Symposium

Food and the Environment: IPM Meets the 21st Century

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Integrated pest management (IPM) programs exemplify the positive impact plant pathologists can have on our nation's production of plants and on our environment. At its best, IPM offers growers ways to reduce pest damage to crops while reducing pest management costs. In the process, IPM often reduces the amount of crop protectant chemicals required to treat diseases and other pests, decreasing possible environmental impacts and calming consumers concerned with food safety. As our nation and the world seek ways to balance ecological and economic concerns, IPM offers a fulcrum that puts plant pathology to work, growing healthy plants and maintaining a healthful environment.

At both the basic and applied levels of research, plant pathology has played a major role in developing successful IPM programs. To give some idea of the variety of IPM programs in the United States, this symposium includes four outstanding examples for fruit, wheat, peanuts, and potatoes. These programs demonstrate the ways in which IPM provides solutions to crop production problems. They also show the methods used to develop and deliver IPM in a set of crops from different parts of the country. Some systems emphasize careful timing of applications of crop-protectant chemicals, others emphasize cultural techniques, and others emphasize genetic techniques—yet each combines the most appropriate techniques. Most IPM programs now use personal computers in some way, either to develop models, monitor and record information, deliver information, and provide decision support or to teach growers what IPM means to their crop. Each example program proved successful in moving a crop system away from an overdependence on pesticides to a more balanced and stable means of production.

If success means adapting to change, IPM will continue to succeed. Three presentations in this symposium focus on major issues facing IPM today. While IPM started primarily as a response to pesticide resistance and increasing crop damage, the emphasis is evolving toward environmental concerns. The success of IPM can be measured in different ways, but however it is measured, the public and policymakers need to be aware of the success and continue to support IPM development. In the future, biocontrol, tools from molecular biology, and an emphasis on host management rather than parasite management will undoubtedly take on increasing importance in crop management. As these papers show, the techniques continually being adapted and developed by IPM researchers will contribute to a more sustainable agriculture in the 21st century.

From Profitability to Food Safety and the Environment: Shifting the Objectives of IPM

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Polluting streams and groundwater, eliminating endangered species, endangering the health of farm workers, and threatening consumers' food safety are just some of the recent headlines that have made the tough business of farming even tougher. Agribusiness's early reaction to this criticism was that the headlines were controlled by extremists—even actors! But, upon closer inspection, after the extremism is filtered away, there are some kernels of genuine concern that are based on fact. Some rivers are polluted with nitrates, some of the wells do have traces of pesticides, some produce does have higher than necessary pesticide residues when harvested. These new concerns, a few of them substantiated, are becoming increasingly important in farm decision making, along with profitability. Integrated pest management (IPM) offers a plan to profitably cope with these new concerns in addition to the traditional pest management mission.

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A Brief History of IPM

From the first philosophical description of integrated control (13), IPM has grown into an intricate series of programs based on pest suppression and management concepts. At present, IPM is a systematic approach to crop protection that uses a variety of information and decision-making paradigms. IPM seeks a balance between a reduction of purchased inputs and crop yield and quality. Concomitant goals include improving the economic, social, and environmental conditions on the farm and in society. Moreover, the concept emphasizes the integration of pest-suppression technologies such as biological control, using beneficial organisms against pest organisms; chemical control, judiciously using pesticides and other chemicals in a responsible manner; legal control, abiding by state and federal regulations that prevent the spread of pest organisms; and cultural control, using rotations, cultivations, and other farm practices that reduce pest problems. IPM programs involve careful monitoring of pest populations and the crop environment in the field. This information allows farmers to institute management practices only when they are needed to attain the farmer's individual goals for his/her crop. In other words, IPM is determining how serious your problem is, and what your management options are, before you take action.

IPM requires the grower to understand how the crop grows, how pest populations develop, what the control options are in each specific pest management case, and what the return on investment in these control options is, along with its impact on the environment and health. Attainment of the benefits of an IPM program requires a more knowledgeable manager and the collection of more information on the crop, the pests, and the environment. This means that more planning and work will have to be done by the farmer, his or her hired help, or a consultant. The extra work usually will be offset by the resulting benefits. The adoption of such a complex scheme requires a substantial educational investment by society, the bulk of which has been provided by extension specialists and county extension agents.

Dwight Isley provided the earliest record of the IPM concept as a formal agricultural practice. Isley's work began in the 1920s, when he pioneered modern pest control by using principles of scouting, economic thresholds, and trap crops along with insecticides to control boll weevil in Arkansas cotton. Isley also studied the biology and ecology of the boll weevil and used this information in a pest management system (4; C. Lincoln, *unpublished*). Despite Isley's innovative program, IPM did not gain prominence until the late 1960s. Initially, progress was slow, largely because of the abundance of inexpensive, effective synthetic organic pesticides; limited knowledge of the long-term effects of pesticides on environmental quality; and the relatively few alternative control strategies available to combat the emerging problem of pesticide resistance. When synthetic pesticides were introduced in the 1940s they were inexpensive, easily stored, readily available, and extremely effective, with predictable results against their targets. However, heavy dependence on chemicals resulted in numerous problems, including the development of resistant pests; the destruction of nontarget organisms, among them natural enemies of the pest; the resurgence of pest populations; the emergence of secondary pests; crop and environmental contamination; and concern for detrimental effects on human health. This led to serious negative impacts on farm profits (6,7,9,11).

In addition to the increasing problems associated with pesticide use, the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA) was modified and the Federal Environmental Pesticide Control Act (FEPCA) was enacted in the early 1970s to increase regulation of the use of chemicals in agriculture, especially where they may threaten human health and the environment. Thus, the need for IPM programs became paramount (3,4,12,14).

Although substantial efforts in research were under way, extension IPM programs began with only two federally funded pilot projects in 1971—tobacco in North Carolina and cotton in Arizona. By 1979, 50 states and three protectorates were included, with 150 separate programs covering 45 commodities (4,12). These federally supported pilot projects emphasized scouting to monitor pest population densities and advised the application of pesticides only when pest levels were economically damaging. Additional state Cooperative Extension Service IPM projects begun in 1972 addressed pest problems in many other crops (1). Another measure of society's investment in IPM is that from 1972 to 1985, the number of extension entomologists grew from 165 to 298 (2).

Even though much of the legislation that supported pesticide regulations and the initiation of IPM programs was based on health and environmental concerns, the primary objective of IPM programs as promoted by extension in the 1970s and early 1980s was farm-level profitability. In almost every measured instance, IPM programs improved profitability. A national study of IPM programs for 3 yr ending in 1985 reported a net return to IPM users over nonusers amounting to $578 million per year in nine commodities. This benefit was based on a $7 million annual federal investment in earmarked extension funds for IPM (13). However, only three states documented pesticide reductions between users and nonusers of IPM (12). This statistic has been a source of criticism for IPM programs, but when viewed in light of the way programs were promoted on the basis of profitability, this is not surprising.

Now, however, reduction in pesticide use and its attendant externalities are of prime importance along with profitability. Does this mean that IPM is no longer relevant? No; not if one recognizes that IPM is a process that can be employed with many different goals over time. The advantage of viewing IPM as a process that is separable from the goals of pest management is that it becomes flexible enough to accommodate a reorientation of goals. In fact, IPM is experiencing a resurgence in interest because it is one of the best answers to the present-day conundrum of reducing chemical contamination of the environment and improving the safety of food while maintaining agricultural viability.

The Evolving Concept of IPM

The contemporary definition of IPM is similar in many aspects to the traditional definition but also includes more reliance on the information gathering and processing activities. More emphasis has been placed on the ability to make site-specific decisions to cope with the dynamic nature of a crop and its pests (including the amelioration of pest resistance). IPM goals have been expanded to include social welfare and environmental sustainability on the farm and beyond the farm gate. IPM now uses more "high-tech" resources such as genetically engineered plants, pheromones, biological and hormone-based pest controls, and computerized decision aids.

IPM must involve the nonfarming community in encouraging and rewarding adoption of IPM practices, thereby increasing the role of the private sector in program delivery. What can we, as agriculutral scientists, do to facilitate the evolution of IPM to meet the new demands placed upon it? We can do much in the areas of legislative activities, farmer incentives, research and extension, private sector support, and education of the public.

Legislative activities. Although many agricultural scientists eschew contact with legislators, legislative contact will ensure that government regulations are more realistic and over time will establish agricultural scientists as a resource for interpreting and predicting the consequences of legislative policy options. Specifically, we should work on the following:

Reconcile conflicting government program goals. Regulations affect many aspects of farming. Some are unintentionally contradictory. For instance, many soil conservation measures, such as no-till corn production, can actually increase the incidence of pest outbreaks by providing winter habitats for pests such as the European corn borer. Agricultural pest management scientists would be able to point out these conflicts so that they could be avoided or at least included in any cost/benefits analysis of government farm programs.

Promote programs that spread the cost of IPM adoption. Society is demanding safer food and a cleaner environment, but it is the farmer who has to bear the initial brunt of the increased costs of these stricter standards. There are at least two approaches to distributing this burden to all of those who benefit from safer food and a cleaner environment. Similar to the federal programs that support crop prices and soil conservation practices, any decreased profits due to managing pests with fewer or less toxic pesticides could be restored by the taxpayer. Another approach that has been established in some crops in several states (e.g., New York, New Jersey, and Pennsylvania) is to underwrite some component of IPM. In most cases, this is accomplished by providing field monitoring or scouting services. In these states, the costs of scouting are shared by the farmer and the state.

Promote more support for extension specialists and county-level personnel. A cornerstone of IPM implementation is the availability of agricultural specialists located close to agricultural sites that provide the expertise for adaptive research, IPM program design and implementation, farmer education, and program evaluation. These specialists should come from several disciplines, including entomology, plant pathology, agronomy, horticulture, economics, and many others. The numbers of these specialists have decreased substantially over the last few years, even though the need for their services has increased. Funding should be provided to fill vacant positions and create new positions where needed.

Promote an increase for implementation funding. During the 1970s and early 1980s when federal funding for IPM programs was increasing every year, we experienced substantial expansion of IPM programs. Moreover, this healthy funding atmosphere for IPM programs provided incentive for individual states to match federal funds. Because of decreasing federal funding levels when viewed in real terms, IPM programs have stagnated in many states and have disappeared in a few. A renewed financial commitment on the part of the federal and state governments is needed to revitalize these implementation programs, which can go so far to alleviate public concern about pest management practices. However, any increase should be incremental, since personnel will have to be trained and placed before IPM programs can experience a substantial expansion.

Support adaptive research. Adaptive research tests the results of basic research in practical on-farm situations. This type of research is necessary to demonstrate the benefits of IPM to farmers and consumers and to discover and rectify any conflicts with other farm practices.

Promote new biological technologies. New biological technologies offer exciting possibilities for the future. The use of insect growth regulators and pheromones, which turn the insect's own biology against itself, may provide safe and effective pest management tactics. Using one species against another, the traditional biological control concept that provided some of the initial successes of the IPM approach, still holds great promise as an alternative to chemical pesticides. However, basic and applied research and program implementation in these areas could benefit from improved financial support.

Promote new information technologies. IPM is an information-intensive activity. There are many new information technologies under development that would greatly benefit IPM programs. These include artificial intelligence, computer networks, satellite communications, and microscale weather predictions among others. Research and implementation funds are needed to develop these technologies for practical use, so that they might augment the traditional information delivery techniques.

Modify regulations to promote IPM tactics. Many new pest management tactics are available for implementation in IPM programs. Several involve the use of chemicals, but these chemicals can be classified as "biorational," since they are either not toxic or only minimally toxic to nonpest species. These chemicals include pheromones, which are naturally occurring sex attractants used to disrupt insect mating systems; insect growth regulators, which are mimics of insect hormones; and insecticides derived from naturally occurring organisms such as bacteria, fungi, and other plants. Unfortunately, these chemicals are still subjected to stringent toxicity and environmental testing programs even though they do not pose nearly as much a threat as more traditional pesticides. This testing prevents or greatly delays the introduction of these tools into commercial agriculture, where they can act as a substitute for more detrimental synthetic pesticides. The regulation of these newer chemicals should be scrutinized to determine if their registration could be expedited.

Farmer incentives. *Promote the demonstration of IPM benefits to growers.* The adoption of any new agricultural technology involves at least a perceived risk on the part of the farmer. A program that would alleviate this perception of risk would facilitate IPM adoption. Demonstration projects, a traditionally successful technology transfer mechanism, would provide the practical view of the advantages of the IPM approach. Extension and other agencies that demonstrate the economic, environmental, and social benefits of IPM practices should be increased.

Promote the modification of crop insurance. The federal crop insurance program underwrites agricultural losses due to catastrophic events, such as frost or drought. This program could be utilized to cover some of the risk inherent in practice change. Promises to repay farmers for crop losses due to new pest management programs would spur adoption. Once farmers gained the IPM experience and realized that there was no increased risk in most cases, the special insurance program could be terminated.

Utilize cross-compliance systems. Cross-compliance regulations mandate that a farmer may not take advantage of a beneficial government program such as grain crop price supports unless he/she is in compliance with a set of regulations, even if those regulations are in an area unrelated to the beneficial program. The use of IPM tactics could be a basis of compliance. Of course, this carries a negative connotation because the farmer is being penalized for not using IPM. This cross-compliance approach should be used only as a last resort, after all educational and other "positive" incentives have been exhausted.

Request more education and certification programs. Just as we have education/certification programs for pesticide applicators, we should institute a similar program to assure that the farmer is knowledgeable about integrated pest management strategies and tactics. The pesticide education/certification program has proved itself useful over several years in raising farmers' awareness about the proper use and disposal of pesticides. Similarly, IPM education programs could be coupled with licensing requirements that would further ensure the adoption of IPM tactics. These programs also could include education/certification goals for private sector pest management consultants who service the farmer.

Research and extension. We as agricultural scientists can make choices about how we represent our research and extension programs. For instance, we can redirect such programs to support the IPM approach. Many of us already are involved in research and extension projects that are compatible with IPM but are viewed as independent entities only because they have not been portrayed as part of a cohesive IPM approach. One of the advantages of consolidating apparently separate pest management research and extension activities under the IPM banner is that new activities benefit from the successes of past activities. Over time, both research and extension funding agencies, as well as farmers and the nonfarming public, will associate economically viable and socially and environmentally sensitive pest management programs with the term IPM. Justification of research and extension will become increasingly stronger as particular IPM programs build a history of accomplishment in connection with the IPM acronym. This IPM program self-acceleration was recently demonstrated by Harp (8).

Agricultural pest management scientists also should recognize that the social sciences play an important role in the diffusion of programs such as IPM. Economics, sociology, psychology, and many others are important tools to be integrated into IPM programs. An emerging frontier in IPM implementation is the use of "soft systems methodology," which includes utilizing community support networks to encourage farmers to adopt new practices and modify old ones (5).

Private sector support. There is great potential for the further development of an already substantial private sector IPM service to promote IPM (10). The private sector includes privately or publicly owned agricultural businesses and grower cooperatives. As the information demands of IPM become more apparent, the demand for qualified personnel to provide this information will increase. At present, the profitability of many such businesses is marginal. This is due to the high cost of doing business, particularly high labor and insurance costs, and the unwillingness of many farmers to pay for these nontraditional services. Several programs might be used to stimulate activity in this sector. Special relationships could be formed between the private sector and universities, so that private sector personnel could remain current in new technologies and have a dependable source of qualified employees. Broad-scale monitoring activities could be established that would benefit these businesses. These may include pheromone trapping networks, agriculturally oriented weather services, and computer data bases.

An agency such as the Small Business Administration might recognize the special problems of this type of firm and provide risk-reducing programs for it. Similarly, business education programs could be tailored to address the needs of the industry. Direct support might include low-interest loans or insurance underwriting.

The success of agricultural marketing cooperatives suggests another type of IPM service sector. Groups of farmers may cooperatively employ the services of IPM technicians to help them manage pests on their farms. These programs are already being tried in several states (J. Pruss, *personal communication*) and have demonstrated improvement in crop yield and profits and reductions in use of fertilizers and pesticides.

Education of the public. The public recently has been bombarded with articles in the popular press about the negative effects of pesticides on human health and the environment. In these articles, the agricultural community and its support institutions are many times portrayed as not being responsive to these problems. To the contrary, the agricultural community has done much to alleviate the secondary impacts of pesticide use but has done a poor job of informing the general public about it. One program that has been extremely successful at reducing pesticide inputs while preserving farm profitability has been integrated pest management.

The education of agricultural and urban pesticide applicators in the principles and tactics of IPM will go far to assure the incorporation of rational pest management practices. However, in order to gain support for this program and quell the fears about food safety, the consumer must be convinced that rational pest management tactics are being used. A knowledgeable consumer can be counted on to support agricultural practices that benefit all of the citizenry and provide a more stable future for agriculture.

IPM has been practiced for many years in most states. However, very little effort has been made to advertise this fact to the public or to describe the economic and other benefits of these programs. Moreover, any discussion of pest management practices has been in response to some crisis situation where public agencies and the agricultural sector are always on the defensive. As a remedy to this situation, promotional programs could be instituted to inform the public proactively about the IPM philosophy and the extent of its use. These might include point-of-sale promotions and information releases to the media. It is the responsibility of the agriculture sector, including agricultural scientists, to accomplish this.

Integrated pest management is still an appropriate process for pest management in agriculture. It is flexible enough to accommodate a change in objectives and provide a realistic and profitable tool for the farmer.

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