Chapter 12
Pest Management I:
Integrated Pest Management

Contents

Integrated pest management (IPM) encourages natural and cultural control of pest populations by anticipating pest problems and managing their numbers to reduce losses, while permitting safer pesticide uses where justified and permitted.

What is Integrated Pest Management?

For millennia, farmers around the world used their wisdom, knowledge and skills to develop and integrate multiple tactics for managing the pests on the crops they grew and the livestock they raised. This use of a combined array of anti-pest tactics would come to be termed integrated pest management (IPM). During the 1940s, however, modern organic insecticides were developed as an offshoot of research on nerve toxins being tested for biological warfare against humans. These insecticides were quickly added to the lists of pest management tactics—and soon overwhelmed them. Many of the ancient and time-tested methods for pest management fell into disuse.

Only after the human health and environmental dangers of using these compounds became apparent in the 1950s and 60s did scientists go back to study the time-tested and traditional methods of pest management and develop new ones in harmony with those traditional ones. At this point, the term IPM was coined and the concept became valued as an intelligent way of managing pests.

Many farmers in Africa who were never exposed to pesticide marketing, sales, or extension agents never stopped using and integrating their traditional tactics. Yet now many others who wish to enter markets for trade, and have the resources for it, do use pesticides. This guide is designed to encourage the use of natural and cultural pest management tactics to the

Sector Description

- IPM uses all available tactics for crop protection
- Pests account for 25–50 percent of crop losses worldwide
- Synthetic pesticides are currently the main method of control

extent possible while permitting the safe integration of pesticides, as needed, with farmers' traditional cropping and pest management systems. These tactics are of several kinds:

- cultural (using resistant varieties, rotating crops, varying the time of planting or harvesting, destroying crop refuse, pruning, planting trap crops),
- mechanical (destroying pests by hand, excluding them by barriers, trapping them), physical (using heat, cold, humidity, traps, sound)
- biological (introducing and/or protecting imported or indigenous natural enemies of pests, propagating and disseminating microbial control agents)
- natural chemical (using attractants, repellents, sterilants and growth inhibitors)
- genetic methods (propagating and releasing sterile or genetically incompatible pests)
- regulatory means (imposing plant and animal quarantines, launching suppression and eradication programs)

Differentiating Between Smallholder and Larger-Holder Farmers. Many smallholder subsistence farmers in Africa grow crops on one to two hectares. Others, who wish to sell produce locally, may farm up to five hectares. Still others have larger plots of land for commercial production. The distinction between smallholder and larger-holder farmers needs to be drawn early on, because the circumstances of each group will affect the production constraints they encounter, and thus their implementation of IPM programs, as well as the types of safety and production equipment they can access.

Commercial producers will be more likely to grow one crop on a majority of their land, creating a pest-attracting monoculture, while smaller farmers are more likely to interplant different crops, thus creating a hindrance to pests. Moreover, larger producers may be able to afford pesticides, as well as pesticide application and safety equipment. In addition, they are more likely to be trained and educated. The distinction between relatively small- and larger-scale producers will be drawn throughout this document, to highlight the type of critical thinking and planning required to deal with both.

Integrated pest management is defined as a farmer-based and knowledge-intensive management approach that encourages *natural* and *cultural* control of pest populations by anticipating pest problems and managing their numbers to reduce losses, while permitting safer pesticide uses where justified and permitted. Many indigenous, as well as newly-developed, non-chemical techniques are available for use. These include combinations of biological control, habitat manipulation, soil health management, use of resistant varieties, and modification of cultural practices (expanded upon below). IPM focuses on long-term *prevention* of pests and their damage, and is USAID policy. Pesticides are considered *curative*, and generally should be used as a last resort.

Pests are defined here as organisms that cause damage or destruction to crops, forest plantations, and domestic animals. They include viruses, bacteria, fungi, plants, insects, mites, nematodes, birds, rodents and other animals. Field and post-harvest crop losses due to pests range from 25 percent to 50 percent worldwide, and may be higher in the developing world. Pests responsible for animal diseases may also infect humans; chronic diseases transmitted by insects inflict pain and suffering and diminish people's ability to work.

Synthetic pesticides (herbicides, fungicides, insecticides, rodenticides and other synthetic chemical controls) have, for the past 50 years, become the dominant means of controlling pests in developed countries. Since the Green Revolution in the 1960s, they have also been heavily used in the developing world, especially Asia and Latin America. Now, African farmers wishing to expand production and reach markets for trade are increasingly using pesticides as well. However, markets for organic products confound this use, as the new "green revolution" in organic and pesticide-free products takes off.

Increasing pesticide use can be attributed to a number of factors, including:

- Larger-scale, more intensive crop, forestry and livestock production to meet the demands of expanding populations. Resulting monoculture conditions are highly susceptible to pest outbreaks and require increased and more intensive use of pest controls.
- The aesthetic requirements of export markets (for visually "perfect" or "clean" food, horticulture and floriculture products).
- Use of high-yield varieties and breeds. This helps feed growing populations and may make crops more cost-competitive on international markets. However, these varieties are often more susceptible to pests than traditional ones.

For more detailed developing country IPM information, consult the 2003 CARE publication *Guidelines for Promoting Safer and More Effective Pest Management with Smallholder Farmers: A Contribution to USAID-FFP Environmental Compliance,* by Gladstone and Hruska, along with the resources cited at the end of this chapter. The CARE publication is one of the most up-to-date resources on pest management for developing countries currently available and provides a basis for much of the information in this chapter. To locate a detailed compilation of established organizations providing IPM support in developing countries, short descriptions of each, and a link to their Web sites, look at the end of this chapter. These organizations are potential partners in planning, designing and implementing IPM programs.

Potential Human Health and Environmental Impacts of Pesticide Use

Human Health Impacts of Pesticide Use

Synthetic pesticides are potent nerve toxins to all living organisms, including humans. Many pesticides, especially those available and used very heavily in the developing world, are *not specific* to the pest on which they are used, and are highly toxic to a broad array of living things.

Humans can have both acute and chronic exposures to pesticides. Acute exposure includes large doses of pesticide that are inhaled, ingested, or absorbed through the skin. Chronic exposure consists of smaller amounts taken into the body with cumulative effects on health over time.

Those at greatest risk are those who experience the greatest exposures—typically smaller-holder farmers, farm workers and their families. These populations are also often the poorest members of society. Larger-holders are more likely to have received training on pesticide risk avoidance; however, laborers hired by them may not. Acute and chronic effects vary from pesticide to pesticide in both type and degree, and are listed below.

Potential Environmental Impacts

Significant hazards are associated with the use of synthetic pesticides in the developing world.

- Intrinsic danger to all living creatures, including humans
- Poor quality control
- Poor use practices
- Resistance developed by pests
- Environmental accumulation of residues

Acute human pesticide exposure

Acute effects from some pesticides include death, vomiting, severe headache, skin damage, temporary blindness, shortness of breath, and uncontrollable nervous tremors.

Chronic human pesticide exposure

Chronic exposure can result in cancers, mutations in unborn children, suppression of the immune system, reduced fertility and/or permanent damage to eyes, lungs, liver and other essential organs.

Environmental Impacts of Pesticide Use

Uncontrolled pesticide use can lead to several unintended and harmful environmental affects. These include contamination of soil and water, pesticide drift, effects on non-target organisms, disruption of natural pest controls leading to pest resurgence, and resistance. Economists have developed methods for determining unapparent or “hidden” losses caused by the impacts of pesticides. These are called externalities, and are covered below as well. Their economic impact can be greater than expected.

Soil contamination

The use of pesticides and their accumulation in the soil can kill and severely reduce the essential soil macro- and microorganisms, including earthworms, insects, spiders, mites, fungi, essential mycorrhizae, and bacteria, thus reducing or stopping important nutrient cycling. Accidental spills on soil, which are usually associated with pesticide mixing and loading operations, can result in localized but severe soil contamination if not contained and dealt with rapidly and adequately.

Effects on surface and ground water

The intense use of pesticides in agriculture or disease vector management can lead to the contamination of surface and ground water. Water runoff resulting from heavy rainfall can transport pesticides and their toxic metabolites to distant places located downstream, contaminating lakes, lagoons, reservoirs, ponds, and estuaries, and adversely affecting aquatic organisms. Discarding pesticides, washing spray equipment, or rinsing empty pesticide containers in or near streams and rivers can cause similar damage.

Pesticide drift

When pesticide is being sprayed, poor aim or a light breeze can cause it to drift away from its intended target. Insecticide drift can be deadly to non-target organisms, including beneficial insects, spiders and mites. Pesticide drift can also expose people to risks associated with such chemicals. Spraying against the wind can poison the person applying the pesticide. Similarly, drifting herbicide can damage non-target crops and native vegetation within reach.

Effects on non-target organisms

Broad-spectrum insecticides not only destroy target insect pests but also destroy the predators and parasitoids that feed naturally on them. Pollinators and insect pests' natural enemies (parasitoids and predators) are especially vulnerable to pesticides—often more so than the pests. Most pesticides are also highly toxic to birds, fish, lizards, snakes, frogs, toads and other arthropods.

Disruption of natural control

By eliminating pests' natural enemies, excessive insecticide use can exacerbate pest problems and create new ones. Without natural enemies to keep them in check, pest populations can recover faster from the effects of a pesticide application than they could have in the presence of healthy natural enemies. This effect is known as pest resurgence. Again, many species that feed on crop plants are normally not a problem because their natural enemies keep their numbers relatively low. Intensive pesticide use, however, can eliminate these natural enemies, triggering a population explosion among their prey. Species that were merely potential pests or secondary pests may rise to "key pest" status as a result.

Pesticide resistance

The development of genetic resistance to pesticides in pest organisms is another adverse consequence of pesticide overuse. Through 1990, at least 504 species of insects and mites, 150 species of pathogens, 273 weed species, 2 species of nematodes, and the Norway rat had developed resistance to at least one pesticide.

Externalities: *Accounting for economic costs of human health and environmental impact*

Externalities are the hidden costs associated with pesticide use, such as lost productivity due to chronic pesticide poisoning and lost ecosystem services such as the activity of natural enemies against pests. Unless these costs are accounted for, the cost to society for the reliance on chemical intensification to increase productivity will be under-recognized. Groundbreaking work on rice in the Philippines showed that when the health costs arising from pesticide exposure are included in the production budget, the most efficient and profitable pest management strategy can be natural control.

Examples of economic externalities of pesticide use in the United States are included in Table 1, next page, to emphasize their economic importance.

Table 1. Environmental and Social Costs (Externalities) Incurred by Pesticide Use in the United States (1997).

COST	$ MILLON/YEAR
Public health impacts	933
Domestic animal deaths and contamination	31
Loss of natural enemies	520
Cost of pesticide resistance	1,400
Honey bee and pollination losses	320
Crop losses (phytotoxicity)	959
Surface water monitoring	27
Groundwater contamination	1,800
Fishery losses	56
Bird losses	2,100
Government regulations to prevent damage	200
TOTAL	**8,346**

Source: Pimentel & Grenier (1997)

Factors That Lead to Risks to Human Health

African Production and Pesticide Use

Use of pesticides in Africa is lower than in other parts of the developing world. For comparison, in parts of Latin America, 90 percent or more of farmers raising a variety of crops use synthetic pesticides. Use in Africa is nowhere near this high, but it is increasing. Where African farmers wish to focus on one silver bullet that will solve their pest problems and can afford pesticides, use is high. The reasons are simple: synthetic pesticides appear to them to be fast, effective, and relatively easy to obtain. The pesticides marketed for farmer use are relatively simple to use, are culturally acceptable, and reduce yield losses to pests over the short term.

However, in Africa, smallholder farmers and many ministry of agriculture officials do not know how to calibrate or use sprayers properly, most farmers do not use safety equipment, recommendations given during safe use pesticide training are not followed, and well-written national regulations are never enforced. Moreover, donors and their implementing partners often do not have the resources to constantly monitor pesticide use schemes to ensure compliance with prescribed regulations and safe use. These problems are outlined below, and are being addressed by USAID programs through initiatives such as the Pesticide Evaluation Reports and Safer Use Action Plan (PERSUAP), described later.

Poor pesticide manufacturing quality control

Almost a third of the pesticides sold in developing countries are of poor quality. They may contain dangerous impurities, pesticide chemical breakdown products that are much more toxic than the active ingredient, and/or excessively high concentrations of active ingredients.

Poor use and dangerous practices

Damage done by synthetic pesticides in Africa is compounded by the way they are used. Synthetic pesticides are intended to be used by trained applicators. The specific pesticide to be used against an identified pest is applied using specially designed machinery, equipment and clothing to protect the applicator. Guidelines are provided on quantity, frequency and timing of application relative to harvest, and these must be followed closely. In Africa, few if any of these procedural controls are adhered to with care by many smallholder farmers, although they are used by more educated larger-holder farmers.

Further, because of economic and educational conditions, smallholder farmers often view the “safe use” paradigm at best a waste of time and at worst a dangerous myth, and they do not appreciate the externalities listed above. Thus smallholders do not and probably will not follow “safe handling” practices even when these practices are taught to them. In addition, they often apply pesticides in excessive quantities, thinking that more is better.

Use of very dangerous new pesticides

Organophosphates, carbamates, and phenylpyrazoles, three families of broad-spectrum pesticides are among the pesticides smallholders most frequently mention using. All of these can cause acute and chronic neurological damage, among other maladies. The World Health Organization has classified some of these insecticides, such as methamidophos and methyl parathion, as extremely or highly hazardous (Class I).

Use of very dangerous old pesticides

Banned synthetic pesticides, such as DDT, dieldrin, aldrin and other so-called chlorinated hydrocarbon pesticides, and pesticides of poor quality are often easy and cheap to produce and are frequently sold, legally and illegally, in developing countries. All farmers tend to use these older pesticides because they are generally cheaper and more potent, and they work well against a broader spectrum of pests. However, larger-holder

Sector Design Elements

IPM is an alternative aiming to:

- Minimize pesticide use
- Minimize health and environmental risks from pesticides

Elements of a program include:

- Understanding of pests and real crop losses
- A clearly defined target audience
- Creating proper conditions for IPM adoption
- Effective activities to promote IPM
- Partnerships with other organizations
- Continuous monitoring and evaluation

farmers focusing on international trade will avoid these, due to developed-country restrictions.

Production and use of homemade botanical pesticide concoctions

Although it is rare, NGO and USAID project managers may, while doing assessments of farmer's own IPM tools prior to project design, find a few smallholder farmers who are using combinations of "natural" products, such as tobacco extracts concocted with other types of plant extracts, that are actually quite toxic to people as well as pests. There are no U.S. Environmental Protection Agency (and thus no USAID) regulations governing the use of many homemade botanical pesticide concoctions. Thus, many of these may not be promoted in a USAID-funded program, and farmers should be cautioned and encouraged to explore alternatives.

Local government policies

Inadequate local policies, regulation, and enforcement pertaining to the manufacture, import, formulation, packaging, labeling, transport, storage, sale, handling, application, and disposal of pesticides and their empty containers contribute to the increasing environmental and especially health risks associated with pesticide use in developing countries (see "Safer Pesticide Use" chapter in these guidelines).

Dangers across the pesticide cycle

Synthetic pesticides pose hazards not only to farmers and farm workers, but also to the health of others and to the environment at several stages in their life cycle:

- manufacturing
- transport, storage and application
- consumption of residues in food
- final disposal of outdated stocks

Hazards at each of these stages must be mitigated (see the "Safer Pesticide Use" chapter in these guidelines and the discussion below), and are the responsibility of the group that orders the pesticide.

Factors That Lead to Risks to Environmental Diversity

Traditional mixed cropping systems, with their wide plant diversity, contain the conditions and resources (refuges, pollen, honey, hosts and prey) needed to support diversified natural enemy populations, which, in turn, contribute to keep populations of plant-feeding species from reaching damaging levels. Several factors discussed below, in addition to those listed above, stimulate overuse of pesticides, leading to environmental contamination.

Monoculture plantings

The introduction of unsuitable crops, cropping systems, and crop-management practices can negatively affect the ecological balance of diverse and stable agro-ecosystems in sub-Saharan Africa. Larger-holder monoculture plantings provide pests with an easily accessible, vast and continuous source of food and shelter in time and space, and are generally predator-free. For instance, cotton grown as a monoculture tends to develop serious pest problems and an increasing dependence on chemical control within a few seasons. Rice and wheat, grown as monocultures, are subject to intense competition from weeds and often require at least one herbicide application per season.

The shift from low-input, highly diversified cropping systems to high-input, large-scale monocultures can exacerbate pest problems in several ways. In addition to the detrimental effects that pesticides have on pests' natural enemies, the introduction of monocultures of itself often results in a loss of natural enemy diversity.

Irrigated production

The introduction of irrigation, primarily by larger-holders, allows crops to be grown year round but also allows some pests to survive and thrive throughout the year, as a new source of food and shelter becomes available during the dry season. These unforeseen pest problems can often lead to increased pesticide use and adverse health, environmental, and economic effects.

Bioaccumulation of pesticides

In some cases, very serious broader or unexpected effects have come to light many years after the introduction of certain inadequately tested pesticides. DDT is perhaps the most famous example. DDT was found to build up or bio-accumulate in the food chain and to have unexpected reproductive and toxic effects, especially in certain predatory bird species.

Factors That Lead to Risks to Both Human Health and Environmental Diversity

Obsolete pesticides

Currently, African countries store an enormous quantity (120,000 tons!) of old pesticides that came from many sources, including donors, the UN Food and Agriculture Organization (FAO), regional development banks and self-purchase by farmers. Many of these now unusable and degraded pesticides were donated for emergency programs against plagues of locusts, grasshoppers, armyworms, rodents, birds, mosquitoes, ticks, tsetse flies, and other disease vectors.

Many of these are not being properly stored. Old deteriorating pesticide barrels leak, non-experts such as children have access to them, streams flow nearby, and some being sold by unscrupulous or unknowing crop protection agents for use. Pesticides often degrade into chemical compounds even more dangerous and toxic than the original pesticide. Be aware of this and beware of allowing the use of these old pesticides in an IPM program. In fact, strongly discourage their use for any purpose.

Pest resistance and a cycle of increased use

When synthetic pesticides are used, a number of naturally resistant members of the pest organism population will survive. Since resistant organisms are the only survivors, the next generation of pests will be more resistant to the pesticide overall than the previous one was. Thus using synthetic pesticides creates a cycle where farmers must use greater and greater quantities of pesticides or turn to new pesticides to control the pest, often at greater expense and/or risk.

Little known about the biology and ecology of many microscopic pests

Pests that cannot be seen, such as viruses and bacteria, or insects that live in hidden habitats during the day and feed at night, are generally unrecognized or misunderstood, except by larger-holder farmers who may have been trained. This lack of knowledge can lead to misuse of pesticides. For instance, some farmers in Latin America have been known to use fungicides against viral or bacterial infections, due to misdiagnosis and/or poor advice.

Market aesthetic quality requirements

High-value crops grown by larger-holders for export, including vegetables, fruits, and cut flowers, are often highly susceptible to pests, yet have high quality requirements imposed by the market. As a consequence, such crops tend to be treated with pesticides more frequently than crops grown for domestic consumption, leading to increased human and environmental dangers. It is not unusual, in such cases, for pest problems to worsen due to pesticide overuse. Farmers then feel compelled to spray more and more often, thus perpetuating and magnifying this unfortunate cycle.

IPM Program Design

The design of an IPM program will ideally be developed with all of the fundamental parts of any good management plan, and will address all of the factors and issues outlined above. The vital parts of a plan include a definition of the targeted primary beneficiaries (small- or larger-holder farmers) as well as secondary beneficiaries (marketers, processors, transporters, and consumers); a list of implementation partners (there are many to choose from, listed at the end of this chapter); and a list production constraints (problem identification), with IPM strategies for dealing with them.

Long-term (three- and five-year) and annual action plans will include the following components: mission and vision statements, goals, intermediate results, activities to achieve these results, a budget for each activity, a responsible person or persons for each activity, indicators of impact, baseline data on human and environmental safety and crop production, and a performance monitoring plan with assessments to check progress.

The special elements and conditions for adoption of successful IPM programs are outlined and expanded upon below.

Elements of an IPM Plan

For IPM to be adopted by smallholders in African countries, it must be effectively marketed and a plan must be written. IPM must actually be equal or superior to current smallholder practice—and the target audience must be convinced that this is so. Initially, the term “integrated pest management” is in itself somewhat of a handicap, since it suggests that IPM is a complicated process. But this hesitency is rapidly overcome once farmers come to realize that they have been using IPM all along.

Concern about the adverse health impacts of pesticide use on family and community—and the local environment—can create strong interest in adopting IPM. This is especially true if health and environmental impacts are communicated in moving and graphic ways. However, if farmers do not perceive the effectiveness of IPM as being *at least equivalent* to that of current pesticide-based practice (generally about 95%), adoption rates may be low.

Be aware that there are many varying conceptions of IPM:

- Some programs almost completely exclude the use of synthetic pesticides. These emphasize the use of physical and biological controls.
- Other programs take a more pragmatic approach. These seek to minimize the use of synthetic pesticides in general and the most hazardous pesticides in particular—but not to the extent that unreasonably complex or expensive controls are imposed that undermine farmers' confidence in IPM.

Remember that the strongest selling points for IPM beyond the health and environmental benefits are:

- IPM is more effective then synthetic pesticides *in the long run.*
- IPM is less damaging to essential soil health and nutrient cycling.
- IPM generally requires less capital investment.
- IPM can be used preventatively to eliminate or minimize the need for "responsive" controls (that is, applying pesticides after a pest outbreak occurs and much damage already has been done).

Step 1: Assess IPM Needs and Establish Priorities. In planning projects, consider the relative importance of agriculture in the overall program. If agriculture is a major component, IPM and pesticide management issues should be addressed. Consider the relative importance of target crops, looking at the surface area they cover, their value (economic, social, nutritional, etc.), and their importance as a source of livelihood for beneficiary farmers. Further, consider crop protection needs, farmers' perceptions of pest problems, pesticide use history and trends, availability of IPM technology, farming practices, access to sources of IPM expertise, support for IPM research and technical assistance, and training needs for farmers and project extensionists. These will vary with farm size.

Next, identify strategies and mechanisms for fostering the transfer of IPM technology under various institutional arrangements, mechanisms, and funding levels. Define what is available for immediate transfer and what may require rapid and inexpensive adaptation and validation research. During the planning stages of an IPM program, the inputs from experienced IPM specialists (such as those from the FAO's Global IPM Facility) will be extremely useful. If possible, set up an initial planning workshop to help define and orient implementation activities, and begin to assign individual responsibilities.

Step 2: Learn and value farmers' indigenous IPM tactics, and link with and use all local resources/partners

Repeated analytic studies and assessments by Africa Bureau and the Global IPM Facility (GIPMF) have found that most farmers are using their own forms of IPM. Many of these are novel, self-created, adapted for local conditions, and many of them work well. These include mechanical and physical exclusion; crop rotation, trap crops, cover crops, and green manures; local knowledge of strategic planting times; water, soil and fertilizer resource management; intensive intercropping; leaving refuge habitat for natural enemies; soil augmentation and care leading to healthy nutrient cycling; transplanting; and weeding.

Accurate assessments of these farmer technologies, as well as of actual losses due to different constraints in farmers' fields, are a must before designing any crop production and pest management program. Be aware that crop-loss figures provided by small- and larger-holder farmers alike, and thus projected and reported by international organizations, are often overestimated.

Before and during project design, key partners will assist you in assessing accurate crop losses and food security in your target country and region. Foremost among this group is FEWSNET http://www.fews.net/, the Famine Early Warning Systems Network funded by USAID, with over 15 years of field-level experience in Africa. Linked with FAO's food security unit, FEWSNET sustains a cadre of local as well as regional experts in most African countries. The experts' primary mission is to scour local markets countrywide for information on commodity availability and pricing, as well as to identify and understand production constraints and losses. They report these monthly and upon request to USAID managers and policy makers. They can also provide valuable insights to market potential for commodities targeted in your program.

Some programs or partners that focus on safe pesticide use training may be using training as a marketing tool for industry. Such training tends to promote use (often overuse) of and reliance on pesticides, frequently promoting brands and formulations that may be inappropriate for the problem or environment. Caution should therefore be exercised when choosing IPM program implementation partners. Links to appropriate partners are given at the end of this chapter.

Step 3: Identify key pests for each target crop. Although hundreds of species of organisms can be found in a crop at any one time, only a few of them may cause substantial crop losses and be considered pests. Become familiar with the key pests of target crops. Know whether they are primary or secondary pests and know how to positively identify them. Monitor their population size, the kind of damage that they cause, and their life cycle.

Key pests usually amount to a relatively small number of species on any one crop and can include any combination of insects, pathogens, weeds, diseases, and vertebrates. A few other species, known as secondary or occasional pests, attain damaging status from time to time, especially if over-spraying occurs and kills natural predators that naturally regulate their populations.

The vast majority of insect species found in any one crop are actually predators and parasites of the plant-feeding species. Many smallholder farmers are not aware of these distinctions and must be taught to correctly identify the more common beneficial species, as well as pests, found in their crops. Incorrect identification of beneficial insects, predators or neutral insect species, may lead to unnecessary pesticide applications. This diagnostic phase requires sampling and careful observation.

The vast majority of insect species found in any one crop are actually predators and parasites of the plant-feeding species—in other words, they help the farmer by feeding on the pest.

Usually, most key pests are fairly well known by local farmers and government extension personnel. However, a few species may be poorly known or understood because they are active at night, hidden, or small. These include soil-inhabiting species such as nematodes and insect larvae (wireworms, white grubs, cutworms), mites, and pathogens (viruses, bacteria, mycoplasma, fungi). In addition, farmers usually do not understand the role of some insects as **vectors** (carriers) of plant diseases.

Step 4: Do effective activities and training to promote IPM. The FAO has shown that a number of activities are very effective in promoting IPM in developing countries:

Learning-by-doing/discovery training programs

Small- and larger-holder farmers in training programs are most apt to adopt new techniques when they acquire knowledge and skills through personal experience, observation, analysis, experimentation, decision-making and practice.

First, frequent (usually weekly) sessions are conducted for 10–20 farmers during the cropping season in farmers' fields by trained instructors or extension agents. Because these IPM training sessions take place in the farmers' own environment, (1) they take advantage of the farmers' own knowledge; and (2) the farmers understand how IPM applies to their own farms.

Of these IPM training sessions, four or five analyze the agroecosystem. They identify and describe such factors as soil type, fertility, and needs; weather; crop stage; each pest; the pest's natural enemies; and relative numbers of both pests and enemies. Illustrations and drawings are provided, as needed. Extensionists use a Socratic method, guiding farmers with questions to stimulate important insights and supplying information only when absolutely necessary.

Farmers may also experiment with insect zoos where they can observe natural predators of their pests in action—and see how pesticide may kill them both. The knowledge and skills necessary for applying IPM are best learned and understood through practice and observation: understanding pest biology, parasitism, predation and alternate hosts; identifying plant disease symptoms; sampling population size; and preparing seed beds.

Recovering collective memory

Pest problems often emerge because traditional agricultural methods were changed in one way or another, or lost. These changes can sometimes be reversed. This approach uses group discussions to try to identify what changes might have prompted the current pest problem.

Smallholder support and discussion groups

Weekly meetings of smallholders, held during the cropping season, to discuss pests and related problems can be useful for sharing the success of various control methods. However, maintaining attendance is difficult except when there is a clear financial incentive (e.g., credit).

Demonstration projects

Subsidized experiments and field trials at selected farms can be very effective at promoting IPM within the local community. These pilots demonstrate IPM in action and allow farmers to compare IPM with ongoing cultivation supported by synthetic pesticides.

Educational material

In many countries, basic written and photographic guides to pest identification and crop-specific management techniques are unavailable or out of date. Such material is essential. Videos featuring graphic pictures showing the effects of acute and chronic pesticide exposure, along with interviews with poisoning victims, can be particularly effective. A study in Nicaragua found videos to be the most important factor in motivating farmers to adopt IPM.

Youth education

Promoting and improving the quality of programs on IPM and the risks of synthetic pesticides has been effective at technical schools for rural youth. In addition to becoming better farmers in the future, these students can bring informed views back to their communities now.

Organic food market incentive

Promoting organic certification for access to the lucrative and rapidly growing organic food market can be a strong incentive to adopt IPM.

Land tenure reform

The more secure people's sense of ownership of the land they cultivate, the more carefully they steward it.

Credit reform

Some financial credit programs may dictate the use of synthetic pesticides in order to receive a loan and thus may discourage IPM adoption. Credit that permits, encourages or requires farmers to employ other less toxic methods, such as microbial controls, can boost adoption of IPM.

Step 5: Partner successfully with other IPM implementers. Many IPM projects consist of partnerships between two or more organization, e.g., donors, governments, private voluntary organizations (PVOs) and non-governmental organizations (NGOs), such as those highlighted at the end of this chapter. If these partnerships are not forged with care, the entire project may be handicapped. The following design steps are considered essential.

Articulate the partnership's vision of IPM

Organizations may forge partnerships based on a common commitment to "IPM"—only to discover too late that that their visions of IPM differ considerably. It is important that partners articulate a common, detailed *vision* of IPM, centered on the crops and conditions the project will encounter.

Confirm partner institutions' commitment

Often, organizations make commitments that they do not intend (or are unable) to fulfill completely. The extent of commitment to integrating IPM into project design and thus implementation depends strongly upon the following key variables:

- **The IPM program's integration into larger projects**. The IPM program is likely to be part of a larger "sustainable agriculture" project. The IPM program must fit into a partner's overall program. The extent of this integration should be clearly expressed in the proposed annual work plan.
- **Cost sharing**. The extent of funds (or in-kind resources) is a good measure of a genuine partner commitment.
- **Participation of key IPM personnel.** Large partner organizations should have staff with expertise in IPM who are assigned specifically to IPM work. In strong partnerships, these staff members are actively involved in the partnership.

Step 6: Monitor the fields regularly. The growth of pest populations usually is related closely to the stage of crop growth and weather conditions, but it is difficult to predict the severity of pest problems in advance. The crops must be inspected regularly to determine the levels of pests and natural enemies, as well as crop damage. Current and forecast weather should be monitored. Farmers, survey personnel, and agricultural extension staff can assist with field inspections. They can train other farmers to be able to separate pests from non-pests and natural enemies, and to determine when crop protection measures are necessary.

Step 7: Select an appropriate blend of IPM tools. A good IPM program draws from and integrates a variety of pest management techniques. IPM does not require predetermined numbers or combinations of techniques, nor is the inclusion or exclusion of any one technique required for IPM implementation. Flexibility to fit local needs is a key variable. Most non-migratory pests of traditional cropping systems in Africa are already under adequate natural (biological) and cultural control; introducing pesticides into such systems may not be economically or environmentally justifiable. In this case, the IPM strategy should be to maximize the effectiveness of traditional and introduced non-chemical control techniques, in the least ecologically disruptive manner.

Pesticides should be used only if no practical, effective and economic non-chemical control methods are available. Once the pesticide has been carefully chosen for the pest, crop and environment, it should be applied only to keep the pest population low. When dealing with crops that are already being treated with pesticides, IPM should aim first at reducing the number of pesticide applications by introducing appropriate *action thresholds* (see "Chemical Control" section below). At the same time, IPM should promote appropriate pesticide management and use practices (see these guidelines' "Safer Pesticide Use" chapter) and help farmers shift to less toxic and more selective products as well as non-chemical control methods. In most cases, NGOs/PVOs will probably need to deal with low to moderate levels of pesticide use. Either way, an IPM program should emphasize preventive measures and protect a crop while interfering as little as possible with the production process.

Step 8: Develop education, training, and demonstration programs for extension workers. Implementation of IPM depends heavily on education, training, and demonstration to help farmers and extension workers develop and evaluate the IPM methods. Hands-on training conducted in farmers' fields (as opposed to a classroom) is a must (see the discussion of "learning-by-doing/discovery training" programs on page 13 of this chapter). Special training for extension workers and educational programs for government officials and the public are also important.

Model Approach to IPM

- Evaluate pests' impact before control programs are implemented, to identify pests, size of problems and possible natural controls
- Evaluate non-pesticide management options, including a range of preventive measures and alternative pest control methods (physical, mechanical, biochemical)
- Evaluate whether synthetic pesticides are necessary or not, whether less toxic varieties are available for the purpose, and how to minimize exposure for users and the environment

Step 9: Monitor and Evaluate. First, develop data collection tools, and then collect baseline data at the beginning of the project to identify and determine the levels of all variables that will need to be tracked. These may include numbers and types of pests, predators, and soil microorganisms; relative numbers of all non-target animals (birds, lizards, etc.) that may be harmed if pesticides are used; soil and water samples to determine levels of pesticide residue; soil samples to learn dominant soil types and to predict soil nutrition, soil requirements, and fertilizer/pesticide activities; pesticides, application and safety equipment available; and the amounts and type of training received by target audiences.

Develop methods for measuring the effectiveness of each IPM tactic used, and of their sum in reducing pest damage and crop losses. Also, develop methods for monitoring environmental health (maintaining and encouraging high levels of predators and soil microorganisms) and human health, if pesticides are used. The "Safer Pesticide Use" chapter includes a checklist for PVOs and NGOs at the end, which will serve as a guide for monitoring pesticide use. Kits are available for determining the level of pesticides to which farmers and applicators have been exposed. Make checklists for farmers to use when applying pesticides that indicate the type of application and safety equipment used, and the rates at which pesticides were applied.

Implementation of an IPM Plan

The following IPM evaluation and implementation process contains very useful preventive and reactive interventions to manage pests. Measures are also included for minimizing risk if synthetic pesticides are chosen as one of the pest management methods integrated into the IPM program.

Step 1: Evaluate and use non-pesticide management options first.

Use both preventive and responsive/curative options that are available to manage pest problems. Farmers may prevent pests (and avoid requiring pesticides) by the way they select plants, prepare the site, plant and tend growing plants. Along with prevention, farmers may respond to or cure the problem via physical, mechanical or biochemical methods.

Preventive Interventions:

Plant selection

- choose pest-resistant strains
- choose proper locally-adapted plant varieties
- diversify plant varieties or intercrop plants
- provide or leave habitat for natural enemies

Site preparation and planting

- choose pest-free or pest-avoiding planting dates (e.g., early planting in rainy season avoids stem borers in cereals)
- improve soil health
- weed before sowing the crop
- use an appropriate planting density
- enhance/provide shade for shade-grown crops
- assign crop-free (fallow) periods and/or rotate crops
- install buffer zones of non-crop plants and/or physical barriers
- rotate crops
- use low-till or no-till methods

Plant tending/cultivation practices

- fertilize and irrigate appropriately
- remove weeds while small

Responsive/Curative Interventions:

Physical/mechanical control

- remove or destroy diseased plant or plant parts and pests
- weed
- install traps

Biochemical control

- pheromones (very effective, but not currently easily accessible or economical; however, they are becoming more so)
- homemade botanical pesticides
- repellents

Biological control

- release or augment predators
- release or augment parasites/parasitoids
- release or augment microbial pesticides

Step 2: Evaluate the use of synthetic pesticides, if needed. The use of synthetic pesticides should be avoided for many reasons. First, they may be serious constraints to IPM adoption. Second, there are many errors associated with pesticide use in developing countries. Below are some common IPM constraints and pesticide use errors, with possible solutions.

Pesticides as Constraints to IPM Adoption

- Manufacturers aggressively market pesticides.
- Governmental policies/donors promote the use of pesticides.
- Institutional habits (extension services, research groups) favor pesticides.
- Centralized decision-making operates in favor of pesticides.
- Economic/financial factors impede training in IPM /use of IPM techniques.

Some Common Errors Associated with Pesticide Use

- Pesticide is not registered in the host country.
- Pesticide is not evaluated/registered in the country of origin.
- Pesticide is not effective for the planned use.
- Formulation is not stable in tropical conditions.
- Formulation is not adapted to the available application equipment.
- Quantities exceed the real need.
- Pesticide is too dangerous for the users.
- Label is missing or is in a foreign language.
- Packaging is too large or too small for the volume of fertilizer.
- Packaging is not strong enough.

Possible Solutions to Help Reduce Pesticide Risks

- Promote IPM as the preferred approach for pest control.
- Help the host country improve its management of pesticides.
- Use good practices in the provision of pesticides.
- Use only EPA- and OECD-registered pesticides.
- Don’t use pesticides in WHO classes Ia, Ib, and II (see below).

- Don't use pesticides found on Prior Informed Consent (PIC) and Persistent Organic Pollutants (POPs) Convention lists (see references at end of chapter).
- Follow World Health Organization guidelines for vector management.
- Determine status of pesticides in Special Review at EPA.
- Determine acceptable levels of pesticide residues for trade and consumption by checking the United Nations for the CODEX limits.
- Go to PEST-BANK (http://www.silverplatter.com/catalog/pest.htm) to order information that can help to determine pesticides' suitability for intended uses
- Know how to treat pesticide poisoning—you can find a good handbook on poisoning at http://www.epa.gov/pesticides/safety/healthcare/handbook/handbook.htm
- Check pesticide labels and the U.S. Code of Federal Regulations on the Web before ordering pesticides
- Follow USEPA's guidelines for biological pesticide registration and use their Web site as a resource for novel green technologies
- Recognize that some botanical pesticides are regulated by USEPA, but additional ones may be evaluated by EPA on a case-by-case basis.

World Health Organization Acute Toxicity Classes

Class	*Toxicity*	*Advice for Africa*
Ia	Extremely Hazardous	DO NOT USE
Ib	Highly Hazardous	DO NOT USE
II	Moderately Hazardous	USE GREAT CARE!
III	Slightly Hazardous	Use with care
U	Unlikely to present any acute hazard in normal use	

Mitigating Potential Pesticide Dangers

If there are no feasible alternatives to pesticides, take the following measures to mitigate and reduce their risks to human health and the environment. Note that risk is a function of both toxicity and exposure. Reducing risk means (1) selecting less toxic pesticides and (2) selecting pesticides that will lead to the least human exposure before, during and after use. For more detailed information on pesticides and their use, refer to the "Safer Pesticide Use" chapter in these guidelines.

Reduce Exposure Time or the Degree of Exposure

Before using

Transport:

- separate pesticides from other materials being transported
- avoid private distribution—it's dangerous

Packaging:

- follow international and national norms and guidelines
- use packaging adapted to needs
- eliminate re-use of packaging materials (even when cleaned, pesticide containers are too dangerous to re-use)

Storing:

- develop strict guidelines for village-level storage
- ensure permanent, well-marked labeling
- follow and respect national norms
- follow and respect FAO norms
- use appropriate language and approved pictograms
- use and respect appropriate toxicology color

Formulating:

- use appropriate type and concentration

During use

Training:

- should be continuous
- identify level and audiences (distributors, farmers, transporters, etc.)

Application equipment:

- should be adapted to user needs and possibilities
- should assure maintenance and availability of parts and service

Protective equipment and clothing:

- should be adapted to local climatic conditions
- should be adapted to user needs and resource possibilities
- should eliminate exposure rather than just reduce it, if at all possible

Focus on "buffer zones" around the following:

- housing
- environment: water, sensitive areas

After using

- know, respect and enforce any **exclusion period** after application (time during which humans, livestock, etc., must be kept away from the treated area)
- assure proper cleaning and rinsing off of:
    - applicators' preparation and application equipment
    - applicators' clothing
    - storage containers
- develop a workable monitoring and evaluation system for:
    - adherence to national and international policies regarding pest management and pesticides
    - health effects on applicators, the local population, and domestic animals
    - efficacy on target pests
    - impacts on environment: water, soils, etc.
    - elimination of pesticide leftovers and containers

Representative International Pest and Pesticide Management Initiatives, Resources, and Programs

This section lists and gives short descriptions of potential international partners and resources for IPM planning and implementation. Here you can find leads to both major and minor IPM resources and ideas.

The Global IPM Facility, Community IPM Program, and Agricultural Conversion 2015 Initiative

The Global IPM Facility (GIPMF) hosted by the FAO intends to be the world leader in developing implementation, experimentation, and policy research in country farmer IPM. Their experience derives from 15 years of IPM experimentation and implementation through the Community IPM Program (CIPMP) in Southeast Asia. It is now active in 30 countries in Africa, Asia, Latin America and the Middle East, and works with all major crop categories. To learn more, see http://www.fao.org/ag/AGP/AGPP/IPM/gipmf/index.htm. Consult GIPMF for assistance with planning or designing an IPM or crop production program, and use their experts to help design and implement your program. They promote South-South collaboration as much as possible and employ trained Africans to train African farmers.

Both the CIPMP and GIPMF use training approaches based on farmer empowerment, farmer field schools, and knowledge-based and discovery learning. In these field schools, communities of farmers are taught to observe and record the daily interactions between the soil, their crop and other organisms. Then, they discuss and design strategies to manage their soil health, crops, beneficial insects and spiders, and pests. With this approach, farmers are the experts, and they become expert trainers.

Farmers in these programs regularly maximize yield while minimizing financial cost, serious health risks, and environmental damage. Lead farmers among these groups even conduct their own experiments, comparing their fields managed using IPM to fields managed with typical pesticide-spraying schemes. IPM-trained farmers, who often further refine their techniques through experimentation, generally succeed in drastically decreasing pesticide use while increasing profits. More than two million farmers in Asia alone have graduated from these community-based farmer field schools since 1990.

In Africa, the CIPMP and new, broadened GIPMF Integrated Production and Pest Management (IPPM) approaches have been pilot-tested and used in 10 African countries, including Burkina Faso, Congo, Ghana, Kenya, Malawi, Mali, Senegal, Tanzania, Uganda and Zimbabwe. They are now being spread to other countries.

The GIPMF is now proposing a bold new approach called AC 2015 (Agricultural Conversion 2015: Detoxifying Pest Management). This sets distinct five-year targets to phase out the most hazardous pesticides first, followed by decreasingly hazardous (though still quite harmful) compounds, while phasing in rounds of new bio-intensive, risk-reducing technologies, methods and policies, through 2015.

Where can one gain access to the types of new technologies that may be phased in as pesticides are phased out? One Web site alone (www.agrobiologicals.com) provides access to a surprising list of over 2,600 companies currently marketing 470 new "green industry" technologies and products designed for low or no impact on human health or the environment. According to EPA, at the end of 2001, there were approximately 195 EPA-registered biopesticide active ingredients and 780 products. As an unintended bonus, many of these new green technologies also augment soil fertility and biodiversity, thus enhancing sustainability. While most of these green technologies target developed countries, it is only a matter of time before developing countries access them. What's more, food security crops are benefiting from this revolution as well.

World Bank IPM Initiatives

The World Bank has a statement in support of IPM and is committed to supporting IPM in client countries through lending and non-lending activities. Find their IPM statement at http://lnweb18.worldbank.org/ESSD/essdext.nsf/26ByDocName/CropsIPMPestControl .

Systemwide Program on IPM (SPIPM)

The primary goal of the SPIPM initiative (http://www.spipm.cgiar.org/) by the Consultative Group on International Agricultural Research (CGIAR) is to contribute to sustainable agricultural development by enhancing the effectiveness of IPM research at the CGIAR's international agricultural research centers (IARCs). This program seeks to encourage better communication and closer coordination among the centers and their partners, the development and adoption of more effective, client-oriented approaches to IPM, and a broader awareness of the benefits of IPM, leading to a policy environment more favorable to its widespread implementation (see Walker 2001).

The centers' most visible successes in IPM include their biological control programs for cassava mealybug and green mites in Africa. Pest management projects (some planned and some implemented) include the following:

- Whitefly and mosaic virus IPM (CIAT)
- Development of farmer participatory methods (CIAT)
- Control of cereal stem borers (CIMMYT)
- Grain legume pest IPM (ICRISAT)
- IPM for nematodes (ICRISAT)
- Management of parasitic plants (*Striga* and *Orobanche*) (IITA)
- Development of microbial pesticides (IITA)
- Weed management in rice (WARDA)
- IPM for soil-borne plant pathogens (ICARDA)
- Analysis of agro-ecosystem diversity and IPM (ICIPE)
- New approaches to loss assessment (Lead center: IRRI)

World Health Organization Africa Regional Office (WHO-AFRO)

The World Health Organization (WHO) (www.whoafr.org) takes the lead on integrated disease surveillance and management for developing countries in Africa. WHO provides integrated vector management initiatives, along with research, publications, international coordination, training, outreach, and inoculations.

Consortium for International Crop Protection (CICP)

The CICP (http://www.ipmnet.org/), a non-profit organization, was formed in 1978 by a group of U.S. universities, led by the University of California. Its principal purpose is to help developing nations reduce food crop losses caused by pests while also safeguarding the environment. CICP's basic goal is to advance economically efficient and environmentally sound protection practices in developing countries and to ensure the health of rural and urban communities. CICP is now headquartered at Oregon State University's Integrated Pest Protection Center.

CICP publishes a useful monthly electronic newsletter, *IPMnet News* (IPMnet@bcc.orst.edu). It provides timely information on IPM for all pests, including latest developments, publications and CDs, important research articles, commentary, Web sites, videos, equipment, materials and services, important policies, and an IPM calendar of upcoming important events across the globe.

Pesticide Action Network International and PAN Africa

The Pesticide Action Network (PAN) International, found at http://www.pan-international.org/, is a network of over 600 participating NGOs, institutions and individuals in over 60 countries working to replace the use of hazardous pesticides with ecologically sound alternatives. Its projects and campaigns are coordinated by five autonomous regional centers. Their Web site provides lists of pesticides to be avoided, USEPA information, and alternatives to toxic pesticides.

The PAN Regional Center for Africa, established in Dakar (Senegal) in May 1996, is coordinated by PAN Africa, http://www.pan-africa.sn. PAN Africa involves volunteers, NGOs, farmers, organizations, institutes, universities and individuals who support the adoption of sound ecological practices in place of dangerous chemical pesticide use all around the world. It publishes three issues per year of *Pesticides & Alternatives*, a newsletter on pesticide news, alternatives to chemicals, and IPM as well as sustainable agriculture.

CAB International Biosciences Crop Protection

The United Kingdom formed CAB in 1913 to support agricultural scientists in what were at the time British colonies. This group of experts identified insects found on crops grown overseas and provided scientific information and technical assistance for their management. In 1985 CABI became fully international, and its services became widely used by other countries working in development. CABI's publishing division produces some of the leading information on IPM in developing countries. The CABI *Crop Protection Compendium* on CD is widely used by IPM professionals worldwide. To use CABI's resources, visit www.cabi.org.

Regional Partners and Initiatives

In Africa, as elsewhere in the world, there are regional networks that deal with pest problems and research initiatives. For migratory pest control, there is the Desert Locust Control Organization for East and Central Africa, the International Red Locust Control Organization for East and Southern Africa, and the Maghreb Task Force for Northern Africa. Most of the international agriculture research centers discussed above also have regional research initiatives to deal with common constraints to production of specific crops. In addition, the Southern Africa Development Corporation (SADC), based in Harare, has regional oversight for agricultural production constraints, IPM, and trade. The African Development Bank, most donors (especially Germany's GTZ), and many NGOs also have regional initiatives. Check for these on the Web, by searching for regional IPM initiatives in Africa.

USAID Pest and Pesticide Management Initiatives, Resources, and Programs in the Developing World

Pesticide Evaluation Report and Safer Use Action Plans (PERSUAPS)

USAID Africa Bureau uses a relatively new concept for permitting safer pesticide use with development funds, while maintaining a reasonable level of control over pesticide choice and use. Targeted studies or evaluations during project or activity design produce documents called PERSUAPS (http://www.encapafrica.org/sectors/pestmgmt.htm). These are produced by or for NGO/PVO and USAID country programs or activities that wish to use pesticides for projects. They accompany an Initial Environmental Assessment (IEE) from USAID, address key USAID regulatory requirements, and emphasize the use of the lowest-risk compounds.

The PERSUAPs focus on the particular circumstances of the programs in question, are locally adapted, outline the risk management choices available, and recommend how a risk management plan would be implemented in the field. Local-level PERSUAPS are needed because many farmers and pesticide users in Africa cannot be expected to act in the same ways as users in the United States, where all of the USEPA's safer-use regulations are formulated and enforced. Literacy rates are much lower, thus most users cannot read labels; most farmers/users do not use safety equipment; regulations are generally not enforced; inappropriate pesticides or formulations are widely used; users often do not know how to properly calibrate or use sprayers safely, leading to gross and dangerous over-applications. PERSUAPS are intended to resolve and prevent many of these risks.

IPM Collaborative Research Support Program (CRSP)

Through the Center for Economic Growth and Agricultural Development in the Global Bureau, USAID supports several agricultural research programs with pest management components. The primary program on agricultural pest control is the Integrated Pest Management Collaborative Research Support Program (IPM CRSP) (http://www.ag.vt.edu/ipmcrsp/). Funded at around $2 million per year, the IPM CRSP is active in seven countries around the world, including Mali and Uganda in Africa. The CRSP's purposes are to develop and implement a replicable approach to IPM that will help reduce agricultural losses due to pests, damage to national ecosystems, and contamination of food and water supplies.

Other CRSPs support pest management activities related to specific commodities. The Peanut CRSP includes two plant breeding projects focused on producing disease- and insect-resistant cultivars. The INSORMIL CRSP supports plant breeding projects developing sorghum varieties resistant to the parasitic plant *Striga*. While not directly involved in pest management, the Soils CRSP at Montana State University (discussed below) is collaborating with the IPM CRSP on a modeling project in Ecuador that incorporates pest management parameters.

Integrated Vertebrate Pest Management Initiatives at USAID

Through the Denver Wildlife Research Center, now the National Wildlife Research Center or NWRC (www.aphis.usda.gov/ws/nwrc), USAID began supporting a vertebrate pest research and management project in 1967. Historically, the agricultural damage wreaked by vertebrate pests has been overshadowed by the public health risks associated with them, such as outbreaks of leptospirosis, salmonellosis, West Nile fever, hantavirus, Q fever, and bubonic plague. These pests, however, cause not only loss of farm yield, but also loss of inputs such as labor, fertilizer, pesticides, water, harvesting, and processing, leading to sectorwide economic damage.

Many African ministries of agriculture (MOAs) also focus on control of birds, primarily Quelea birds. These birds can come in plague proportions and can, at times, be extremely destructive to grain crops such as rice, maize, millet and sorghum.

Integrated Vector Management (IVM) Initiatives at USAID

USAID's Global Health Bureau (http://www.usaid.gov/our_work/global_health/) provides program support to several malaria control projects, primarily in Africa. Its insecticide-treated bednet (ITN) program is the largest management element of USAID's malaria control efforts. The ITN program supports a number of individual NGO/PVO projects as well as the NetMark project, an Africa regional project to promote the use of ITNs through collaboration with the commercial sector. This program provides technical assistance for community-based malaria prevention as well as the materials for bednets.

To promote judicious use of pesticides, USAID participates in the WHO Pesticide Evaluation Scheme task force. USAID also gives technical support to strengthen national programs to control malaria and other vector-borne diseases through surveillance, operations research, monitoring and evaluation, and more strategic collaboration with the manufacturers and distributors of public health pesticides. USAID also works closely with WHO on the global Roll Back Malaria initiative.

Integrated Ectoparasite Management

Ectoparasites are generally arthropods (insects, ticks and mites) that live on the surface of other animals. In African countries, development program managers will likely encounter ectoparasite problems on cattle, sheep, camels, goats, horses and other livestock and farm animals. Tick dips using pesticides are routinely used in pastoral communities such as those in Eritrea, Ethiopia, and the Sahel. Contact the International Livestock Research Center (http://www.cgiar.org/ilri/) to learn more about integrated ectoparasite management.

Migratory Plague Pest Species

Numerous species of animals become pests irregularly and then in massive quantities. The desert locust is probably the best known of this group. Other pests, such as the red locust, brown locust, migratory locust, tree locusts, armyworms, rodents, Quelea birds, and several species of grasshoppers, are capable of substantial outbreaks and plagues. In non-plague years, these pests are present in levels that do not cause concern, but when their numbers increase rapidly, during a plague, their effects can be devastating for some unlucky farmers. Control of these pests is generally attempted by farmers using indigenous knowledge. However, often the plagues build and move too fast and farmers require assistance. African MOAs are generally well versed in the management of these pests, but often require international support and coordination.

FAO maintains an African program, the Emergency Prevention System or EMPRES (www.fao.org/EMPRES), to coordinate MOAs' efforts in emergency pest management with those of the donors and regional organizations. Most European donors, including the European Union, cooperate in this program. The African Development Bank and several regional organizations, such as the Desert Locust Control Organization (DLCO), assist as well.

Conceived in 1987, USAID's AELGA (Assistance for Emergency Locust and Grasshopper Abatement) project pursues activities including environmental assessments, emergency assessments, bilateral train-the-trainer farmer training, regional training, research into novel IPM tactics, coordination with FAO, outreach, and obsolete pesticide disposal. Contact AELGA (see http://www.aelga.net/) if a plague appears imminent or if large quantities of dangerous old pesticides are located.

Issues Impacting International Pest and Pesticide Management Initiatives

Biotechnology and Genetically Modified Organisms (GMO) for Pathogen and Insect Resistance

Genetic engineering may offer new pest management tools, particularly through the existing model of host plant resistance. Transgenic crop plants exhibiting resistance to particular plant pathogens or insect pests are under development for a wide range of crops, including several important staple crops such as rice and cassava. Use of these new varieties may allow higher yields and/or drastic cuts in pesticide use, with attendant economic, health and environmental benefits.

However, potential benefits must be weighed against a range of problems. These include possible ecological impacts (e.g., harm to non-target species, creation of novel invasive weeds), lack of consumer acceptance, and uncertainties regarding access to seeds and seed saving.

In addition, there is great concern among experts that some transgenic crops will rapidly select for resistance in the target pest population. A GMO technology that increases yields dramatically for several years and then collapses due to the pest evolving to overcome the crop's genetic protection will not serve a long-term goal of reducing yield instability. Therefore, resistance management strategies appropriate to developing countries are essential to realize the potential benefits of Bt crops. One source of information and a site that rates biotech products is http://www.biotech-info.net/.

Invasive species

Non-native species may be introduced into countries on purpose, with the idea of cultivating or breeding them there, or by accident. Often, unfortunately, in the absence of their native natural enemies, the populations of these foreign species grow unregulated, and they may become new pests. Developing countries generally have neither the resources nor the technical talent to manage invasive species. Invasive species may also become barriers to trade with non-infested countries.

Trade Opportunities in Organic and Reduced Residue Products

Most agricultural development programs starting up in Africa and elsewhere now aim not only to increase the production and quality of food security crops, but also to grow crops that can be traded. Moreover, they clearly recognize and encourage the use of green and bio-intensive technologies. Worldwide, organic and ecological farming, begun in response to dangerous pesticide use and unwise soil management practices, has blossomed into a multi-billion-dollar mainstream business.

Factors that drive people to adopt sustainable practices include concern for the land and long-term nutrient cycling; consumer demand for environmentally sound practices; competitive advantages; cost reduction; and compliance with regulations. While laws affecting environmental and human health conditions have become stricter, the costs, risks and liabilities of pesticide use have increased. Green practices often help reduce these costs.

New, cutting-edge technologies include resistant crop varieties; pest predators, parasites, pathogens, antagonists and their enhancers; baited traps; pheromones for monitoring, mass elimination, and mating disruption; genetic techniques that cause natural populations to crash; botanical compounds; light oils, soaps, and various fatty acid compounds for arthropods and fungi; and many others. These types of technologies are opening new possibilities for trade in organic produce and other high-value clean plant products with developed countries, especially those in the European Union.

Cut flowers, green beans, vanilla, mangoes, peanuts, cassava, tomatoes, cabbage, plantain, tea, coffee, cocoa, and soybean are but a few well-known examples. Food security crops like maize, rice, millets, sorghum, and cowpea are benefiting from these programs, as well as from the new revolution in genetically modified organisms (see above). Ghana, Kenya, and South Africa, the regional economic engines for growth in Africa, are vigorously using and promoting green technologies, gaining access to lucrative overseas markets in the process.

One of the main obstacles to success is the continued influence of the old, chemical-intensive model of agriculture. The other is lack of information. It is important for projects to consider the possible niche markets for green products in developing IPM programs. GMO uses and cautions are discussed earlier in this section.

Valuable Indigenous Green Technologies

Ecologically based integrated production and pest management techniques were and are used in many indigenous and traditional agricultural systems. Many of these techniques are specially adapted to the unique environments in which they have been developed, and they focus on preventing pests before they reach damaging levels. It is important that programs not try to replace all of these valuable techniques with new ones. Rather, these centuries-old techniques should be carefully integrated with new ones, since many of the principles used in traditional systems remain relevant to this day. For example, soil biological activity and the resulting rich nutrient cycling are of primary importance to these traditional processes, yet they are often wiped out with pesticide use, necessitating additional costly inputs.

International Codes of Practice in the Horticulture Industry Governing ISO 14000 standards

Several groups, including some UN bodies and the International Development Research Center (IDRC), are working in East and Southern Africa on horticulture, floriculture and organic foods products and growers. They are using and implementing International Organization for Standardization (ISO) sets of environmental management standards and rules (ISO 14000) critical to facilitating trade. The standards focus on social and environmental standards, as well as standard economic factors. Specifically, they address sanitary and phytosanitary (SPS) issues, such as regulations on pesticide applications that maintain maximum pesticide residue levels for trade with EU countries. They also address organic standards, certification, and institutional support for international trade. The UN groups and IDRC work to sensitize growers to these SPS issues and provide ready access to information needed for trade. Projects that link to these resources will be on the leading edge of organic and green production trade with Africa.

Botanical Pesticide Use

While some farmers in Africa use relatively safe botanical pesticides, most could use more (for a list of botanical pesticides regulated and registered by the USEPA, see the "Safer Pesticide Use" chapter of these guidelines). To date, NGOs and PVOs have been testing the efficacy of the botanical pesticides, but have lacked the means to test their toxicities. They could put together advisory panels composed of staff from academic institutions or the CGIAR centers to develop screening mechanisms or tests, review traditional uses, and related plants. USDA's Agriculture Marketing Service is looking into botanical pesticides for certification to use in organic agriculture in the United States. In addition, such a group could provide suggestions for mitigating potentially hazardous effects.

EPA has two documents on botanicals: one on the definition of biochemical pesticides and a list of biochemical active ingredients; and the other a list of active and inert ingredients that are exempt from FIFRA. They can be found on the EPA Web site. The Board on Science and Technology for International Development (BOSTID) has an excellent collection of publications (for example, booklets on uses and toxicity of neem tree extracts) already in use, and might therefore be interested in disseminating any materials that are developed.

Push-Pull Strategies for Managing Stem Borers and *Striga* in Maize Farming Systems in Eastern Africa

Stem borers and parasitic weeds are two major constraints to increased maize production in East Africa, creating yield losses of 20–40 percent and 30–100 percent respectively. Both are difficult to prevent, and chemical control is impractical for resource-poor farmers, most of whom are women. Recently, a novel bio-intensive technique called "push-pull" was developed by ICIPE (the International Center for Insect Physiology and Ecology, at http://www.icipe.org/icipe/index.shtml), in collaboration with the Kenya Agricultural Research Institute (KARI), the Kenyan Ministry of Agriculture, and the UK's Institute of Arable Crops Research, with support from the Gatsby Charitable Trust.

The strategy involves trapping stem borers by luring them to highly attractive trap plants at field edges ("pull"), while driving them away from the center of the maize field using repellent intercropped plants ("push"). Planted on the field edges, both Napier grass and Sudan grass attract (pull) stem borers. The grasses produce a gummy substance that traps and holds the stem borers there so that they cannot enter the maize field. Both grasses can also serve as fodder.

Meanwhile, silver leaf *Desmodium* legume and molasses grass intercropped in the middle of the maize fields repel stem borers. The *Desmodium* also binds nitrogen, helps soil retain moisture and prevents erosion, and can likewise be sold for fodder. But the most exciting result of using the *Desmodium* is that it also suppresses the growth of *Striga* parasitic weeds by a factor of 40 percent. In addition, farmers are now growing dairy cattle on the *Desmodium,* which gives them extra income. These techniques are now being adapted and extended to Ethiopia, Tanzania, Uganda, Malawi and South Africa.

Economic Tradeoffs Between Agricultural Production and the Environmental Impacts of Agriculture

Economic tradeoffs between agricultural production and the resulting environmental impacts of agriculture have traditionally been difficult to ascertain. Now, Montana State University's "Tradeoffs" project, operated by the USAID Soil Management CRSP, has developed a decision support system (DSS) for assessing these tradeoffs in such areas as pesticide leaching, erosion and soil fertility decrease (see http://www.tradeoffs.montana.edu/ for details). Results of ongoing studies in Senegal and Kenya may be helpful to planning IPM programs in Africa.

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Internet Sites for Information on Pesticides and Pest Management

There are hundreds of Internet sites that provide information about pesticides and pest management. Not all are equally reliable or useful. National and international regulatory agencies are the best source of information about pesticides. Some of the best sites on IPM are sponsored by universities and international and national agencies with mandates to promote IPM. Below are sites identified by CARE (2003) as particularly useful and stable sites; many offer links to other sites. They are ranked:

*****	Not to be missed
****	Highly recommended
***	Very useful

Pesticides

www.who.int/pcs This World Health Organization site includes The International Programme on Chemical Safety. The most authoritative site on human health effects of pesticides. Not all documents are online yet, but the WHO Recommended Classification is one of the most cited sources of acute toxicity information. *****

www.epa.gov/pesticides The U.S. Environmental Protection Agency's site on pesticides is a goldmine of information. Thousands of technical documents are available online, including the March 2000 edition of "Status of Chemicals in Special Review." *****

irptc.unep.ch The joint UNEP and WHO site. A wealth of authoritative information on many international programs and agreements, such as PIC and POPs. *****

ace.ace.orst.edu/info/extoxnet EXTOXNET: The Extension Toxicology Network. An excellent source if you're looking for information by substance. ****

http://www.fao.org/docrep/V8966E/V8966E00.htm. For information on *Pesticide Storage and Stock Control Manual*. FAO.***

http://www.fao.org/ag/agp/agpp/pesticid/Code/Download/label.doc See *Guidelines on Good Labelling Practice for Pesticides.* FAO.***

http://www.fao.org/ag/agp/agpp/pesticid/Code/Download/goodpra.doc See *Good Practice for Ground and Aerial Applications of Pesticides* (1988). Food and Agriculture Organization of the United Nations. **

http://www.fao.org/ag/agp/agpp/pesticid/Code/Download/protect.doc *Guidelines for Personal Protection When Working with Pesticides in Tropical Climates* (1990). Food and Agriculture Organization of the United Nations, Rome. ****

- www.who.int/pcs/docs/pcs98-21rev1.pdf Pesticides in WHO class Ia and Ib: do not use chemicals in this list*****
- irptc.unep.ch/pops Prior Informed Consent (PIC) list: do not use chemicals in this list*****
- www.pic.int Persistent Organic Pollutants (POPs) Convention list: do not use chemicals in this list.*****

http://www.epa.gov/oppsrrd1/docs/sr00status.pdf To determine status of Chemicals in Special Review, to see if any of the chemicals you propose using are being reviewed for safety reasons*****

http://www.codexalimentarius.net/ For the United Nations CODEX pesticide residue limits for food and trade.****

http://www.silverplatter.com/catalog/pest.htm PEST-BANK information. A guide to ordering information from two databanks covering all of the approximately 27,500 currently registered U.S. pesticides used in agriculture, industry, and general commerce as well as details on about 40,000 cancelled products.****

http://www.epa.gov/pesticides/safety/healthcare/handbook/handbook.htm For a pesticide poisoning handbook.*****

http://www.epa.gov/pesticides/ For U.S. Code of Federal Regulations, labels, restricted-use pesticides, etc. A guide to pesticides and those that are currently restricted, cancelled, and suspended for use in the United States. ****

www.epa.gov/pesticides/biopesticides/ For biological pesticide regulations. A list of biological pesticides currently registered for use in the USA. Includes lists of products that may replace synthetic pesticides if organic or 'green technology' choices are sought.*****

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Thrupp, L.A (2002). Fruits of Progress: Growing sustainable farming and food systems. World Resources Institute. 85pp. Up-to-date information on organic and green technology advances, with case studies from U.S. producers using these techniques. Order at: http://www.wri.org/wri/sustag/publications.html *****

UC-Davis (2001). IPM in Practice: Principles and Methods of Integrated Pest Management. Publication 3418. Great source for the IPM professional and novice alike. Order at: http://www.ipm.ucdavis.edu/IPMPROJECT/ADS/manual_ipminpractice.html *****

www.communityipm.org An excellent source of information on the FAO Asia "Farmers' Field School" methodology. Many interesting and valuable downloadable documents. *****

ipmworld.umn.edu Radcliffe's IPM World Textbook. A great resource text constantly updated and improved. Excellent for students, teachers, extensionists who want a concise presentation of thematic areas or of the state of the art in IPM by crop. *****

http://www.ipmnet.org/ A very good portal to a host of IPM resources, including a searchable database of IPM resources, Radcliffe's IPM World Textbook, periodicals including back issues of IPMnet News, reviews of recent publications, a searchable database of IPM experts and more. Very well organized. Sponsored by the Consortium for International Crop Protection. *****

www.nysaes.cornell.edu/ent/biocontrol Biological Control: A Guide on Natural Enemies in North America. An excellent guide to natural enemies. Limited geographically, but great photos and summary of biology and ecology. ****

www.ipm.ucdavis.edu/pmg The University of California Pest Management Guide. Very complete and useful guides by crop. Some a bit dated. ****

www.epa.gov/oppfead1/pmreg/ U.S. EPA Pesticide Management Resource Guide. A guide to pesticide information resources at EPA and elsewhere designed to help national pesticide authorities find information for use in pesticide management decision-making. ***

www.who.int/pcs World Health Organization guidelines for disease vector management.****