; involvement of both agricultural and pesticide authorities; use of traditional agricultural networks; a whole-systems approach; consideration of economic impacts on and risks borne by farmers who use alternatives to pesticides; and public awareness and support.

California's Multipronged Approach to Pesticide-Risk Reduction, David Supkoff, Department of Pesticide Regulation, California Environmental Protection Agency

The State of California has long been a bellwether for the nation when it comes to pesticide policy. At present, more than half a dozen different State-level programs directly affect pesticide use or associated risks. First, California has its own Worker Protection Program that prescribes the conditions under which farmworkers may legally use pesticides. Enforcement has proved to be a critical function of that program. Second, like all States, California has a program for pesticide-applicator certification. A unique aspect of this program is that, to be certified, pesticide applicators must have training in biological control. Third, California's Groundwater Protection Program directly addresses the use of pesticide materials found to be groundwater contaminants. Water-quality protection with respect to pesticides in California is greatly aided by interagency agreements with the State Water Quality Board to coordinate regulations. Fourth, California has initiated an IPM Innovator Program that gives public recognition to individuals and groups that have implemented strong IPM programs or practices. Basically a form of rewarded moral persuasion, this program has been successful not only in getting pesticide users to experiment with alternatives, but also in gaining broader acceptance of the IPM approach. Fifth, a granting program, Innovations in Pest Management, supplements the State's Extension IPM initiatives. In addition, State pesticide restrictions apply under a variety of other programs, including California's activities toward compliance with the Clean Air Act.

The Role of Risk Analysis in IPM, Nell Ahl, USDA Office of Risk Assessment and Cost-Benefit Analysis

Risk analysis involves risk assessment, risk management, and risk communication to identify potential hazards, determine the likelihood (probability) of their manifestation, and gauge the magnitude of the consequences should the hazards manifest themselves. As an interesting case of pest-management program strategies illustrates, risk analysis can bring added value to IPM-policy decision making.

The eurasian pine shoot beetle (PSB) emerged as a new and potentially serious pest of timber in the upper midwestern United States in 1992. Prior to risk assessment, the State of Michigan proposed 25 mitigation measures, including several required pesticide sprays for trees and logs and met resistance from the timber industry. Risk assessment performed by the USDA's Animal and Plant Health Inspection Service showed, however, that 99.8 percent of the risk from PSB originated in a 2-week period in slab wood at the sawmill site. Treatment of slab wood by burning or grinding it up prior to the end of the 2-week period in the PSB life cycle effectively managed the risk, required no pesticide use, and was a strategy the industry complied with, without the need for regulation. Lessons learned from this experience included: (1) risk assessment should precede risk-management policy decisions; (2) risk communication can work when all parties come together early in the process; and (3) good risk assessment can be an analytical tool to support IPM decisions.

Risk assessment is required for major USDA regulations. In conjunction with cost-benefit analysis, it can give power and context to pesticide-reduction-policy decision making.

Imperatives for Pesticide Reduction Policy, Carolyn Brickey, National Campaign for Pesticide Policy Reform

Clarification or reform in four critical areas of U.S. IPM and pesticide policy are needed to assure pesticide risk reduction. First, a clear, science-based definition of "biologically intensive IPM" is needed to guide policy directions. The definition should provide measurable goals so that policy progress and success can be gauged. Second, USDA should implement an IPM policy goal based on the logical paradigm that IPM lessens reliance on pesticides, less reliance translates into less use, and less use means less risk.

Third, there is a myriad of problems involved in using the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) as the basis for managing pesticide risk. For instance, the practice of pesticide product-by-product review rather than review by class of pesticide slows the process and can result in restricted products being replaced by riskier alternatives. Further, the FIFRA process is not providing adequate incentives for technological change, and it perpetuates the promotion and defense of pesticides as the principal tool for pest management.

Fourth, a range of new institutional roles are needed. USDA should make itself a leader in the development of nonchemical pest-management technologies. In particular, public research funds need to be better targeted toward this goal. EPA, in the meantime, needs to change the basis for its risk-benefit determinations, particularly as they address the hormone-mimicking and immuno-logical effects of pesticides. Finally, the food-processing industry needs to adopt and promote new standards for the protection of its customers.

Audience Discussion

Ensuing discussion was brief but clearly underscored the complexity of pesticide-risk reduction policy-making. A number of comments and questions concerned the issues of what ought to constitute risk and where public policy should "draw the line" on unacceptable levels of risk. While such areas of questioning are informed by science, the answers themselves are squarely in the realms of policy and politics.

Responding to Consumer Concerns About Agricultural Chemicals

Carol Kramer
Economic Research Service, USDA
Moderator

The panel was asked to address the subject of consumer concerns about chemicals; to identify policy and program responses that potentially make sense, given consumer concerns and public health information; and to discuss the extent to which a policy or program response, such as that embodied in the IPM Initiative, can be responsive and successful. The panelists were selected to represent a diversity of perspectives and expertise. Panel participants included Eileen van Ravenswaay, Michigan State University; Molly Anderson, Tufts University; Fred Kuchler, Economic Research Service; and Allen Rosenfeld, Public Voice for Food and Health Policy.

The policy elements that establish the context for the departmental IPM Initiative include:

- public concerns of the 1980s and 1990s about pesticides in food, water, and the environment as well as concern about worker/operator exposure;
- the 1993 Administration policy to reduce pesticide use;
- the Administration policy to support achievement of IPM on 75 percent of crop acreage; and
- the EPA's policies to reduce risk from pesticide use and encourage environmental stewardship.

The Economic Research Service (ERS) sees its role, in support of the policy goal of reducing the risks from pesticide use, as one of assuring that the assessment methods and mechanisms are put in place to test the logic and establish the outcomes of the policies and programs that are implemented. In the end, ERS seeks to be able to answer whether IPM methods can be developed for 75 percent of U.S. crop acreage; where they are adopted, if adoption reduces chemical use; and if the reductions in chemical use are well-targeted so that areas of highest water-quality vulnerability, chemicals with the highest toxicity, and chemicals with the greatest environmental or public health risk are most affected. These are not simple results to know, but only by systematically targeting programs and evaluating their success will we truly understand if the IPM Initiative approach will have the intended payoffs.

The first panelist, Eileen van Ravenswaay has conducted extensive research in the area of consumer perspectives on pesticide use, chemical residues in food, and their implications for public policymakers. The first major finding from her research is that perceptions of risk from pesticide residues differ greatly among members of the public. One implication is that there are major differences in information needs, policy preferences, and market niches among the public, although these differences are not very systematic. A second is that the risks from pesticide residues are, and are perceived to be, broader than cancer alone. A corollary here is that the sole focus of risk communicators on cancer does not address these concerns. A third is that the concern about agrichemicals is not limited to residues, but includes concerns about the environment and about farm workers. A corollary here is that the focus of risk communicators on cancer from residues does not address these concerns. A fourth is that trust in the government, industry, and scientists is very low and may be more important than risk perceptions. A corollary here is that restoring trust should be a high priority, and there should be a focus on the process of ensuring safety for consumers and the environment in order to do so.

van Ravenswaay also discussed perceptions of the benefits of pesticides and their implications. The public generally believes that pests need to be controlled and economical alternatives to pesticides already exist. The implication is that they expect IPM to be used. Many consumers are willing to pay more for less pesticide use, but product price differences are important. An implication here is that the public is willing to pay for IPM research; also, there are some market-niche opportunities. Public views on organic foods indicate confusion. One implication is that selling "less pesticide" (as opposed to organic "no pesticides") to the public will require a major marketing effort. Processes used by growers, shippers, and handlers may be important.

Molly Anderson reported field research on consumer reactions to IPM certification, her conclusions, and her experience working with the Massachusetts IPM apple growers. She noted the importance of learning about consumer reactions to IPM certification, particularly in light of evident public interest and government support. Because Massachusetts is the first State with an active IPM-certification program and label, it was a good venue to test response to IPM-labeled foods and to find out if consumers buy IPM-grown foods preferentially. The IPM certification method in Massachusetts consists of a checklist of practices, from which farmers must accumulate at least 70 percent of possible points.

The study investigated consumer awareness of IPM and the effects of a "passive" and an "active" marketing strategy. Thirty customers were interviewed at each of six farm stands and six farmers' markets in eastern Massachusetts, selected to allow comparisons between income levels and ethnic mixes. The short questionnaire probed purchase motivation, IPM awareness, certification awareness, and personal characteristics. The IPM definition used stressed environmental benefits, with no mention of food safety.

Results indicated little initial consumer awareness of IPM (only 19 percent). However, 50 percent of consumers "cared" how their food was grown, and some 85 percent said they would prefer IPM, after explanations. Many consumers associated IPM with food safety, even though the educational messages did not mention food safety, only environmental protection. Demographic characteristics were insignificantly correlated with IPM support, and the point-of-purchase educational strategies used were relatively ineffectual. Nonetheless, Anderson concluded: high percentages of customers claim to prefer IPM-certified products after hearing a definition; consumers will accept necessary pesticide use; potential advantages of IPM certification are strong; IPM certification programs must be combined with consumer education programs to be effective.

Fred Kuchler presented newly available analysis based on recent data from USDA's Pesticide Data Program. The program allows analysts to trace pesticide residues on fruit and vegetables to four sources: on-farm pesticide use; post-harvest pesticide use; pesticide use on imported foods; and canceled pesticides (canceled registrations for use) that persist in the environment. The data show that post-harvest pesticides capture the largest share of residue detections.

The data show that farmers' pest-control choices influence consumers' pesticide dietary intake, but the way in which food is marketed and the history of pest-management techniques used on farms may have greater influence. Agricultural research intended to develop on-farm pest-control alternatives will not address all of the sources of pesticide risks in consumers' diets.

Allen Rosenfeld addressed public-policy concerns related to pesticide residues in foods and in the environment. He also provided an update on developments related to the farm bill. He noted that pesticide policy reform was not directly involved in the farm bill discussion. He pointed out challenges in communicating the benefits of IPM to a public concerned about pesticides, given the diverging philosophies associated with pesticide use among IPM users and within the IPM community.

One issue evident from the discussion was that while the public is concerned with pesticide residues in foods, the majority, but not all, of those residues of concern (according to the ERS analysis) result from post-harvest use, use on imports, and canceled pesticide use or residues. IPM is unlikely to have an impact on those sources of dietary exposure. One implication is that IPM may be most likely to gain strong public support if it can achieve and demonstrate accomplishments in the realm of environmental stewardship and if it can be expanded to include health benefits from reducing occupational exposure. A final issue discussed was producer acceptance of certification programs that are needed to accompany any label or promotion efforts. Whereas some producers see an advantage to certification and participate voluntarily, others see a potential problem. Some Massachusetts producers had concerns that IPM certification standards would become mandatory and progressively more restrictive to producer autonomy over time.

Areawide IPM as a Tool for the Future

C. O. Calkins
Agricultural Research Service, USDA
Moderator

Participants in this session were: R. M. Faust , J. R. Coppedge, L. D. Chandler, D. D. Hardee, and M. R. Bell, Agricultural Research Service, USDA, and J. F. Brunner, Washington State University.

Overview, Goals, and Premises

The areawide pest-management program administered by ARS involves a coordinated program with active grower participation to suppress or maintain a low-level pest population over large definable areas, as opposed to on a farm-to-farm basis, through environmentally sound, effective, and economical approaches. To gain participant support, this type of partnership program must include a meaningful list of benefits, such as lower costs and increased profits. A benefit to the grower should include more sustainable pest control at costs competitive with insecticide-based programs. A reduction in chemical insecticide use is, of course, one goal. Our partners include other Federal agencies, university research and extension, State departments of agriculture, and the private sector as well as the growers, commodity groups, and other stakeholders.

The ARS, in the USDA IPM Initiative under the Strategic Implementation Plan, is charged with "establishing a program to support the IPM needs through implementation of areawide pest-management projects." Scientists working in support of IPM have also been requested to proactively increase their linkages and partnering with the State and private sectors actively involved with IPM in general and with the USDA IPM initiative specifically. The overall mission and goals of the areawide pest-management program are to establish and implement areawide pest-management research and action programs for key pests and crop systems that have been identified as high priority. These research and action programs are to (1) result from a stakeholder partnership and collaboration dedicated to the development and adoption of improved crop-management technologies; (2) demonstrate the positive impacts and advantages of such a program over a large area through enhanced grower profits, reduced worker risks, an enhanced environment, and a proven superiority of an areawide IPM strategy as compared to past and current control approaches; and (3) achieve a mature areawide pest-management system so farmers, consultants, and local organizations will be left with an operational program that will meet the overall goals through its adoption. These research and action programs will require a unified effort among Federal, State, local, and private interests, and the participants will be involved in this voluntary program from conception to adoption.

The success of an areawide pest-management program depends on several premises. To achieve the goals, pest-specific management tools are needed and should be available and implementable. The tools must control the pest, be economical, impact little else in the environment, and not form residues on the food product where they could be a hazard to the health of the consumer. Many pest-specific management tools are most effective when used areawide because of the dispersal characteristics of certain target pests, as opposed to simply using them on a field-by-field basis. The program is to consider other pests in the system. Also, the management of pests areawide implies that communities become involved in the process. In addition to grower groups, local representatives from several agencies of USDA, EPA, and other organizations need to be involved in the planning and implementation of the projects.

Finally, some of the generic criteria that are considered to be important in terms of site selection for the projects include some or all of the following, depending on the scope of the program: (1) The participants should support the concept of areawide pest management and be willing to allocate people and resources over and beyond the ARS support to the extent possible. (2) The large-scale pilot test sites identified must be typical production settings with representative pest problems and be definable by biological criteria. Each selected area should be sufficiently large that meaningful data can be extracted on efficacy as well as on economic and environmental benefits. (3) Populations of the key pest should occur consistently in the proposed area, and the study should attempt to determine the infestation levels at which treatment is economical. Site-specific IPM-based treatment measures should attempt to account for the spatial and dynamic nature of the key pest as well as of other associated pests that may come into play. (4) Producers and producer groups within the proposed test area should have a cooperative stance and be willing to share costs, where needed, for the technology used to mitigate pest problems that would normally be dealt with at the producer level. (5) There should be interest and participation by local representatives of federally and State funded groups, such as the EPA, Farm Service Agency, Natural Resources Conservation Service, Extension, and others, as appropriate. (6) The locality and the participant-partners in the areawide project should have (or be able to find and train) the technical support personnel (e.g., private consultants, Extension specialists, scouts, applicators, and others) needed to help conduct the study. (7) The State or region has (or can develop) the organizational structure to support and establish the enhanced IPM systems in the local community.

Areawide Management of Bollworm and Budworm with Pathogens

Research to develop improved methods of managing serious insect pests of delta crops, especially cotton, by use of natural insect pathogens was begun in 1987 at the USDA-ARS's Southern Insect Management Laboratory (SIML) at Stoneville, Miss. Previous research had shown that noncrop hosts, particularly early-season weeds, act as hosts for the tobacco budworm, *Heliothis virescens* (F.), and cotton bollworm, *Helicoverpa zea* (Boddie), prior to the presence of crop hosts. It was theorized that tobacco budworm and cotton bollworm populations could be managed by either controlling the insects on the weeds with insecticides, or by controlling the early season hosts themselves via herbicides or mowing. Because insect pathogens (microbial insecticides) are considered to be among the safest methods of insect control, research was begun to investigate their use in a management scheme. Positive results of small-field and cage tests led to large-area studies, beginning with a 64,000-acre test in 1990 and culminating in 215,000-acre tests in 1994 and 1995. Results of tests to date indicate that virus application could be accomplished at a reasonable cost and that such treatment consistently reduced the number of moths emerging from weed hosts by more than 70 percent.

Areawide Management of Codling Moth

The western States produce 54 percent of the total U.S. apple production (236,000 acres with an annual crop value of $1.5 billion) and 97 percent of the pear production (70,000 acres and $0.2 billion). This economically important fresh-pome-fruit-growing industry suffers significant annual pest-related losses. Crops in this region are sprayed with nearly 2 million pounds of insecticides (excluding petroleum distillates and *Bacillus thuringiensis* products) to control a large number of insect pests. The codling moth *Cydia pomonella* L. (CM), the key pest of pome fruit, is the target of many of these sprays and, if not controlled, causes the majority of damage. Traditional pest-control methods, chiefly multiple sprays with organophosphate insecticides, have led to the development of resistant strains of codling moth, reduced populations of beneficial insects, and increased secondary-pest outbreaks while contributing to environmental degradation and increased concerns over farmworker safety. Intensive use of pesticides has eroded consumer confidence in the safety of pome fruits, particularly for infant consumption. In addition, some countries impose quarantine import restrictions on fruit produced in the western region because of the existence of codling moth with the potential for serious financial consequences and a negative impact on the balance of trade.

There have been active research programs on mating disruption with the sex pheromone of CM for several years in the Pacific Northwest. Collective experience indicates that mating disruption can provide population suppression and control when low densities of moths are present but may require supplemental applications of insecticides under moderate to high populations. The potential to use mating disruption over large contiguous areas as part of a CM-population-suppression strategy formed the basis for the USDA-ARS project for management of CM in the western United States.

The goal of the Areawide Suppression Program for Codling Moth is to marshall a western-regional, multi-institutional program to assess, test, and implement an integrated strategy for the management of codling moth populations on fruit orchards that will alleviate the impact of neurotoxic pesticides on natural enemies and will open the opportunity for use of more environmentally friendly control tactics for secondary pests.

Areawide suppression uses all of the technological tools available, including mating disruption, biological control [parasites, predators, granulosis virus, and *Bacillus thuringiensis* (B.t.)], the sterile-insect technique, and orchard sanitation. The earliest tool may be a chemical or a B.t. pesticide applied to lower the initial moth population, followed with mating disruption and release of biological agents (such as parasites) on apples and pears. By applying the protocol in successive years, the natural enemies would increase, and the popu-lation should be kept under control with reduced pesticide usage and at a low cost to the growers.

The objectives were: (1) to enhance the efficacy of nonpesticidal systems for the control of codling moth and other major fruit pests by reducing nonessential neurotoxins in IPM programs for fruit pests; (2) to demonstrate that mating disruption of codling moth works better when applied over large areas because less pheromone can be used and the cost thus reduced; (3) to aid fruit producers in the transition to production systems less reliant on neurotoxic pesticides by developing an incentive program for the adoption of mating-disruption techniques by growers that will result in lower pest-control costs; (4) to drastically improve chances for biological control and other population-regulation tactics for secondary pests; (5) to develop alternative management tactics that will complement the use of mating disruption, such as sterile-insect technique, B.t. sprays and mass release of selected parasitoids; (6) to develop an areawide monitoring program for mating disruption of codling moth with traps, damaged fruit, tethered females, etc.; (7) to establish treatment thresholds for use of alternative control means, including organophosphate insecticides, when needed; (8) to use GIS and conventional aerial photography to map fruit production in the States and to develop specific areawide pilot demonstration projects; (9) to improve the perception that fruit production is based on environmentally friendly methods and that the fruit has the highest safety standards for consumers; (10) to improve the environment for orchard workers by reducing the level of organophosphate insecticide use, thus removing restrictions on reentry because of organophosphate residues.

To demonstrate the feasibility of areawide suppression, pilot test sites were established at Randall Island, Calif.; Medford, Ore.; Yakima, Wash.; Howard Flats, Wash.; and Oroville, Wash. The test sites were managed by University of California, Berkeley; Oregon State University; Washington State University; and USDA-ARS. The growers at each site contributed heavily to the expense of conducting these studies.

The results of the first year of the 5-year program revealed that natural-enemy populations recovered rapidly in the program of reduced use of CM insecticides. Little or no pesticides were required for control of leafhoppers, leaf miners, and aphids. Parasite levels increased dramatically over those in conventionally treated control areas.

Codling Moth Pheromone-Based IPM in Washington

One site established in Washington was at the Howard Flats growing area near Chelan, a fairly isolated production area of about 1,200 acres. Thirty-six growers farm at Howard Flat, packing fruit at four cooperative warehouses, and 16 crop consultants provide advice on pest control and horticultural practices. Codling moth mating disruption was used on 1,150 acres in 1995. Insecticides coupled with pheromones limited crop loss to an average of less than 0.1 percent by midsummer. Harvest samples indicated that the average codling moth fruit injury in blocks from Howard Flats was 0.55 percent, even with no insecticides applied during the second half of the season. Leafrollers were identified as a potential pest of concern for 1996, but other secondary pests were below treatment thresholds in all orchards. The use of codling moth mating disruption to radically alter pest management in the apple orchards of Washington appears to hold great promise for reducing reliance on broad-spectrum insecticides. A pheromone-based pest-management system for apples and pears would allow growers to take greater advantage of biological controls for many pests, rely on "soft" chemical controls to suppress pests when needed, and reserve the fast-acting broad-spectrum insecticides to stop pests that cannot be controlled with other means. This should lead to a stable, safe, environmentally friendly, and (it is hoped) economical pest-management system.

Corn Rootworm Areawide Management Technology

In response to many problems associated with traditional corn rootworm (*Diabrotica virgifera virgifera* LeConte and *Diabrotica barberl* Smith & Lawrence) management practices, scientists with USDA-ARS and the agricultural experiment stations of several midwestern States developed a new management concept to suppress beetle populations with a semiochemical insecticide-bait. The insecticide-bait uses behavior-modifying chemicals that are specific for corn rootworm beetles and that induce them to feed compulsively on the bait formulation. These baits have been developed as either dry-flowable microspheres or polymer-based tank mixes. The primary components of these baits are cucurbitacins, bitter tasting tetracyclic triterpenoids that attract beetles and repel nontarget insects. They are found in high concentrations in roots of the wild-growing buffalo gourd, *Cucurbitia foetidissima* H.B.K. Dried and ground roots of this plant mixed with a small amount of toxin (carbaryl) and a nontoxic edible carrier are the basic components of these formulations. Recent research at two sites in South Dakota has demonstrated that, because of the high mobility of adult corn rootworms, management of beetles with these baits is more effective when done over a relatively large area. The use of semiochemical insecticide-baits in combination with other rootworm-management tactics (crop rotation, biological control, etc.), state-of-the-art population-monitoring technology, and new corn-management technology will greatly improve chances of successfully implementing a corn pest-management system on some of the estimated 1 million acres of corn production with significant corn rootworm populations.

USDA-ARS, with the cooperation of partner universities and other Federal agencies, is currently developing a program to evaluate an areawide management system for pests of corn, specifically on acreage where the corn rootworm is a key pest. Study sites will be developed to evaluate the concept of areawide IPM with semiochemical insecticide-baits as primary rootworm-management components and biologically based management approaches for other economic pests, as needed. ARS recognizes that areawide management of corn pests must be compatible with ongoing or emerging corn IPM systems to be an acceptable management approach. ARS, therefore, feels it is appropriate and desirable to investigate the impact of an areawide management initiative for primary corn pests as part of an IPM program. Three regions are under consideration during 1996 for development of full-scale programs in 1997: 1)Illinois/Indiana; 2)Minnesota/Iowa/South Da-kota; and 3)Kansas/Nebraska. These regions repre-sent the wide diversity in corn production systems found across the Corn Belt. Each region also has significant and unique problems related to the management of corn rootworm. Within each region, ARS expects to develop a single evaluation site with a cooperative approach among partner State research institutions.

Areawide Pest Management of Mexican Corn Rootworm and Cotton Bollworm

The USDA-ARS Areawide Pest Management Research Unit (APMRU) at College Station, Tex., is involved in two areawide pest-management studies: (1) the Mexican corn rootworm (MCR) areawide pest-management pilot study in the active stage and (2) the cotton bollworm (corn earworm) project in the development stage.

The MCR project involves the use of adult control with attract-and-kill pesticide formulations (attracticides) as a replacement for soil-applied or broadcast pesticide applications. The successful transfer of this attracticide technology to producers would represent a 95- to 98-percent reduction in pesticide use for this pest. In 1996, the unit will be conducting a pilot study in Bell County (Central Texas, near Temple) to evaluate this management approach on 3,000 acres of corn. The corn in the test area will be intensively monitored and treated, as needed, based on the number of adult MCR present. If successful, this new technology will be transferred to producers in 1997 or 1998. The adoption of this technology has the potential only to not reduce pesticide use but also increase yield and reduce production cost.

The APMRU is also developing a program for the areawide management of cotton bollworm (also known as corn earworm). The crop damage from this pest exceeds $1 billion a year. The corn earworm overwinters in only the southernmost part of Texas and northern Mexico. It emerges from overwintering each year and completes one generation on corn in the source (overwintering) zone. The progeny of this generation infest corn, cotton, tomatoes, and other crops in Texas, Oklahoma, and much of the midwestern United States. The APMRU is conducting research on population dynamics of the corn earworm in the source and recipient regions, movement and migration times and pathways, an attract-and-kill formulation for reduction of adults in the source regions, and natural markers for corn earworm. The research group plans to have an areawide pest-management strategy in place within the next 5 years.

Exotic Pest Plants, Biological Control, and IPM: A Trio with a Date for the Future

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Moderator

Biological control of immigrant weeds, or exotic pest plants, has been used for more than 90 years. Two early successes were the programs against prickly pears in Australia and Klamathweed in California. The prickly pear success was actually a cluster of successes. Several species of prickly pears were controlled by multiple species of insects in various countries. In Australia, a South American moth, *Cactoblastis cactorum*, was released in 1926 and within 14 years most of the infested land had been reclaimed. A total of 48 species of insects were sent to Australia during that project, although not all were released. Small sucking insects, the cochineals, *Dactylopius* spp., controlled several prickly pear species not controlled by the moth, both in Australia and elsewhere. The Australian success stimulated a program in California in 1940 by the USDA-ARS and the University of California to control Klamathweed, *Hypericum perforatum*. Almost a million hectares were infested before two leaf-eating beetles, *Chrysolina* spp., brought the plant under spectacular control, reducing it to less than 1 percent of the original infestation. Later, in the sixties, the aquatic alligatorweed, *Alternanthera philoxeroides*, was controlled in the southeastern United States by a leaf-eating beetle, *Agasicles hygrophila*. Weeds of pastures, wastelands, and waterways have been the traditional targets for biological control programs, but future targets must include plants that are rapidly invading natural areas. Examples of these new exotic pest plants include climbing euonymus, kudzu, and vinca in the Great Smoky Mountains National Park; honeysuckles and privets along roadsides and natural areas in the eastern States; melaleuca, Brazilian peppertree, and hydrilla in Florida; purple loosestrife and Eurasian watermilfoil in the northern States; and saltcedar in the western States. Increasing amounts of herbicides and manpower are used to contain this invasion. To accomplish our IPM goals, greater effort is needed to control these natural-area weeds and crop weeds with biological controls, including plant pathogens, and to integrate biological controls with other controls.

Integrated Management of Tansy Ragwort in Oregon, D. L. Isaacson, Oregon Department of Agriculture

Tansy ragwort was first detected in Oregon in 1922, and by the mid-fifties had become recognized as a serious pest, causing poisoning of livestock and competing with desirable forages in 16 western Oregon counties. In 1974, the Oregon Department of Agriculture initiated an interim control program, and in 1975, the Oregon Legislature passed a law formalizing the program and provided funding support. Control in western Oregon originally emphasized biological control especially distribution of the cinnabar moth and the ragwort flea beetle, with the goal of effecting complete distribution of these agents over the entire range of ragwort as quickly as possible. By 1978, cinnabar moth populations had been established within 350 of approximately 400 infested townships (approximately 10 x 10 km) by redistributing cinnabar larvae to approximately 5,580 sites. By the early eighties redistribution of flea beetles was also essentially complete. Another agent, the ragwort seedfly, dispersed throughout western Oregon with limited redistribution efforts.

Field monitoring and experimentation documented marked reductions in ragwort densities by the cinnabar moth and the flea beetle. Herbicide recommendations for ragwort control were developed and demonstrated, and pasture management practices that reduced ragwort infestations were distributed. By the late eighties, incidence of livestock losses were reduced, and in 1992, economic benefits of ragwort control in western Oregon were estimated at $4 - $5 million annually.

In eastern Oregon, pioneering infestations of ragwort were discovered with increasing frequency, with ten discovered in 1975. In 1979, an employee was reassigned to eastern Oregon with the primary responsibility of detecting and controlling new infestations of ragwort east of the Cascade Mountains.

Tansy ragwort remains below economic thresholds on almost all sites in western Oregon where it had once been a severe problem, and only four of the several hundred sites found in eastern Oregon are not considered eradicable.

Biological Control: The Indispensable Element in Integrated Management of Leafy Spurge, P. C. Quimby, Jr., J. L. Birdsall, and A. J. Caesar, USDA-ARS; H. McNeel, USDA-BLM; N. E. Rees USDA-ARS; R. Sheley, Montana State University Extension Service; and N. R. Spencer, USDA-ARS

Leafy spurge infests more than 5 million acres of rangelands and pastures in a least 23 States. To manage leafy spurge, all available strategies must be applied in an integrated system to achieve the goals desired for the land. These strategies include education, prevention, containment, and reclamation and restoration. Education (i.e., technology transfer) is a strategy in and of itself, but it also applies to all other strategies. Prevention is an appropriate strategy for managers of clean, uninfested lands. For large stands of existing leafy spurge, containment tools may include prescribing fire, applying chemicals, and grazing sheep or goats. Without additional treatment, fire will only temporarily slow leafy spurge and then stimulate new growth. Properly applied herbicides can temporarily contain leafy spurge, but these chemicals are prohibitive in cost and are probably limited to peripheral and spot treatments.

Some herbicides may produce environmental risks in the long term, especially to desirable native forbs. In general, herbicides are a static answer to a dynamic problem. Sheep and goats can be managed as domesticated "biological control" tools to contain leafy spurge, but once the animals are removed from the system, the weeds will return to their original density and expansion rate. The strategy of reclamation and restoration may include the tools of reseeding competitive vegetation and biological control. For most low-value rangelands, reseeding is prohibitive in cost and in some cases replaced one exotic plant species with another. For the dynamic, wide-area invasive leafy spurge problem, only a comprehensive, dynamic biological-control program can produce near-restoration of native plant communities. The classical biological control approach provides a self-perpetuating, economical solution to manage-ment of leafy spurge in low-value rangelands.

Examples of insects and plant pathogens working together are now available that suggest an incipient success story is on the horizon for biological control. These examples provide evidence that biological control will be the indispensable element in the integrated management of leafy spurge. The whole process of learning how to manage leafy spurge can be accelerated by more research to fully integrate biological control with management tools. Education and technology transfer are critical to the success of the process.

Management of Exotic Aquatic Plants, Alfred Cofrancesco, U.S. Army Corps of Engineers, Waterways Experiment Station.

The Rivers and Harbors Act of 1899 directed the removal of aquatic vegetation that was hampering the operation of navigable waterways in Florida and Louisiana. This was the first effort by the United States to manage aquatic vegetation.

Three general methods are available to manage exotic aquatic plants: mechanical or cultural, chemical, and biological. All of the methods have positive and negative aspects that need to be considered when determining which control strategy will be employed. The oldest method is mechanical or cultural removal; it can be as simple as the manual removal of individual plants or as sophisticated as the use of specialized equipment specifically designed to remove a certain type of vegetation. This method gives rapid results but usually is costly and difficult to conduct in the aquatic environment.

The use of chemicals to regulate populations of exotic plant pests has progressed through many phases. In general, chemicals are effective in reducing nuisance aquatic vegetation. However, many chemicals affect a broad target population so their impact may not be limited to just the nuisance plant. The action of the chemicals is usually rapid, requiring only a few weeks to see extensive impact. Chemical applications are usually less expensive than mechanical or cultural control methods but may have to be repeated on an annual basis.

Biological control is based on the concept that the target plant has natural control agents present in its native range and the introduction of these natural enemies will reestablish the pressure that the noxious plant normally experienced. In this approach, control agents (natural enemies) are introduced into areas that are not part of their native range to manage an introduced noxious plant. In general, these agents are host-specific arthropods, nematodes, or plant pathogens. This control method is usually very cost effective. Once agents are released and established, their populations are maintained without cost, and the agents usually disperse to other infected areas.

In dealing with any of the target plants, the resource manager must understand exactly what types of options are available for management of a target pest and the extent of management that is needed. If a waterway needs to be completely clear of a particular type of vegetation in 1 to 2 months, then mechanical or cultural or chemical control methods are the only choices. However, if long-term management of a target is required and a biocontrol agent exists, then a management program that uses the biological agent needs to be implemented.

Plant Pathogens for Biological Control of Weeds, William L. Bruckart, USDA-ARS-NAA
Plant pathogens have a proven track record for biological control of weeds and are clearly suitable for integration with other pest-control strategies. More than 50 percent of the important weeds in North America are introduced, many without plant pathogens or insects in their new habitats. Generally, the inoculative (classical) approach is considered for these, which involves introduction of a pathogen collected from the native range of the weed. Successful control of *Chondrilla juncea* (rush skeletonweed) by the rust fungus, *Puccinia chondrillina*, was achieved in this way. Other weeds occur in row crops. Some pathogens can be grown on artificial media and applied in a high concentration when the weed is most vulnerable. This, the inundative (bioherbicide) approach, results in a rapid and highly effective plant kill, similar to that from chemical herbicides. Successful use of the product Collego, which contains spores of *Colletotrichum gloeosporioides* f. sp. *aeschynomene*, involves this approach. This product also can be integrated with chemical herbicides by tank mixing to control several weeds with one application. Broad-spectrum weed control is a new idea pursued with plant pathogenic fungi, either as weak pathogens in special carriers or as mutant strains of broad-spectrum pathogens. Improved efficacy and reduction in chemical herbicide requirements may result from genetic engineering of weed pathogens. Other new areas include development of plant pathogenic bacteria and viruses. All of these pathogens are studied and used under regulation of either the USDA, Animal and Plant Health Inspection Service (APHIS), or the Environmental Protection Agency (EPA).

Limitations to Implementation of Biological Control for IPM

Michael Benson
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Moderator

Impediments to Biological Control: A California Perspective, Robert F. Luck, University of California

Fundamental to the development of an IPM program is an ecological understanding of the organisms involved and their interactions with one another. These organisms include the plant, the organisms inhabiting the plant's rhizosphere, and those inhabiting the aerial portion of the plant (i.e., the microorganisms, saprophytes, phytophages, and predators). This understanding defines the biological potential that can be realized in managing the commodity. It also provides the foundation for an economic analysis of the commodity and for its management in a particular context. With respect to managing arthropod pests, this understanding requires a tritrophic perspective. The lack of this perspective and the absence of ecological knowledge about this interaction has impeded the development of a sustainable pest-management program. This ignorance is especially apparent at the third and higher trophic levels. I wish to illustrate the consequence of this ignorance with a practical example.

Host selection by a parasitoid may seem arcane as an example of an impediment to biological control, but it is not. It is an ecological process of fundamental interest, and the linkage between the fundamental and practical aspects of this process is the foundation of pest management and of biological control. Unfortunately, the fundamental aspects of host selection are all too frequently viewed as irrelevant to pest management.

In host selection, a parasitoid chooses an insect stage as a host on (or in) which to produce offspring. (Hereafter, I will refer to this insect stage as a host.) The host it chooses for its offspring will die during the offspring's immature development. In selecting a host to parasitize, a parasitoid is making a choice about the quality of its offspring arising from this host. The host is the only package of resources that will be available to the developing offspring. Research has shown that the parasitoid's choice of a particular host individual depends on the host's attributes. An important attribute on which this choice is based is host size (e.g., Klomp and Teerink 1982, Luck et al. 1982, Luck and Podoler 1985, Waage and Ng 1984, Schmidt and Smith 1987). Host size is correlated with the size of the parasitoid's offspring at maturity (e.g., Waage and Ng 1984, King 1987). Offspring size (that is, the size of the daughter) is correlated with the offspring's probability of finding hosts for its offspring in the field (Kazmer and Luck 1995). Thus, the manner in which a parasitoid exploits a host resource for the production of offspring is crucial to understanding and forecasting pest suppression to be expected from the third trophic level.

A second behavior of importance to pest suppression in most ectoparasitoids is the size of host on which it produces daughters versus those on which it produces sons. Daughters are the sex that is responsible for pest suppression, the sex that lays the egg on the host and programs that host's death. Knowledge of the host attributes that result in the female parasitoid allocating daughters to the host are important in understanding this interaction and its consequence for pest suppression. And parasitoids can determine the sex of their offspring at oviposition. If the female parasitoid fertilizes the egg as it is laid, the egg will become a daughter: if she does not fertilize the egg, the egg will become a son. Most female parasitoids mate once and store the sperm from this mating in a spermatheca for the rest of their lives. Thus, by controlling whether or not the egg is fertilized, the female parasitoid chooses whether to produce a daughter or son. The attributes of the host that entice the female to produce are crucial to the evaluation of biological control and the determination of pest suppression. And the proportion of daughters that are produced and their relative abundance determines the success of biological control. Daughters are produced mostly on larger hosts, whereas mostly sons are produced on smaller hosts (King 1987). In the case of the citrus system in which I work, more than 90 percent of the daughters are produced on hosts larger than a particular size (0.39 mm^2 in area) (Luck and Podolar 1985). Thus, in the field, the size of the host at the time it is contacted by the female will determine, in large part, whether the host is parasitized and, if it is parasitized, whether it will be allocated a daughter or a son.

Several factors influence the size of the host in the field. First, the host's size is determined by its age (stage); the older it is, the larger it is. Second, the size of the host also depends on the time of the year during which it grows. If the host grows in the spring or autumn it will be larger at a given age than if it grows during the summer (Luck and Podoler 1982, Hare et al. 1990). Finally, the size of the host depends on the part of the tree in which it grows. If it grows on fruit (in this case an orange) it is larger at any given age than if it grows on a branch. A host that grows on a leaf is of intermediate size (Luck and Podoler 1985, Hare et al. 1990).

Thus, the size range of the host during development varies with age, season, and location within the tree (Luck and Podoler 1985, Hare et al. 1990). These variables affect the length of time during which the host is available to the parasitoid for the production of daughters and its probability of being parasitized. From the parasitoid's perspective, the upper size limit of the host is set by the size of the host when it transforms from the last immature stage to an adult. [In the case of the host with which I work, the upper limit occurs when the host mates. With other host species of insects, it is most often the size of the host at pupation (Luck 1995).] A host that grows during the summer or on branches will reach this stage at a smaller size than one that grows during spring or autumn or on the fruit. From the wasp's perspective, the lower limit to the size of the host is that on which it can produce daughters. Thus, the window during which the host resource is available for the production of daughters is narrower in summer or on the branches than it is during the spring or autumn or on the fruit. Moreover, in summer and on branches, the size range of the scale as it passes through this window in summer or on branches is smaller than it is during spring or autumn or on the fruit. Thus, during summer, the scale is at less risk to parasitization because the wasp is less interested in it than during spring or autumn or on fruit. It is not as high in quality as those in spring or autumn or on fruit. Clearly, this window size has implications for the likelihood of biological control and for the prospects of pest suppression.

Understanding the interaction between host size and the production of daughters has two additional consequences of practical value for pest management. First, it allows us to assess the seasonal availability and quality of the host resource from the parasitoid's perspective. This assessment, when coupled with the host and parasitoid phenology, provides one element that determines the intervention thresholds. We have translated this understanding into a brochure and a training program for pest managers and growers (Forster et al. 1985). The second consequence for pest management is in the use of parasitoids as augmentative biological control agents. In our case, the parasitoid can be grown inexpensively in large numbers and released in citrus groves for suppression of the host (pest) (DeBach and White 1960, Moreno and Luck 1992). Knowledge of the host attributes that result in the commercial production of quality wasps (principally daughters of large size) and in efficacy of the field releases allows us to maximize the efficiency of this tactic of pest suppression.

At this point, one might be asking, can we afford the expense of developing this understanding for each and every parasitoid– host interaction? The answer, of course, is that we cannot. It requires too much detailed biology. But this question assumes that the same research knowledge must be obtained for each host–parasitoid interaction with the same research effort. It does not. The linkage between the fundamental and practical aspects of ecological research in pest management makes such detailed research for each interaction unnecessary. The body of theory and the principals that emerge from the research testing the theory reduce the need to duplicate this research. What I have outlined above is a research program that tests hypotheses arising from foraging theory (Stephens and Krebs 1986) and sex allocation theory (Charnov 1982; see also Godfray 1994). As this body of theory is tested and the results are found to meet predictions and experience, the theory then becomes a shorthand way to project what can be anticipated from a tritrophic interaction. In a practical sense, it provides the guidelines within which to judge whether pest suppression can be expected. It provides the specifics of what to look for in the field to recognize whether such suppression is occurring (Forster et al. 1995). Departures from expectation, when they occur, become a focal point for additional research to understand why the expectations were not met. This approach makes research efficient. Moreover, it provides the feedback loop that leads to steady progress in understanding the ongoing ecological relationships and interactions in the commodity of interest.

Unfortunately, much of the research in IPM during the past decade or two has fallen short of this goal, especially ecological research. (I will note here that the degree to which a tritrophic interaction exists in a commodity will clearly vary with the commodity and its location. I am well aware of the complexity in these systems but my point is that a way exists to understand this complexity. Unfortunately, the pest-management community has not used it very often, and this lack of use has impeded the development and application of biological control and of ecologically based pest management in many commodities.)

There are at least two implications to this linkage between practical and fundamental research. The first implies a long-term commitment to conducting research in the commodity. The effort must involve a team of people, comprising growers, extension personnel, pest control advisors (privately employed advisors hired by the grower to advise him on pest conditions within the commodity), and university researchers. All of these individuals must be involved in the design and review of the research. These teams are difficult to establish because their success depends on the membership having individuals with a particular set of personality traits and shared values. Moreover, small teams are more likely to succeed than large teams, as was clear from the National Science Foundation's International Biological Program during the sixties and seventies. The second implication regards funding. Developing an ecologically based pest-management program implies a major commitment of funding to support research over a substantial period of time. This support must include commodity support and funding from some of the traditional sources, such as the USDA competitive grant program; IPM regional research funds; and, in the case of California, such resources as the University of California Integrated Pest Management program. Without such a funding commitment, continuity will be lost. But such funding must be contingent on rigorous peer review that has two purposes: to evaluate the quality and progress of the research program and to provide an additional source of expertise in developing and improving both research objectives and design. In other words, such a review should have the ideal of the free and positive exchange of ideas. Without this process, little prospect exists for the development of a sustainable, ecologically based pest-management program.

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Bioherbicides: Limitations and Promise, G. J. Weidemann, University of Arkansas

Because herbicides account for approximately 85 percent of the pesticides used in field crops, significant reductions in pesticide inputs will have to come from the reductions in herbicide use. However, alternative technologies for weed control (including various types of cultural management, such as tillage, and biological control) are limited. Naturally occurring plant pathogenic fungi can be used as so-called bioherbicides to control problem weeds much like a herbicide. In the bioherbicide approach to weed control, indigenous fungi are commercially produced, applied with conventional application technology and integrated into existing weed-management programs.

Two fungi commercialized in 1982 for control of specific weed problems generated a great deal of interest in the bioherbicide concept. One, Collego, was developed for control of the leguminous weed, northern jointvetch, in rice and soybeans in a cooperative program between the University of Arkansas and the USDA, ARS. The other, DeVine, was developed at the University of Florida for control of stranglervine in citrus groves. Both fungi offered a number of positive features for weed control, including high specificity for the target weed, lack of toxicity to crop plants or other nontarget organisms in the environment, and relatively low cost of production. Despite the excellent efficacy of both agents and high expectations for other biological agents, no new bioherbicides have been commercialized since then. In part, other successes have been limited by a number of biological, technological, and economic constraints shared by many other biological-control agents. Future success in biological control will be dependent on overcoming these constraints.

Biological constraints to the use of bioherbicides include a host range that may be too broad or too narrow for effective use, pathogen virulence that is too low to achieve the desired level of weed control, and environmental limitations to effective use. However, research has shown that it may be possible to alter host range and modify pathogen virulence through the use of formulation or tank-mix additives, such as surfactants, host extracts, or herbicides at sublethal concentrations. For example, the fungus *Pyricularia grisea* is a common pathogen of crabgrass but applications of the fungus alone generally provide limited mortality. However, a tank mix of the fungus and the crabgrass herbicide, fenoxaprop, at 0.1 times the recommended rate gave excellent control comparable to the herbicide alone at the full rate. Use of this combination would give good control of crabgrass yet reduce chemical inputs from the herbicide by 90 percent.

For biological agents, environment often is limiting, reducing the consistency of performance. In particular, free moisture of up to 12 hours often is required for spore germination and plant infection. However, the addition of crop oils and emulsions has been shown to minimize the free-moisture requirement and improve overall infectivity of the fungal agent.

Fermentation and formulation technology has proved to be a major constraint to the successful development of many biological agents. For many fungi, fermentation and scale-up with traditional liquid fermentation systems has proved to be difficult, expensive, and technologically problematic. Formulation is another area that has limited commercialization of several biological agents. Formulations must be developed that assure high viability, have a long shelf life, maintain pathogen virulence, and remain economical. Formulation of a biological agent is relatively new technology requiring a high investment and considerable risk for a commercial firm.

Finally, economics often limit commercial development of an agent. For many biocontrol agents, market size remains a serious limitation. Often, the potential market proves to be too small to justify the cost and risk of development in comparison to chemicals.

Despite the limitations to the successful development of bioherbicides, research continues to find ways to overcome many of these limitations, and continued technological improvements will minimize many of the current constraints to use. To achieve greater use of biologicals, an improved public-private partnership is needed to help overcome the problems of technological limitations and small market size.

EPA's Pesticide Environmental Stewardship Program: Making a Difference Through Partnerships

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Moderator

The Pesticide Environmental Stewardship Program (PESP) was launched in December 1994. The goal of the program is to reduce pesticide risk. PESP is a voluntary program that forms partnerships with pesticide users. There are two categories of membership in PESP, partner and supporter. Partners are those organizations that are direct pesticide users. Supporters are organizations that work with pesticide users. Both organizations make decisions about which pesticides to use and when to use them. Participants in PESP make a commitment to reduce pesticide risk and exhibit this commitment through a strategy that directs their implementation of risk reduction.

A key role of PESP is its grant programs. During the past two years, despite budget difficulties, PESP was able to award several small grants to many of its partners and other organizations demonstrating pesticide risk reduction. Through the National Integrated Pest Management Foundation for Education, eight PESP partner grants were awarded in 1996. The grants were awarded to those organizations because they best demonstrated pesticide-risk reduction and innovative IPM techniques. Some of the grants were also awarded to support the development and implementation of the partner's risk-reduction strategies. There were also EPA regional grants awarded that were designed to support original research and promote IPM and the goals of PESP. Finally, through a partnership with the USDA, grants were awarded through the ACE Program (Agriculture in Concert for the Environment).

Our partners and supporters of PESP are making a difference. The Mint Industry Research Council, is reducing risk by using innovative techniques including: (1) using disease-free rootstock to establish fields, thereby reducing the spread of insects, diseases, and weeds; (2) development and use of economic thresholds and economic injury levels to their crops; and (3) conservation and augmentation of natural-enemy populations through the use of selective pesticides as well as the release of predators. Another PESP Partner, New England Vegetable and Berry Grower's Association, is working on the development of IPM standards and an IPM Certification Program.

Through a cooperative effort, the University of Massachusetts and the Massachusetts Department of Food and Agriculture have developed crop-specific IPM standards and the first IPM certification program in the United States. The standards address key parts of a successful IPM program that includes soil management, nutrient management, and cultural practices. Within each category, specific practices and actions are listed that, if followed, result in a successfully integrated approach to crop production. Growers accumulate points that result in the designation of a crop as "IPM Certified," which they can use as a marketing tool. There is an ongoing effort to expand the number of crops in this program. The U.S. Department of Defense has made a commitment to reduce pesticide use by 50 percent by the year 2000, thereby reducing risks. One of the key ways they are reducing risk is by developing alternative strategies for pesticide use. The Strategic Environmental Research and Development Program awarded funding for a multiyear, major research demonstration project with USDA to develop "precision targeting" risk assessment and alternative IPM technologies for managing and reducing risks from pests and pesticides.

For more information on PESP, call our PESP INFOLINE at 1-800-972-7717 or find us on the Internet at EPA's Home Page under New Innovative Initiatives.

The following lists show the partners and supporters who have joined EPA's Pesticide Environmental Stewardship Program (as of 11/8/96).

Partners

American Association of Nurserymen
American Corn Growers Association
American Electric Power
American Mosquito Control Association
Arizona Public Service
Atlantic Electric
California Citrus Research Board
California Pear Advisory Board
California Pear Growers
California Tomato Board
Carolina Power & Light
Cranberry Institute
Delmarva Power
Duke Power Company
Eastern Utilities
Edison Electric Institute
Florida Fruit and Vegetable Association
Global Integrated Pest Management
Golf Course Superintendents Association
Hawaii Agricultural Research Council
Hood River Grower-Shipper Association
Mint Industry Research Council
Monroe County School District
National Potato Council
New England Vegetable & Berry Growers Association
New Orleans Mosquito Control Board
New York State Gas & Electric
Northern Indiana Public Service Company
Northwest Alfalfa Seed Growers Association
Oregon-Washington-California Pear Bureau
Oregon Wheat Growers League
Owen Specialty Services
Pear Pest Management Research Fund
Pebble Beach Company
Pennsylvania Electric
Pennsylvania Rural Electric Association
Pineapple Growers Association of Hawaii
Processed Tomato Foundation
Professional Lawn Care Association of America
Sun-Maid Growers
South Dakota Cattlemen's Association
Tennessee Valley Authority
Texas Pest Management Association
U.S. Department of Defense
U.S. Apple Association (formerly the International Apple Institute)
Utilicorp
Virginia, Maryland, Delaware Association of Electric Cooperatives
West Virginia Power
Wisconsin Ginseng Growers Association
Wisconsin Public Service Corporation

Supporters

Aqumix, Inc.
Bay Area Stormwater Management Agencies Association
Campbell Soup Company
Del Monte Foods
Farm*A*Syst/Home*A*Syst
Gempler's
Gerber Products Company
Glades Crop Care, Inc.
General Mills
U.S. Golf Association

Emerging Issues Influencing Integrated Pest Management (IPM)

Michael Fitzner
Cooperative State Research, Education, and Extension Service, USDA
Moderator

Precision Farming, C. R. Amerman, USDA, ARS

I would like to acknowledge the valuable help in collecting material for this talk of Dr. Gerald Anderson, ARS Subtropical Agricultural Research Laboratory, Weslaco, Tex.; Dr. Edward Barnes, U.S. Water Conservation Laboratory, Phoenix, Ariz.; Drs. Alan Olness and Frank Forcella, ARS North Central Soil Conservation Research Laboratory, Morris, Minn.; Dr. Edward Schweizer, ARS, Ft. Collins, Colo.; Dr. Kenneth Suddeth, Cropping Systems and Water Quality Research Unit, Columbia, Mo. Any errors in fact or interpretation are mine.

IPM has been defined as "a systems approach that combines a wide array of crop production practices with careful monitoring of pests and their natural enemies. Practices and methods vary among crops and among different regions of the country" (U.S. Department of Agriculture 1994).

The term precision agriculture is popularly used to refer to the juxtaposition of several technologies. They enable or enhance site-specific management, where the word site may be taken to mean an area of relatively uniform characteristics or conditions in terms of the particular management target. Another way to look at it is that precision farming is expressed as varying rates of inputs according to the varying needs of different areas of a field.

For example, the management target might be a specific weed whose density of occurrence is influenced by such factors as soil texture, crop-plant density, and soil-water regime. Soil texture and topography are relatively constant over time and easily mapped. For some soil textures, the weed density may never be great enough to warrant the expense of control measures. For other textures, one may possibly control the weed by varying crop planting density according to the map of texture. An area at the toe of a slope or along a geologically controlled seep line may stay wet for extended periods and require the use of herbicides for effective control, where the herbicide application is controlled according to the mapped position of the wet spot or spots.

We have practiced precision farming at some scale since our ancestors began encouraging the first food or medicinal plants to grow better by removing the competition from around them. It is probably only in recent, mechanized time that we have expanded the scale of our control over inputs to whole-field size. As mechanization took over, land areas tended by a single farmer increased, and both time and labor requirements forced us to manage by large land units and largely ignore the in-field variations. What is happening now is that technology has developed to a point that again enables us to feasibly address field variations over short distances.

Why do we want to do this? It is expected that site-specific management will optimize agricultural production and minimize agricultural insults to the environment. Whether or not this expectation is fully realized will depend greatly on the crop and animal production expertise and philosophies of producers that are using the technologies and on the information base available to them. Precision farming is not so much a philosophy of farming as it is an application of technology to do things that we have not been able to do easily since we began climbing on tractor seats. As the tractor has become ubiquitous, so, I think, will the tools of precision farming.

So the question for this group is which of these tools offer possibilities for the furtherance of IPM objectives?

Feasible implementation of precision farming today is made possible by geopositioning systems (GPS) tools that enable one to locate oneself fairly precisely on the landscape. Among other things, it can be used for mapping purposes and for relocating to a mapped point, like signaling to a sprayer that it is over a wet spot.

Geographic information systems (GIS) have been under development for more than a decade. GPS technology makes GIS more useful in the precision farming context. GIS is a database that looks like layers of maps. Map several characteristics or conditions over a field, and you create a GIS for that field (soil types on one map, textures on another, and problem areas of weed or other pest infestations on still another). Then, queries to the GIS by a computer that is fed real-time location information from a GPS-equipped field machine, enables the computer, with access to appropriate decision aids, to determine the specific treatment for that location and transmit control instructions to the machine.

Many farmers who using precision farming have harvesters equipped with computers, GPS receivers, and yield monitors so that they may map crop yields as they harvest. With the yield maps, they can identify and investigate both low- and high-yielding areas of their fields for possible modifications in treatments on those areas.

Roberts et al. (1993) discuss the uses to IPM of GIS in a large-area context. Weisz et al. (1995) write about Colorado potato beetle mapping in the context of site-specific IPM. They observe that to use this technology effectively, entomologists will need to develop new sampling and analysis methods.

Of course, the ability to vary the rate of input application under computer control requires equipment that can accept and act on the computer's commands. Four-bay fertilizer spreader trucks are now in operation that can mix fertilizers or other granular substances to a computer-specified recipe and spread at computer-controlled rates. Spray rigs are now capable of mixing varying amounts of pesticides from several carboys prior to spraying.

A number of efforts are underway to develop real-time sensors of various types. Organic matter sensors, for example, are being developed for use in controlling herbicide rate applications. Artificial vision with pattern recognition probably will enable spotting, identifying, and spraying individual pests if that is what is needed. We already have remote sensors that can evaluate leaf moisture stress and control irrigation.

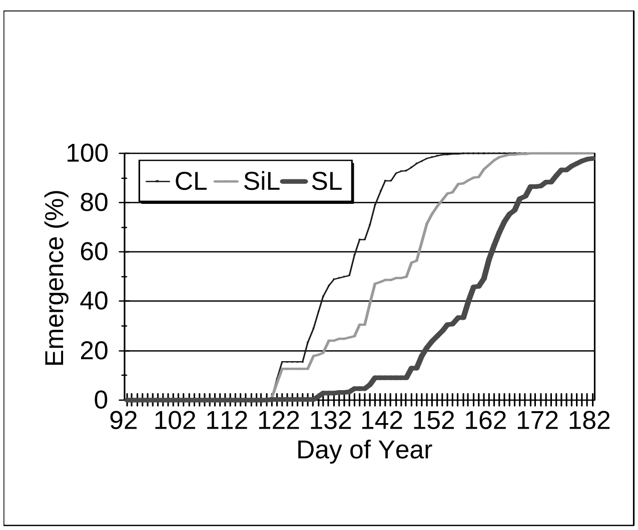
Precision agricultural tools are rapidly appearing; companies and lines of equipment are proliferating. A number of farmers already have several years of precision-farming experience. It seems probable that precision farming is going to require its practitioners to know more than they do now in terms of a much wider variety of conditions on their farms and, particularly, of what to do to optimize their operations under each of them. This has implications for information systems development and marketing. A Minnesota study described the timing of redroot pigweed emergence as influenced by soil texture, as in the accompanying figure. I quote from the material provided with the figure (Forcella 1996): “Postemergence herbicides quickly are becoming the most popular form of weed management in agronomic crops, despite their relatively high expense. These herbicides typically are effective only if they are applied after the weeds have germinated and emerged. They usually are applied about 3 to 4 weeks after sowing (about days 141 to 147 on figure 1). At that time, the pigweed emergence model predicts about 10-percent, 50-percent, and 90-percent seedling emergence on the sandy loam, silt loam, and clay loam soils, respectively.”

If a contact-type postemergence herbicide (e.g., acifluorfen or Blazer) were used, the high level of seedling emergence on the clay loam soil at the time of application would be expected to provide excellent control because most of the seedlings had emerged. In contrast, control with the same herbicide would be expected to be only fair to poor on the silt loam and sandy loam soils because of correspondingly lower emergence percentages.

How could growers overcome this problem of spatially variable weed control? One solution might be a timed sequence of site-specific spot spraying of pigweed on the differing soil types with acifluorfen. This would help ensure high and consistent levels of control. Another solution would be to select a postemergence herbicide with residual soil activity, like imazethapyr (Pursuit). A blanket application of this herbicide over the entire field would control both emerged and emerging pigweed (Forcella et al. 1992; Harvey and Forcella 1993; Forcella 1993).

Forcella's example illustrates two aspects of dealing with site-specific knowledge. The first is, knowing the variability across a site, what does one do with it? The pigweed seedling emergence curves given in the figure were derived from a weed-seed-emergence model, a decision aid that can be made available to any farmer with a computer. Such decision aids, models of weeds, crop development and growth, and so on, may be the principal means of helping producers manage inputs in dealing with site-specific issues. For greatest effectiveness, these decision aids will reflect state-of-the-art science and thus may become a major way of delivering scientifically based knowledge to farmers and ranchers.

The second aspect is ready access to a good database or information base, in this case a pesticides information base. Often, as in this example, such information will be enhanced by expert interpretation of what is in the information base--a major challenge for information providers that in many cases will require significant scientific input.Site-specific management also has many implications for research; more detailed questions are going to be asked. There is a suggestion, for example, that differential responses to soil chemistries may become important in dealing with germination and emergence patterns and with subsequent competitiveness between crops and weeds. Soil chemistry may be one of the factors responsible for the differences in weed indices and soybean yields for four soils as seen in table 1. These are preliminary data from the first year of a study being conducted in Minnesota (Olness 1996).



Schweizer (1996), referring to Vandeman et al. (1994) observed that a number of IPM components (practices) clearly relate to precision farming, but some do not. Chemical methods, as discussed earlier, lend themselves well to variable-rate application technologies. A cultural control, such as cultivation, by the relatively inflexible nature of the tools involved, does not presently appear to relate well to precision farming. Table 2 presents Schweizer's preliminary ideas on the subject and may serve as a starting point for discussion.

The adoption of IPM principles and of precision farming are, of course, influenced by farm financial considerations. In considering precision farming as a technology within which to apply IPM, scientists will need to consider socioeconomic impacts and ways to ameliorate those that are negative. In this regard, we may do well to consider multiple IPM/ precision farming implementations. For example, implementation designed for vegetable production may be quite different from one designed for large wheat producers, which, in turn, may be different from one designed for a small multicrop/animal producer. Socioeconomic impacts of IPM/precision farming should be a fruitful research field.

Table 1. Soil-weed interaction

Soil Type	Weed Index	Yield Soybean Variety 9091	9061
		---(Mg/ha)---	
Barnes	0.02	3.54	3.38
Hamerly	0.09	3.37	3.15
Parnell	0.11	3.12	2.97
Buse	0.16	3.14	2.89

Table 2. How does IPM relate to precision farming?

	Are these IPM practices related to precision farming for these pests?			
IPM Practices	Diseases	Weeds	**Insects**	**Nematodes**
A. Chemical methods used in IPM programs				
1. Fungicides	Yes			
2. Herbicides		Yes		
3. Insecticides			Yes	
4. Nematocides				Yes
B. Nonchemical methods used in IPM programs				
1. Cultural controls				
a. Cultivation	No	No	No	No
b. Crop rotation	?	?	?	?
2. Biological controls				
a. Biopesticides (mycoherbi cides)	---	Yes	---	---
b. Natural enemies (beneficials)	No	No	Yes?	No
c. Semiochemicals (i.e., pheromones)	No	No	???	No
3. Strategic controls				
a. Planting location	No	No	No	No
b. Planting date	No	No	No	No
c. Timing of harvest	No	No	No	No
d. Plant density	Yes	Yes	Yes	Yes
e. Row spacing	Yes	Yes	Yes	Yes
4. Host-plant resistance				
a. Crop varieties	Yes	No	Yes	Yes
5. Genetically engineered crop varieties	Yes	Yes	Yes	Yes
6. Irrigation, pivot	Yes	No	Yes	?

Precision farming with IPM approaches may be expected to provide for highly desirable environmental benefits. This claim can be validated only by environmental impact research.

The tools for precision farming may give us some amazing capabilities in terms of positioning, sensing, and control. Will we be able to match such mechanical precision with precision in prescription?

Perhaps the more relevant question is, do we need to? Just as there are economic thresholds for pests, there are most likely economic thresholds on the precision necessary for optimum crop and land management.

For IPM purposes, we may be some distance from understanding the economic threshold for prescription precision. That is for the attendees at this conference to decide. If we are not very close to it, then you may have some challenges ahead.

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The National Organic Program: Status and Issues, Harold S. Ricker, Agricultural Marketing Service, USDA

Organic sales have grown from about $1 billion in 1990 to $2.3 billion in 1994 averaging about 22 percent per year. In addition to growth in natural-foods supermarkets, major conventional retail food chains are beginning to add organic products into their retail mix, especially in neighborhoods where successful natural foods stores are thriving. Premium prices on some organic products reflect the fact that demand still exceeds supply.

We do not have a good estimate of the total number of producers producing organic foods because many are still self-certified, but the number of certified organic farms has increased to 4,050 in 1994, up from 3,500 in 1993 and 2,841 in 1991. This number is still less than 1 percent of all U.S. farms. Five hundred handler/processors were certified in 1994.

In terms of a marketing opportunity, we view organic products as representing a niche that will eventually become a mainstream market opportunity. The Agricultural Marketing Service (AMS) does not make a food-safety claim for organic food, because it is not residue free, nor does it claim that it is better for the environment.

The Organic Foods Production Act (OFPA) was requested by the organic community after they had observed a number of problems developing in the marketing of organic products. For example: There was and continues to be fraudulent use of the term "organic," resulting in the mislabeling of products.

Consumers are confused about what the term organic really means. They think it represents "pure food," even though it is not necessarily residue free, or that it is more nutritious, when there is no scientific basis to prove it.

There are currently 33 private and 11 State certifiers. Each has its own standards and seal and wants the seal on the products from processes it certifies. As a result, there are reciprocity problems creating difficulty for multi-ingredient manufacturers and reciprocity issues among certifiers.

The purposes of the Act are threefold:

1. establish national standards governing the marketing of certain agricultural products as organically produced;
2. assure consumers that organically produced foods meet a consistent standard; and
3. facilitate interstate commerce in fresh and processed food that is organically produced.

Note that the Act calls for one national standard; it does not call for certifiers to have enhanced standards. It calls for a consistent standard to get away from the confusion of private and State organizations' having different standards. The Act calls for the program to facilitate interstate commerce. We expect it to facilitate international commerce as well. One national standard with USDA oversight of the certification process will open up international markets and facilitate international trade in organic products. Other countries are eagerly waiting for the U.S. organic program to be in place.

Organic agriculture is complex in that it touches on activities of all of the agencies in USDA; several in FDA, EPA, and BATF; and most State departments of agriculture. Every day we hear from consumer groups, environmental groups, input suppliers, and the organic community. We are concerned that the principles of organic agriculture are not compromised.

There will be no mandatory requirements for those eligible for the less-than-$5,000 small-farmer sales exemption, but a qualifying farmer should have a signed declaration on the premises indicating compliance with the production and handling practices provided for in the OFPA.

The Act called for the Secretary to establish a National Organic Standards Board (NOSB) to advise him on the development of a National List of approved and prohibited substances and any other aspects of implementing the program. The Secretary appointed the NOSB on January 24, 1992. The Board is composed of: four farmer/growers, two handler/processors, one retailer, three consumer/public interest representatives, three environmentalists, one scientist, and one certifying agent. The NOSB has met 11 times as a full Board, has held 11 separate committee meetings at locations around the country, and has received public input at all of its meetings. The NOSB has now completed recommendations covering all of the program, and the National Organic Program staff is drafting the proposed rule.

The Board still needs to approve a definition of organic, and until it does, the following represents a draft policy statement:

> Organic agriculture is a sustainable production-management system that promotes and enhances biodiversity, biological cycles, and soil biological activity. It is based on minimum use of off-farm production inputs, on management practices that restore and enhance ecological harmony, and on practices that maintain organic integrity through processing and distribution to the consumer.
>
> The term "organic" on the label refers to products that have been certified as produced in accordance with the requirements and standards of the National Organic Program

These documents represent the recommendations of an advisory Board, and the Secretary of Agriculture may make some modifications in the regulations that are developed. But, the Department is indebted to the Board for the hard work expended in providing this information for consideration in implementation of this program. The recommendations from the Board can be summarized under five topics.

Crops

An organic farm plan that includes livestock is the keystone of organic certification. For the producer, the farm plan provides a flexible, useful, and affordable tool for developing an ecologically sound resource-management system on her or his farm. It allows the producer to plan and evaluate farm-management practices and make tangible improvements in the farming operation. For the certifying agent, the plan provides essential information for assessing compliance.

Split farming operations (conventional and organic) are allowed, provided that appropriate measures are taken to ensure the integrity of the organic production. In a farming operation where both organic and nonorganic fields, crops, and livestock are managed, the time table and level of transition to organic production is at the discretion of the producer.

Specified procedures should be followed for securing seeds, seedlings, and planting stock that are to be allowed in organic production. Emphasis is placed on use of organically produced planting stock and untreated seed to the extent they can be obtained, as verified by the certifying agent. Seed treated with pesticides and other substances prohibited by the Organic Foods Production Act (OFPA) shall not be allowed, with the exception of fungicides in cases where the producer can document to the certifying agent that untreated seed is not available. Seed originating from recombinant DNA technology shall be prohibited.

Organic products subjected to emergency sprays that are a direct result of intentional local, State**,** or Federal emergency spray pest eradication programs shall not be sold as organically produced or fed to organic livestock. The certifying agent will determine the need for residue testing for subsequent crops in the following 3 years. Subsequent crops shall not have pesticide residues that exceed the FDA action level or 5 percent of the EPA tolerance for any prohibited pesticide to be labeled as organically produced or to be fed to organic livestock.

Provisions similar to those under the Emergency Spray program apply to drift of prohibited pesticides or fertilizers from the intended target site onto a certified organic farm. Misapplication is when these materials are directly applied to the farm by someone who is neither the producer nor a person working under the direction of the certified producer.

The certifying agent shall conduct periodic residue testing of agricultural products to be sold as organic in cases of pesticide drift, when there is suspicion of residue problems, during the 36 months following an emergency spray, and in response to complaints. Produce shall not contain residues in excess of the FDA action level or 5 percent of EPA tolerance.

Processing

An organic handling plan shall include a general description of the handling/processing operation with procedures for handling organic foods and maintaining organic integrity. It requires record keeping, pest management, livestock care, and material inputs (to be developed) and contains an optional section on waste management. It also includes good manufacturing practices, general guidelines applicable to the handling of all organic food at handling and processing facilities.

Labeling will identify the total percentage of organically produced ingredients, foods that are organic, and foods that are made with organic ingredients.

Livestock

A livestock-production farm plan will contain specific references to livestock health, care and breeding practices, manure management, animal and feed sources, handling practices, housing, and living conditions. It will be incorporated into the organic farm plan.

A livestock health plan will contain general provisions for the treatment and management of animals, including a focus on the production environment.

The use of synthetic antibiotics as medication or growth promoters is prohibited in slaughter stock. Restricted use of antibiotics will be allowed in breeder stock, and milk products from a cow that has been treated with antibiotics cannot be labeled as organically produced during 90 days after treatment. This policy will be reviewed in 2 years.

The use of parasiticides is prohibited for slaughter stock, restricted for breeder stock, and limited in dairy stock, with a 90 day withdrawal period. Deviations from the above will be done on a species-specific basis.

Conditions for production of organic breeder stock are defined. Each animal or flock must be traceable throughout the life cycle with documented records, and, to the extent possible, obtained from organic stock. Feed fed to organic livestock shall be certified organically produced feeds and supplements, except under the conditions specified in the emergency-feed-availability provision.

Accreditation

The approved accreditation program for private certifying bodies seeking to be accredited identifies the competencies, transparency, and independence required of agents. The AMS will accredit State and private persons to become certifying agents for the Department to perform the certification of producers and handlers to the national standards. AMS will provide the oversight for the program to ensure that the purposes of the program are followed and perform other administrative functions in accordance with the National Organic Program, such as determination of equivalency of foreign programs for imports into the United States; participation in the development of international standards; accreditation of certifying agents; coordination of enforcement activities with other agencies that have responsibility for specific aspects of the program; operation and conduct of the petition process for materials review; provision of support for the National Organic Standards Board; and development and operation of the user fee program.

Materials Process

The NOSB has undertaken the required review of botanicals and placed strychnine, tobacco dust and nicotine on the proposed National List as prohibited naturals. The NOSB has also made recommendations for a number of allowed synthetic substances to be used in organic production and processing.

While not a part of the NOSB recommendations, IPM will continue to be an important tool in the organic plan to help reduce dependency on other off-farm production inputs. There has been some success in using trichogramma wasps for control of european corn borer, but some of the species that have been reported by researchers to be most successful are still not commercially available. The twelve-spotted lady beetle (*Coleomegilla maculata)* is a distinctive, pinkish, lady beetle that preys upon european corn borer eggs as well as aphids. It can cause significant reduction in both pests, depending on its numbers. Several drops of mineral oil applied directly to the neck of each ear on the silk (applied once, after pollination, when the silk just begins to dry) have been effective for some farmers. It is laborious, but makes the difference between marketable and unmarketable corn. It controls the borer as well as the worm. In another trial, vegetable oil mixed with B.t. had 95-percent control. Pheromone traps have also been used to trap corn earworm and fall army worm moths. These examples relate to reducing damage to sweet corn, but organic farmers are using similar beneficials or treatments to control other pests.

We do not know what the costs will be, but are working to establish reasonable fees, because we are required to operate on user fees.

Many are impatient that it has taken us so long to get our program in place. Part of the reason for the delay is budgetary problems, but a major reason is because we have involved the organic community in developing the program. They have provided a lot of public input that has helped to develop recommendations by our National Organic Standards Board and that provides the framework for the national program.

Because we are dealing with other government agencies, portions of the program must be reviewed by them. For example, the Food and Drug Administration reviews rules supporting processed food labeling that uses the word “organic,” and materials being considered for the National List.

USDA must also consult with the Environmental Protection Agency to determine the potential impacts of materials on the environment.

When it is ready and cleared, the proposed rule for the National Organic Program will be released for a 90-day comment period before preparing the final rule. The proposed and final rules will have an implementation and phase-in period.

Upon implementation:

- The program will have the force of law.
- USDA will establish controls for the use of a seal, probably on a licensing basis to demonstrate certification and compliance to the national program.
- Enforcement of the program can begin.
- Federally backed organic standards will facilitate the marketing of organic products in international trade.
- FDA will begin to recognize the definition of organic as a common and usual term with a specific meaning and to allow the term on organic labels.

One of the benefits to consumers and the organic community will be a consistent national standard, so that the term “organic” will have meaning for consumers, processors, handlers, retailers, and international traders.

New Computer Technology: Focusing GIS and Expert Systems on IPM, W. P. Kemp, Agricultural Research Service, USDA

Space and IPM

An understanding of the geographic variability in distributions and densities of pests is required for any IPM program. Pest densities influence the intensity of sampling required to define the area infested and the timing and economics of various management options. However, until recently there has been a general lack of analytical and data management tools that pest managers and researchers could use in IPM planning and execution. Among several new methods currently being evaluated and demonstrated in a variety of IPM systems are geographic information systems (GIS), global positioning systems (GPS), and expert-system (ES) technologies.

First Consider GPS

GPS refers to an advanced navigational system that was developed primarily for military applications. GPS consists of a number of satellites orbiting the Earth. These satellites have the ability to communicate with any appropriately equipped plane, ship, vehicle, or individual and to indicate the geographic position on the face of the Earth and the elevation of the receiver. Position accuracy within feet may be obtained with appropriate equipment.

Because of the obvious improvements in guiding or tracking for commercial uses, some portions of the GPS have been made available to the public. Hand-held GPS receivers are finding wide usage throughout the public and private sectors. For the purposes of IPM, the GPS offers several capabilities. The advanced navigational capabilities afforded by GPS are increasingly exploited by the participants of IPM programs in the guidance of aircraft and precision farming equipment as well as in field scouting.

On to GIS

A GIS is a set of computer programs that can store, use, and display information about places of interest to us. Examples of places of interest to a pest manager might be a 20-acre field, a 20,000-acre watershed, or the 2 million square miles of rangeland or forest in a particular State. Examples of information for any place of interest are soil types, rainfall and temperature patterns, land use, ownership patterns, roads, vegetation types, and topography (landform). A GIS stores two types of data that are found on a map, the geographic definitions of Earth surface features (spatial reference) and the attributes or qualities that those features possess. It is generally agreed that a true GIS is capable of several characteristic activities: (1) the storage and retrieval of information with a spatial reference (point A is located in Section 20 of Township 5, Range 8, and has soil type B), (2) the input, (3) analysis, and (4) reporting of spatially referenced information in digital form.

GIS Applications and IPM

Liebhold et al. (1993) described GIS as “enabling technology” because GIS provides pest managers with the capabilities to store, retrieve, process, and display spatially referenced data. It seems only logical that GIS technology will be rapidly embraced because so many questions from insect ecology to pest management have a spatial component. Whether studying the patch dynamics of host and herbivore or predicting a multistate pest hazard, GIS technology provides today's researchers and pest managers with the ability to answer questions that frustrated their predecessors.

Now it is possible to identify two general areas where GIS technology has been used in entomology: applied insect ecology research and insect pest management. Within the general area of applied insect ecology, perhaps the major use of GIS is in the relation of insect outbreaks to environmental features of the landscape (Cigliano et al. 1995). Using grasshoppers as an example, investigators in Canada used GIS products to examine the relationship between historical grasshopper outbreaks and soil characteristics (Johnson 1989a) and between weather and survey counts (Johnson and Worobec 1988). From these geographically referenced data, Johnson (1989a) found that grasshopper abundance in Alberta was related to soil type, but not to soil texture. Furthermore, a significant association was found between rainfall levels and grasshopper densities. Populations tended to decline in areas receiving above average rainfall (Johnson and Worobec 1988).

Future efforts to characterize habitat susceptibility probably will use remotely sensed data extensively because of its high spatial resolution and its availability in virtually every portion of the globe (for a complete review of remote sensing in entomology, see Riley 1989). For example, Bryceson (1989) used Landsat data to determine areas in New South Wales, Australia, that were likely to have egg beds of the Australian plague locust. Through the use of an index that indicated the general greenness of local vegetation, Bryceson (1989) was able to geographically identify resulting nymphal bands through changes in the greenness index that resulted from rains during March. (Nymphal bands tend to be associated with green areas that result from rain.)

Similar “greenness mapping” exercises have been conducted in Africa for grasshoppers and locusts (Tappan et al. 1991). In addition to illustrating the apparent ecological association between nymphal bands of grasshoppers or locusts in Australia and Sahelian Africa and changes in greenness indices, studies of Bryceson (1989) and Tappan et al. (1991) have immense practical utility because they produce rapid estimates of the location and extent of potential pest problems. Through such methods, it has been possible to vastly improve sampling efficiency for detection of problems as well as to reduce the guesswork involved with planning and execution of pest-management programs.

The second major area where GIS products have been used is for compilation and analysis of insect census data that are collected regularly by the USDA’s Animal Plant Health Inspection Service (APHIS). One example of this application for rangeland insects in the United States is the use of a GIS for developing a distribution atlas for grasshoppers and Mormon crickets in Wyoming (Lockwood et al. 1993). Additionally, Kemp et al. (1989) and Kemp (1992) provide methods for the development of rangeland grasshopper GIS coverages and hazard forecasts, that use annual adult grasshopper survey data collected in Montana. [See Johnson (1989b) for similar studies for grasshoppers in Canada.]

The Expert System Connection

The compilation and interpretation of spatially referenced insect and habitat data is a complex process, if for no other reason than the sheer volume of information. Although GIS software is designed to successfully handle this complexity, these systems often are not easy to use. To make a GIS more accessible to applied problems, GIS is increasingly being linked as a part of a larger decision support system (DSS). These systems typically use a GIS to manage habitat, geophysical, political, and census data. The DSS uses these data, along with other data as input to mathematical models and other modeling methods to produce useful abstractions or recommendations (Power 1988). These outputs might be maps of high damage hazard or even maps of proposed control areas. Hopper, a DSS for rangeland grasshoppers (Berry et al. 1991) currently has the ability to display density coverages. Future plans include a closer link to GIS procedures. Coulson et al. (1991) use the term "intelligent geographical information system" (IGIS) to describe systems that use a GIS and rule-based models to combine landscape data and knowledge from a diversity of scientific disciplines.

GIS: The Growth Years

GIS brings a great deal of analytical horsepower to the complex tasks associated with managing our natural resource base. However, expectations frequently associated with bringing GIS activities into the IPM realm frequently result in frustration for both pest managers and GIS professionals. Two major reasons why frustrations develop are: (1) People generally underestimate the resources required to get information into a GIS, and (2) GIS products are, at present, frequently complex enough to require specialized training. Another confounding problem that we should add is communication. Pest managers frequently lack in-depth familiarity with computer systems and at times may distrust all the apparent complexity involved with GIS activities. GIS technicians, on the other hand, frequently lack the biological expertise necessary to assist the pest managers with creative solutions to a particular problem. These communication problems can be frustrating to those on both sides of the table and may result in little advancement toward the solution to the current pest-management problem. Nevertheless, when properly developed, GIS, GPS, and ES technologies will offer solutions to future IPM programs that we have only begun to understand.

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