Perspectives

Integrated pest management (IPM): definition, historical development and implementation, and the other IPM

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1 INTRODUCTION

The late RJ Prokopy defined integrated pest management (IPM) as '... a decision-based process involving coordinated use of multiple tactics for optimizing the control of all classes of pests (insects, pathogens, weeds, vertebrates) in an ecologically and economically sound manner.'[1] For the IPM practitioner, this implies the following:

- simultaneous management of multiple pests;
- regular monitoring of pests, and their natural enemies and antagonists as well;
- use of economic or treatment thresholds when applying pesticides;
- integrated use of multiple, suppressive tactics.

In the long run, this holistic approach to dealing with pests should reduce pesticide use, provide economic savings for the farmer and protect both the environment and human health.

The term 'integrated' implies incorporation of natural enemy/antagonist levels into decision-making, and use of compatible, non-disruptive tactics that preserve these agents. Integration can be viewed as either vertical (i.e., within a class of pests; sometimes called first-level) or horizontal (i.e., among all classes of pests; sometimes called second-level). For example, an insecticide applied for control of an insect pest that also kills natural enemies of that and other insect pests represents a lack of vertical integration; similarly, a fungicide applied for plant disease management that also kills natural enemies of insect or mite pests represents a lack of horizontal integration. Historically, the lack of such integration has been one of the major impediments to the implementation of IPM in agriculture.

2 HISTORICAL DEVELOPMENT

The seeds of the IPM movement were planted shortly after World War II. A few, far-sighted scientists recognized that indiscriminate use of the new synthetic organic insecticides would prove to be problematic. Californian entomologists, for example, responded with the concept of 'supervised control,' in which insect control was to be supervised by qualified entomologists.[2] This entailed periodic monitoring of both pest and natural enemy populations and application of insecticides only when necessary – in contrast to calendar-based or insurance treatments. The first program in supervised control was initiated 60 years ago and targeted alfalfa caterpillar, *Colias eurytheme* Boisduval; it was supervised by the late KS Hagen who went on to a distinguished career in biological control.

A decade later, the problems with indiscriminate use of insecticides were becoming evident, including pest resistance, target pest resurgence, secondary pest outbreaks and environmental contamination. It was in this setting that four University of California entomologists put forth the concept of 'integrated control,' which was defined as 'applied pest control which combines and integrates biological and chemical control.'[3] This was one of the first clear definitions of 'integrated' in pest management. These authors also introduced the concepts of economic threshold and economic injury level. The first integrated control program was devised for managing spotted alfalfa aphid, *Therioaphis maculata* (Buckton), on alfalfa grown for hay.

However, integrated control as originally formulated had a relatively narrow focus. In the 1960s, the competing concept of 'pest management' gained favor in some quarters; it was broader and included multiple, suppressive tactics such as host plant resistance, semiochemicals and cultural control. However, integrated control and pest management gradually became synonymous, although each remained largely insect oriented. It was not until the incorporation of all classes of pests in the early 1970s that the modern concept of IPM was born.[4,5] Over the past 30 years, IPM has been a valuable paradigm for organizing research and extension efforts worldwide.

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3 IMPLEMENTATION

In spite of all this effort, however, there is little evidence that IPM (as originally envisioned) has been implemented to any significant extent in American agriculture.[6–8] This apparent failure can be traced to at least three constraints. First, for farmers, IPM is time consuming and complicated; given the multiple demands of farm production, farmers cannot be expected to carry out the integration of multiple, suppressive tactics for all classes of pests. Second, pest control consultants who might be hired by farmers usually have little time for closely monitoring pests and their natural enemies/antagonists; besides, many of them are employed by pesticide companies and have a built-in conflict of interest. Also, pesticides can be a cheap insurance policy when there is a possibility of losing an entire crop. Finally, pest scientists in the colleges of agriculture at the state (land-grant) universities have resisted the integration of the pest disciplines; most seem content to study individual ingredients of IPM, and this is reinforced by the incentive system in which they work. The result is a dearth of pest management programs that feature both vertical and horizontal integration.

There are similar concerns at the international level. For example, Vereijken[9] concluded that, with a few exceptions, IPM as originally envisioned had not been implemented to any significant extent in Western Europe. Barfield and Swisher[6] questioned whether or not American-style IPM was 'ready for export.' Morse and Buhler[10] observed that, while IPM has had limited success in terms of adoption by farmers in developing countries, it has a very successful history of adoption by scientists, special interest groups and policy makers. They rightfully asked: 'Why should farmers follow an agenda which has been created by scientists for scientists?' More recently, the World Bank[11] issued a report concluding that IPM adoption remained relatively low in most of the developing world, and that there was no convincing evidence for changes in pesticide use in targeted crops such as rice or cotton in Asia.

Measuring the level of IPM implementation is no simple matter. For example, in 1993 the US Department of Agriculture (USDA) launched the National IPM Initiative, the goal of which was to have 75% of US crop acreage under IPM by 2000. To measure the level of adoption, USDA put forth the PAMS concept, the acronym for prevention, avoidance, monitoring and suppression.[12] To qualify as an IPM practitioner, a farmer was required to utilize at least three of the four PAMS components. There were two problems with this approach: there was little or no commitment to integration of multiple tactics, and, because only three of four components needed to be employed, monitoring of pests and their natural enemies/antagonists was optional.[8,13] In 2002, the USDA launched the National Road Map for IPM,[14] which to some observers was a tacit admission that the National IPM Initiative was not successful. Measuring IPM implementation is further confounded by the fact that there are now over 65 definitions of IPM,[5] so almost any party can find a definition that fits what they are already doing.[13]

Another metric for IPM implementation is reduction in pesticide use. This, of course, requires an attendant database. California has had mandatory pesticide use reporting since 1990, so there is a growing database for analysis. For example, Epstein and Bassein[15] analyzed California pesticide use patterns from 1993 to 2000 and concluded that there were no obvious trends in decreased use of most compounds used against plant disease. They noted reductions in use of organophosphate insecticides, but attributed this largely to replacement with synthetic pyrethroid insecticides. In 2005, the California Department of Pesticide Regulation (DPR) reported an increase in use of commercial pesticides during 2003, compared with 2002.[16] Maintaining the status quo was not a good enough goal for the DPR Director, who directed the DPR Pest Management Advisory Committee to begin developing 'a blueprint for IPM progress.' Finally, a recent study[17] by the University of California's Agricultural Issues Center revealed that pesticide expenditures accounted for a growing share of total expenditures of farm production inputs, increasing from 3–4% in the 1950s to 7–8% in the 1990s. While this finding does not address pesticide use *per se*, it can hardly be viewed as a sign of progress.

4 THE OTHER IPM

Much of what is billed as IPM is better described as integrated *pesticide* management, i.e., the 'other IPM.' Integrated pesticide management can be defined as the *discriminate* use of pesticides, and is similar in some ways to supervised control of the late 1940s. This other IPM is not necessarily a bad thing, as judicious use of pesticides should be encouraged. The problem with this approach is that too often it becomes an end in itself. This perpetuates a 'quick-fix mentality' that targets symptoms and fails to address the root causes of pest problems. For insect pest management, it can result in a kind of 'quick-fix shuffle,' in which monitoring (get the quick fix ready) and treatment thresholds (when to apply the quick fix) keep the farmer or pest consultant in a treatment or quick-fix mode; in this mode, different pesticides are juggled to manage pest resistance to the pesticides (extend the life of the quick fix), and new pesticides are evaluated for input substitution (replace the old quick fix with a new one). In recent years, 'resistance management' has evolved into a distinct subdiscipline in its own right; for insecticides there is even a new acronym for this – IRM, for insect resistance management. The problem with pest management programs based on resistance management is that they tend to give an illusion of progress, as they fail to address long-term solutions to the problems at hand.

An example of the other IPM is the pecan IPM program in Texas.[18] Prior to the program, standard management practices included spraying nutrient amendments, insecticides or fungicides separately or in combination on about nine occasions during the growing season. In contrast to this 'pesticide prophylaxis' approach, the IPM program gave growers decision-making tools to enable them to assess pest problems over time so that management actions would be applied only when significant damage was likely to occur. As a result, Texas pecan growers were able to reduce the use of fungicides and insecticides, primarily by reducing the number of sprays containing zinc, fungicide and insecticide in a tank mix. The reductions in fungicides and insecticides were achieved primarily by removing them from tank mixes where they were 'piggybacked' onto otherwise needed applications. For the Texas pecan growers, this is a commendable example of pesticide use reduction; however, it should not be billed as true IPM.

5 CONCLUSION

In the future, the other IPM can be expected to continue to be a dominant theme in agriculture. This will include increased use of reduced-risk pesticides and genetically engineered (GMO) crops with built-in pesticides. Applying a quick fix is simple and represents the path of least resistance for the farmer or pest consultant; in contrast, real IPM is complex, demands an ecological understanding of pest problems and can be challenging to implement. For those who insist on practising real IPM, it will be necessary to develop:

- a workable definition that incorporates the key components of IPM;
- from this definition, a set of performance standards to permit a quantitative assessment of IPM implementation in the field.

This will help prevent 'mission creep' towards the other IPM. Policy makers and funding agencies at all levels would do well to recognize the differences between these two types of IPM.

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