Version: March 2009
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Environmental Guidelines for Small-Scale Activities in Africa (EGSSAA)

Chapter 13: Pest Management II: Safer Pesticide Use

Contents

While pesticides usually succeed in their main purpose—killing pests—they should be used as a tool of last resort because of their unintended effects on health and environment. The "safer pesticide use" approach advocates considering, testing and integrating all options for pest management.

Introduction: "Safe Use" versus "Safer Use"

The "safe pesticide use" paradigm, particularly as promoted by the agrochemicals industry, has been a common approach in attempting to mitigate the health problems caused by pesticides. All too often, however, "safe use" fails to emphasize the array of pest management choices available to farmers—choices that include pesticides, but are not limited to them. Rather, the approach focuses only on pesticide-related matters, such as pesticide selection, new and correct application technologies and methodologies, registration issues, and use of personal protective equipment such as masks and protective clothing.[1] As a result, many stakeholders, whatever their degree of education, see pesticides as the crop protection

[1] The latter, ironically, are too expensive for most resource-poor farmers and are intolerably hot and uncomfortable under tropical conditions.

This EGSSAA Chapter was prepared by The Cadmus Group, Inc. for International Resources Group, Ltd. (IRG) under USAID Africa Bureau's Environmental Compliance and Management Support (ENCAP) Program, Contract Number EPP-I-00-03-00013-00, Task Order No. 11. Its contents are the sole responsibility of the authors and do not necessarily reflect the views of USAID or the United States Government.

method of choice—a "silver bullet"—when, in fact, there may be many less toxic alternatives that are never even considered.

In reality, overwhelming evidence from around the developing world shows that "safe pesticide use" programs are not especially successful. This is true whether studies measure people's adoption of safety gear and practices or their rates of exposure. Particularly disturbing is the paradoxical fact that the use of protective equipment often *increases* people's exposure to pesticides. Poor user habits (due to lack of water, soap and initiative) allow pesticides to accumulate in protective clothing and masks. Users are then subject to more exposure and higher doses with every "safety equipment" use.

Protective Equipment: A Mixed Blessing?

Protective clothes and masks are commonly promoted as part of safe pesticide use.
But too often they fail to help, because:

- They are too costly for most African farmers to buy;
- They are often too hot to wear in tropical climates;
- When worn, they often accumulate pesticides because they are not thoroughly washed between uses, thus exposing the wearer to *more* toxins.

The new focus on "safer pesticide use" promotes the principle that all options for pest management should be considered, tested and integrated into strategies for sustainable and environmentally sound crop production. A longer-term view of production and pest prevention is favored over the short-term, reactive view. The strategy that provides farmers with the most choices is **integrated pest management (IPM).** Pesticides are not excluded from this equation: they are considered as yet another option or tool to be used, especially in short-term or emergency situations, but usually not as the primary (or only) focus. IPM recognizes that pesticides usually succeed in their main purpose—killing pests—but maintains that they should be a tool of last resort because of all their unintended effects on health and environment. The challenge is to maximize their effectiveness when they do have to be used, while reducing the risks of damage to human and environmental health as much as possible.

This chapter provides guidance on maximizing the safety of pesticide use when such use is unavoidable. But no pesticide use should be considered before preventive and alternative measures have been examined and, where possible, adopted. It is in this light that USAID's pesticide procedures were formulated. Before analyzing the risks and benefits of pesticide use, the procedures specify that project planners must (1) consider all reasonable IPM alternatives, and (2) describe all measures to be taken.

Smallholder versus Larger-Holder Farmers

The information contained in this chapter is applicable to groups working with farmers in Africa. However, there are several different types of farmers, reflecting the size and intensity of their farms as well as the farmers' education and training levels. The conditions for working with them may vary greatly.

Smallholder farmers—roughly speaking, those with 5 hectares or fewer—may have less training, use more diverse cropping systems, and be less familiar with pesticide use. Moreover, their goals often differ from those of larger-holder farmers. They may be producing for subsistence as well as for limited local market sales to generate income, and they may have less money to buy pesticides.

Larger-holder farmers may aim to sell their produce in local, regional and international markets, depending on the size of their land holdings, so they may be able to afford to buy pesticides. If they sell in international markets, however, their use of pesticides may be limited by residue restrictions. And although they are often better trained or educated, and thus more likely to understand the constraints and dangers of pesticide use, they may not transfer this knowledge to their hired farm laborers who may use pesticides.

A program aimed at improving crop production will need to define the types of producers encountered and the methods for working with each of them, depending on their knowledge and goals.

Pest Management Issues in Africa

African villagers and farmers are bombarded by pests, ranging from those that feast on their crops in the field to those that infest crops in storage, and from parasites and disease vectors affecting livestock to vectors of human diseases. More sporadic, but highly devastating, are massive pest plagues. This section briefly addresses these disparate but related issues.

Agricultural Crop Protection. In the field, legumes such as peanut and cowpea are attacked by insects that bore into pods, chew leaves, and roll and mine stems. Maize is attacked by stem-boring moth larvae that cause stems to lodge young stalk-cutting insects like armyworms, while ears are eaten by moth larvae known as earworms. Aphids, mealybugs and leafhoppers suck sap from all plants and transmit debilitating diseases to them. Grasshoppers eat almost every species of plant, chewing leaves, stems and seed heads completely. Cucumber beetles and squash bugs attack various melons and squashes, damaging the fruit and spreading plant diseases. Beetle larvae, called white grubs, and wire worms in the soil attack plant roots, weakening the plants, and chew holes through tubers like potatoes, yams and cassava. Millets and sorghum seed heads are attacked by blister beetle larvae and birds. Mammals such as elephants, monkeys, baboons, and rodents can also cause devastating losses under certain circumstances.

Africans who do use pesticides on their crops most often apply them with hand-pumped backpack sprayers, with ultra low volume (ULV) sprayers, or by hand, using powder formulations. These sprayers may be purchased individually by larger holders or shared through smallholder farmer cooperatives. Unless development projects are paying, there is generally no larger pesticide equipment, such as motorized backpack or truck-mounted sprayers: these are far too costly for most smallholder and even larger-holder farmers to buy and maintain.

Most farmers do not use safety equipment or gloves when applying these pesticides. Even if they do, toxic residues remain from previous sprayings because they have too little water for cleaning and lack cautionary training. They also usually do not know how to calibrate (adjust) the sprayers

Pest Management Needs

Problem areas where pesticides might be applied according to safer pesticide use principles:

- Protecting both growing and stored crops from pests.
- Managing emergency migratory pest outbreaks.
- Protecting high-value and export crops from pests.
- Protecting livestock from parasites and insect infestation.
- Managing human disease vectors such as mosquitoes.

correctly so they will apply the right amount of pesticide. As a result, they often apply too much, wasting the pesticide and increasing the danger to humans and the environment.

In addition, backpack sprayers leak in various places—at the top loading end of the tank; where the outlet hose is connected; along the hose, especially where the hand-operated flow regulator attaches; and from the nozzle. Pesticides spill down the sides of the tank when filling and mixing and are not wiped off. If any of these leak or spill sources are not mitigated, and bare skin or clothing is exposed to the concentrated pesticide, the farmer will be poisoned.

Project managers should be alert to ways they can help clients to access lucrative overseas markets for organic and other high-quality crops—if they can eliminate pesticides and their residues.

The accompanying chapter on IPM contains lists of techniques and resources for controlling pests with few or no pesticides; this chapter contains lists of both chemical pesticides and botanical pesticides that may work to regulate pests by repelling or killing them. Projects should try to combine several techniques, in an integrated way, for optimal pest management at reduced cost and risk. Experimenting with the "push-pull" technologies described in the IPM chapter should yield very useful pest management approaches. Project managers should not forget about opportunities for their clients to sell organic and lucrative overseas markets, if

Pesticides are sometimes necessary to maximize agriculture production or protect stored food. But they should always be handled with care.

they can find ways to eliminate pesticides and their residues.

Stored Commodity Pest Management. Once crops are out of the field, they still are not safe. In storage and processing or during shipment a number of (often very tiny) beetle, weevil, and moth larvae, roaches, termites, ants, silverfish and mites feed on the grain, seed and processed

products, causing losses of up to 100 percent. Rodents such as rats, gerbils and mice may not only eat much of the goods, but also compromise the rest by urinating on and defecating in the seed or product, thereby affecting quality and potentially transmitting deadly diseases to humans. Many beetle and moth larvae and mites enter the grain in the field and are brought into the storage within the grain.

Unfortunately, many farmers do nothing about the threat and find their granary filled with grain dust because the pests have chewed through it. Yet there are a number of ways to confront the pest problem. Cleanliness, reduction of moisture, and carrying over fewer materials from year to year help to reduce all stored product pests. Storage areas can be cleaned with a mixture of lye, water, and miscible (emulsifiable) oil. To deal with pests that infest stored grain, many smallholder farmers put pest-repelling plant parts like tobacco or neem leaves in with the grain. Larger-holder farmers may use pesticidal powders or toxic baits to repel and kill pests in storage. (Care must be taken so that children and pets to do not come into contact with toxic baits such as rat poison.) Some farmers have cats to control rodents. If farmers in a cooperative have enough resources, they may fumigate communal granaries with a toxic gas ("bug bomb"). Residual-spray pyrethrins also reduce insect pests. Heating (when outside temperatures are very high) and cooling techniques can also be used to kill pests if storage areas are relatively airtight. Botanical repellents, listed in Table 4 later in this chapter, may also be used to keep pests out of storage areas.

Emergency Migratory Pest Management. Migratory pests, whose populations may build rapidly into overwhelming plagues, can cause severe damage to the crops of unlucky farmers in their path. This does not occur every year, however. Most plagues, though unpredictable, strike in 3- to 10-year cycles. Moreover, they closely track sudden environmental changes, such as exceptionally rainy periods following several years of drought.

Migratory pests in Africa include several species of locust (desert, red, brown, migratory and tree), armyworms, rodents, grain-eating quelea birds, and several species of grasshopper. Desert locusts and certain species of grasshopper feed on most crops and plants; red and migratory locusts and armyworms feed on grasses and grain crops; and rodents and quelea birds feed primarily on grains.

Smallholder farmers generally try to manage these pests using indigenous techniques, such as trenching or beating with sticks, usually with little effect. Most ministries of agriculture (MOAs) are equipped to help farmers to manage migratory and outbreak pests. However, larger-holder farmers, who have more political clout and more crops at stake, tend to receive more attention and resources.

When outbreaks do occur, MOAs take charge of the situation and donate government resources, such as pesticides, to farmers. In addition, other ministries, such as the ministries of forestry and the environment, may be

Defenses Against Pests in Storage Areas

- Keeping the area clean and keeping moisture low
- Carrying over fewer materials from year to year
- Putting pest-repelling plant parts or processed botanical repellents in with the grain
- Keeping cats
- Using pesticidal powders or toxic sprays
- Fumigating with toxic gas or pyrethrins
- Heating or cooling airtight storage areas

Protecting people and the environment during a pest plague

Competing interests may overstate crop losses and call for using too much pesticide—or the wrong kind. It is critical to:

- Ensure honest crop loss assessments
- Set "no pesticide" boundaries around villages, waterways and national parks
- Set up pre- and post-spraying environmental monitoring
- Continuously test pesticide users for overexposure

tapped for staff and vehicles to help out with monitoring and plague control. MOAs often request assistance from international, regional and bilateral sources, such as the United Nations Food and Agriculture Organization (FAO), the regional desert locust control organization, and such donors as USAID.

If enough resources are located, truck- and aircraft-mounted pesticide sprayers may be enlisted for locust, armyworm and grasshopper control. Farmers are often lent motorized backpack sprayers, ULV sprayers and safety equipment to spray their own fields. For rodent control, farmers may be given poisons to use. Unfortunately, these poisons are often intercepted by children, household animals and other non-target beneficial wildlife. Quelea bird control is even more problematic, being accomplished by controversial pesticides that are toxic to all bird species and/or by dynamite; thus most donors do not support it.

Expect to put many regular crop protection activities on hold if a pest plague occurs, because it will capture all of the affected country's attention, along with that of neighbor and donor countries, and many farmers will be concerned only with rapid crop protection. Further, many IPM schemes may temporarily fall by the wayside.

The human health and environmental concerns listed above, and more besides, become acute during a big plague control campaign. The difficulties may increase because of the chaotic nature of control campaigns and the competing interests trying to get a piece of the quick, and often very lucrative, action. Rival pesticide vendors and many different so-called experts with differing interests add to the cacophony. Often the wrong pesticides or formulations are sold, unknowingly and knowingly.

To forestall these problems, villages, waterways and national parks must have "no pesticide use" boundaries around them, and pesticide users must have continuous blood tests for pesticide overexposure. Environmental monitoring should be set up immediately to plan and carry out pre- and post-spraying testing. IPM-focused activities in the field can help with all the human health and environmental needs that arise during a control campaign, as well as the need for honest assessment of crops that have already been lost.

Pest Management for High-Value and Export Crops. High-value and export crops, like vegetables, fruits, fresh plants, ornamentals and flowers, spices, cacao, vanilla, cashew, cotton, sisal, tobacco, coffee and tea, are generally grown by larger-holder or commercial farmers. These are also menaced by a long list of pests. Thrips, aphids and whiteflies attack flowers and ornamental plants. Fruit flies can devastate mangoes and other tropical fruits. Pod-boring larvae attack vanilla and cacao pods. Spices are attacked by the few insects adapted to deal with these plants' strong smells and tastes (most others are repelled). Vegetables are attacked by many of the same insects as those listed above.

Little visible insect damage can be tolerated in these crops because of consumer demand for clean or "perfect" products. However, the word "clean" has begun to take on a new meaning, as European countries reject shipments of products that have unacceptably high pesticide residues on them; the "clean" requirement is now a double-edged sword for most growers. Production of organic crops takes this one step further by using revolutionary new green technologies in place of pesticides. Certification as organic gives access to important niche markets, but also entails extra costs.

Cotton receives the lion's share of pesticides applied in many countries**,** since it is both valuable and vulnerable to pest attack. Serious cotton pests include bollworms and boll weevils, along with grasshoppers, aphids, whiteflies, sucking and stinking bugs, and spider mites. Pests that enter the boll are difficult to control with pesticides, so cotton should be harvested as early as possible. Early-maturing varieties should be used, and all stalks and remaining bolls should be plowed under or destroyed at the end of the season. New, relatively safe toxic baits have been developed for use against bollworm adult moths, using synthetic pheromones to attract them to the poison. The use of genetically modified "Bt" cotton (discussed below) may drastically reduce the amount of pesticides required.

Tobacco is attacked by many worms (larvae of moths) such as cutworms and hornworms, along with beetles, sucking bugs, leaf miners, seedling worms and maggots. Its buds are attacked by budworms, and its roots are attacked by white grubs, wireworms and mole crickets. Several species of beetle and moths infest tobacco in storage. Again, several methods can be combined to manage this threat. In the field, crop stubble should be destroyed at the end of the season. Fields can be burned over before planting to destroy waiting pests. Large worms such as hornworms can be hand-picked easily from leaves. An innovative approach that is relatively safe is to lace poisoned baits into bran and other carriers for use against other worms—cutworms, for example. Adult moths can be attracted to traps laced with attractants and a pesticide with low toxicity for humans.

Ornamental plants, houseplants, flowers and fruit trees, often grown in greenhouses, hothouses and nurseries, generally receive relatively high amounts of pesticide sprays to reduce visible damage. Many biological techniques, such as Bt and relatively nontoxic soaps and oils, have been developed to counter these pests, complementing or replacing synthetic pesticides.

Management of Livestock Ectoparasites and Flies. Livestock are also a target of pests. Ectoparasites such as mites, ticks, chiggers, lice, fleas and certain flies bite or bore into the skin of farm animals, weakening them, causing weight loss, ruining hides, and in some cases transferring debilitating diseases. Biting flies such as black flies, sand flies, horn flies, mosquitoes and others suck blood and irritate animals, leading to weight loss, and transmit exotic diseases such as sleeping sickness, rinderpest and river blindness.

Combating Pests That Prey on High-Value Crops

Protecting against visible insect damage is important to ensure the "clean" product many consumers demand. Farmers may:

- Plant early-maturing varieties to give pests less time to grow
- Plant pesticide-resistant Bt strains
- Plow under or burn stubble in fields to destroy eggs and larvae
- Hand-pick large worms (e.g., hornworms) from leaves
- Use poisoned baits in bran and in traps with pheromone attractants
- Spray ornamentals and fruit trees with relatively non-toxic soaps and oils

Bear in mind that many European countries also define "clean" as "having low levels of pesticide residue." Meeting both definitions of "clean" is difficult—but may be necessary, if farmers want to capture the export market.

Tsetse flies, mosquitoes and flies that transmit river blindness have been controlled in the past through large spray campaigns using aerial and truck-mounted sprayers. Other biting flies are controlled with poisoned baits and sprays, while ectoparasites are controlled using cattle and livestock insecticide dips. These dips present several problems, however. The animal can absorb too much toxin, spills are likely, operators are often exposed to the poison, and the used dip water must be disposed of properly. The list of botanical products given below provides several less-toxic options for repelling and killing mites and ticks.

Management of Human Disease Vectors. Humans are susceptible to many insect-transmitted diseases, and in many parts of Africa, exposure is both widespread and intense. Malaria is the primary disease that debilitates and kills Africans. Mosquitoes of certain species transmit the plasmodium parasite that causes malaria. Along rivers in West Africa, black flies transmit a parasite that causes river blindness by destroying the victims' corneas. In East and Southern Africa, tsetse flies transmit sleeping sickness to both cattle and humans. Mosquitoes also transmit yellow fever, dengue fever, encephalitis and filariasis. Houseflies everywhere transfer bacteria from fecal and decaying sources to food, thus contributing to death, especially among children, from diarrhea and dehydration. Lice, too, infest many people.

In many countries, malarial mosquitoes are controlled by indoor sprays on walls and ceilings, water management, screens, and pesticide-treated bednets (see Hirsch et al., 2002). Populations need to be warned when the sprays occur so they can take appropriate precautions, and operators may require blood testing to detect overexposure to pesticides. House inner-wall sprays require use of long-residual pesticides. Mosquito-breeding waters can be treated with conventional pesticides, biological pesticides such as Bt spores, and the introduction of mosquito-eating fish. Window screens should be used in houses to keep out mosquitoes and other flies, and mosquito repellents can be used on the skin. Body lice are controlled with insecticidal shampoos and soaps, and houseflies are controlled through sanitation, baiting, trapping and spraying.

Obsolete Pesticides in Africa. There were over 120,000 tons of obsolete pesticides in Africa as of 2002. Old pesticides came from many sources, including donors, the FAO, regional development banks and the user's own purchase. Often 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 stored properly. Old deteriorating pesticide barrels leak, non-experts such as children have access to them, streams flow nearby, and some are being sold by unscrupulous or unknowing crop protection agents.

Pesticides often degrade into chemical compounds even more dangerous and toxic than the original pesticide. Be aware of this and beware of allowing

Outdated Pesticides Spell Danger

Pesticides often degrade into chemical compounds even more dangerous and toxic than the original one. There were over 120,000 tons of obsolete pesticides in Africa as of 2002.

- Never use old pesticides in an IPM program.
- Strongly discourage using them for any purpose.

use of these old pesticides in an IPM program; in fact, strongly discourage their use for any purpose.

USAID's Pesticide Procedures

USAID's pesticide procedures derive from the only Environmental Impact Statement (EIS) conducted thus far on USAID's programs. The result of a 1975 legal challenge to USAID's policies on provision of pesticides, this EIS also stimulated the agency to develop comprehensive regulations governing environmental assessment of all its activities. These rules are variously referred to as the USAID Environmental Procedures, 22 Code of Federal Regulations 216, CFR 216, or Reg 216. *If USAID's resources are proposed for any activities that involve assistance for the procurement or use, or both, of pesticides, planners must take these procedures into account.* "Use" is defined in the sidebar at right.

Remember that IPM is at the heart of USAID's intended pest management strategies. Other elements of USAID's strategy include:

- strengthening pest-management infrastructures in developing countries
- improving schemes to regulate pesticide usage
- monitoring the human and environmental effects of pesticides
- working to exert a greater degree of U.S. leadership among the international community.

Although USAID's pesticide procedures require that any proposed use of pesticides be limited to products registered, without restrictions, for the same or similar uses in the United States by the U.S. Environmental Protection Agency (USEPA), there are exceptions. Developing countries have crops, diseases, habitats and other pests not found in the United States, and pest problems do not exactly mirror those found in the United States. For instance, certain pesticides effective against tsetse flies, locusts or malarial mosquitoes might be ideal in Africa, yet in the United States they would never need to be used. As a consequence they would remain unevaluated by USEPA. Any proposed pesticide use that cannot be shown to conform to U.S. standards should be subjected to an Environmental Assessment or Environmental Impact Statement.

USAID finances pesticides only on a case-by-case basis (not on the basis of an approved commodity list), and then only after specific additional evaluation that considers the potential benefits conferred by the proposed pesticide. Furthermore, USAID does not finance procurement of pesticides through non-project assistance (i.e., through USAID Commodity Import Programs such as Title II, described below).

What is pesticide "use" according to USAID?

It is important to note that USAID broadly interprets "use" to include all *direct or actual use or acquisition* of pesticides, including handling, transporting, storing, mixing, loading, applying and disposing of them, as well as cleaning up spray equipment. It also includes any *indirect support for pesticide use,* such as providing fuel for transporting pesticides and giving technical assistance to pesticide management operations. An environmental review is required when USAID supports any such actions.

In contrast, *support for limited pesticide research and pesticide regulatory activities* is not subject to scrutiny under the pesticide procedures. Likewise, USAID may provide *support to train people in safer pesticide use* without environmental review when the training does not involve actual application of pesticides.

Important Restrictions on USAID-Supported Pesticide Use

- USAID finances pesticides only on a case-by-case basis.
- USAID does not finance pesticides through non-project assistance.
- Pesticides canceled or suspended by USEPA are never approved for USAID use.
- Products classified as "Restricted Use Pesticides" by USEPA are almost never approved for USAID use.
- USAID-financed (approved) pesticides may not be used in combination with non-approved pesticides.
- USAID-funded equipment should not be used to apply non-USAID-approved pesticides.

However, the USAID Administrator may waive certain rules in an emergency.

The kinds of factors to be considered in assessments such as an Initial Environmental Examination or Environmental Assessment should include, but not necessarily be limited to, the following CFR 216 parts:

- the USEPA registration status of the requested pesticide(s);
- the basis for selecting the requested pesticide(s);
- the extent to which the proposed pesticide use is part of an IPM program;
- the proposed method or methods of application, including availability of appropriate application and safety equipment;
- any acute and long-term toxic hazards, either human or environmental, associated with the proposed use, as well as measures available to reduce such hazards, if not eliminate them;
- effectiveness of the requested pesticide(s) for the proposed use;
- compatibility of the proposed pesticide(s) with target and non-target ecosystems;
- the conditions under which the pesticide(s) are to be used, including climate, flora, fauna, geography, hydrology and soils;
- the availability and effectiveness of other pesticides or non-chemical management methods;
- the requesting country's ability to regulate or control the distribution, storage, use and disposal of the requested pesticide(s);
- provisions made for training users and applicators; and
- provisions made for monitoring the use and effectiveness of the pesticide(s).

The types of environmental studies required by USAID, depending on USEPA regulatory status, are provided as a guide in Table 1. Pesticides canceled or suspended by USEPA (Table 2) are never approved for use in a USAID project. Similarly, products classified as Restricted Use Pesticides by USEPA (Table 3) are almost never approved for use in USAID projects.

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 Pesticide Evaluation Report and Safer Use Action Plans, or PERSUAPs (see http://www.encapafrica.org/sectors/pestmgmt.htm). PERSUAPs:

- describe the particular circumstances of the programs in question,
- assess the hazards posed by the pesticides proposed for use,
- outline the risk management choices available, and
- recommend how a risk management plan can be carried out in the field.

These documents are produced by or for country programs or activities that wish to use pesticides for discrete activities and that are supported by USAID, by non-governmental organizations (NGOs) or by private voluntary organizations (PVOs). PERSUAPs accompany an Initial Environmental Examination (IEE) and address the key Regulation 216 concerns listed above, emphasizing use of the lowest-risk compounds.

Local-level PERSUAPs are needed because, even though the USEPA may consider a pesticide safe for use in the United States, many farmers and pesticide users in Africa cannot be expected to handle pesticides in the same ways as U.S. users. Literacy rates are much lower, so users cannot read labels; farmers/users do not use safety equipment; regulations are not enforced; inappropriate pesticides or formulations are used; and users often do not know how to properly calibrate sprayers or use them safely, leading to gross and dangerous overapplications of pesticide. PERSUAPs are intended to foresee and prevent many of these risks.

Commingling of USAID Pesticide Funds with Others' Pesticide Funds. If more than one donor or NGO is involved in an activity, care must be taken that no USAID funds are spent on USAID-approved pesticides that might be used in combination with non-approved pesticides provided by another donor or group. Likewise, pesticide application equipment bought with USAID funds should not be used to apply non-USAID-approved pesticides. Good communication and program field monitoring will prevent this, at least over the short term or for the life of a project.

Title II Food Assistance and Natural Botanical Pesticides. U.S. Public Law 480 Title II development and emergency food assistance, administered by USAID's Office for Food for Peace, provides cereals and other foodstuffs to targeted vulnerable groups in developing countries. As part of this program, USAID funds grants from the Food Security Fund (FSF) through PVO/NGOs, like ACDI-VOCA. Pesticide training, procurement and use may be part of grantees' programs.

Administrator Authority/Waivers. Under certain circumstances, such as locust or rodent plagues or exotic introduced pest outbreaks (e.g., screwworm in cattle), the Administrator of USAID may write a waiver to authorize or approve

- using compounds not normally used, or

Pesticide Evaluation Report and Safer Use Action Plan (PERSUAP)

PERSUAPs describe results of risk assessment studies for proposed pesticide use, describe possible plans to address the risks, and then recommend one of the plans. Country programs use them together with an Initial Environmental Examination. PERSUAPs help USAID maintain a level of control over pesticide use in local projects.

- expediting actions with minimum or no environmental review.

Generally, this requires that requesting countries or projects forward emergency requests for assistance through USAID's Office of Foreign Disaster Assistance (OFDA).

Listing of pesticides. On the following pages are three tables that may be of use in deciding which pesticides to use. Table 1 outlines the different levels of USAID evaluation required by different combinations of pesticides and uses. Table 2 lists pesticides whose use has been cancelled or suspended by USEPA or that USEPA has never registered for use. Table 3 lists pesticides whose use has been restricted by USEPA.

Two other sites have helpful lists of pesticides. The **Pesticide Action Network (PAN)** site has a comprehensive database of pesticides used in many places (particularly the United States), including insecticides, herbicides and more. Along with the database, the site has a pesticide poisoning diagnostic tool, an international pesticide registration page, information on aquatic ecotoxicity, notes about California pesticide use, a pesticide tutorial and reference guide, a discussion of least/non-toxic alternatives to dangerous pesticides, and a set of links to other resources.

PAN list: http://www.pesticideinfo.org/Index.html (if you have problems, go to the PAN home page at http://www.panna.org)
PAN's famous "Dirty Dozen" list of highly hazardous pesticides is at http://www.pesticideinfo.org/Docs/ref_toxicity7.html#DirtyDozen

The FAO's **Prior Informed Consent (PIC)** Web site lists only hazardous chemicals. Under the 1998 Rotterdam Convention, exporters trading in any hazardous substance found on the PIC list have to obtain the prior informed consent of importers before proceeding with the trade. The interim PIC list contains 22 pesticides, 9 industrial chemicals and 6 severely hazardous pesticide formulations. The site also has tables listing several classes of problematic chemicals proposed for the PIC list ("candidate chemicals").

PIC list: http://www.pic.int/en/ViewPage.asp?id=231 (if you have problems, go to the PIC home page at http://www.pic.int/)

Table 1. Classification of Candidate Pesticides for Specific Evaluation

Categorization in terms of proposed use and USEPA regulatory status	**Review requirements in accordance with USAID Regulation 216**
1. Pesticide to be used for research or limited field evaluation purposes only, irrespective of its current regulatory status in United States	IEE[b]
2. Projects involving demonstration or use of pesticides for specified use:	IEE[b]
(a) Pesticide registered for same or similar uses[a] in United States without restrictions	IEE[b]
(b. Pesticide registered for same or similar uses[a] in United States, restricted on basis of user hazard	IEE and, if approved, user hazard warning to and certification of awareness from recipient[b]
(c) Pesticide registered for same or similar uses[a] in United States, restricted on basis of environmental hazard	IEE plus EA or EIS[c]
(d) Pesticide registered for same or similar uses[a] but currently under Special Review, notice of intent to cancel, or subsequent notice of intent to suspend issued by USEPA	IEE plus EA or EIS[c] and, if approved, notice of impending action to recipient
(e) Pesticide previously registered for same or similar uses[a] but cancelled for environmental hazard	IEE plus EA or EIS[c]
(f) Pesticide previously registered for same or similar uses[a] but cancelled for health reasons	IEE plus EA or EIS[c]
(g) Pesticide registered for a different use in United States	IEE plus EA or EIS[c]
(h) Pesticide not registered for any use in United States, but tolerances established	IEE plus EA or EIS[c]
(i) Pesticide not registered for any use in United States, no tolerances established	IEE plus EA or EIS[c]

[a] Similar use is defined to include the use of a substantially similar formulation in a comparable use pattern. The term "use pattern" includes target pest; crop or animals treated; application site; and application technique, rate, and frequency.

[b] Pesticides in this category are not ordinarily subject to further analysis; however, the decision to undertake such analysis is made on a case-by-case basis.

[c] Pesticides in this category, following the IEE, automatically trigger at least an EA or an EIS, the choice of which continues to be governed by USAID Regulation 216.

Abbreviations: IEE: Initial Environmental Examination; EA: Environmental Assessment; EIS: Environmental Impact Statement; USEPA: U.S. Environmental Protection Agency. Source: USAID 1976a in Tobin 1994.

Table 2. Pesticide Compounds with USEPA-Cancelled or Suspended Products

The following is a list of generic or accepted common chemical or compound names for problematic pesticides. At least half of the products made with each pesticide are suspended, cancelled, or not registered (i.e., they have no "Active" registrations) in the United States by the U.S. Environmental Protection Agency (USEPA). Note that thousands of trade names exist, few of which appear on this list. Carefully examine the label of any pesticide to ascertain whether the accepted common (or generic) name appears on this list.

acetamide-na
acrolein-cna
acrylonitrile-c
alachlor-cna
alar
aldicarb-dd
aldrin-dd-b
allyl alcohol-c
alpha chlorhydrin-c
aluminum phosphide
amitraz-cna
amitrole
arsenic acid
arsenic trioxide-s
arsenic pentoxide-cna
atrazine
avitrol-cna
azinphos methyl
bendiocarb-cna
benomyl
BHC-dd-b
bis (tributyltin) oxide
brodifiacoum-c
bromoxynil
bromoxynil butyrate-b
butylate-c
cadmium-b
cadmium chloride-c
calcium arsenate-b
calcium cyanide-c
captafol-b
captan
carbofuran-s
carbon tetrachloride-b-c
chloranil-b
chlordane-dd-b
chlordimeform-dd-b
chlorfenvinphos-c
chlorbenzilate-b
chlorophacinone-cna
chloropicrin
chlorothalonil
chromic acid
coal tar-cna
coal tar creosote
copper arsenate-b
copper oxychloride-c
coumaphos-na
creosote-c
creosote oil
cupric oxide-c
cyanazine-cna
cycloheximide-c
cyhalothrin-na
cyhexatin-b
cypermethrin
daminozide-s
DBCP-dd-b-c
DDD (TDE)
DDT-dd-b
demeton-c
diallate-c
dichloenil (2,4-D)
dichloropropene
diclofop methyl
dicofol
dicrotophos-cna
dieldrin-dd-b
diflubenzeron
dimethoate
dinocap
dinoseb-b
dioxathion-cna
diphacinone-c
disulfoton
dodemorph-c
E-mevinphos-c
endrin-dd-cna
EBDCs
EDB-dd-b
endrin-cna
EPN-c-b
EPTC
ethion-cna
ethoprop-cna
ethyl parathion-cna
ethylene dibromide-c
fenamiphos-cna
fenitrothion-cna
fensulfothion-c
fenthion
fenvalerate-cna
flucythrinate-c
flouroacetamide-c
fluvalinate-c
fluoroacetamide
fonofos-c
heptachlor-dd-s
hydrocyanic acid-c
hydrogen cyanamide-na
imazaquin-c
isazofos-c
isofenphos-c
kepone
lead arsenate-b
lindane-dd-b
magnesium phosphide
metaldehyde
methamidophos
methiocarb
methomyl-cna
methyl bromide-cna
methyl parathion-dd
mercury compounds-b
mevinphos-c-b
mirex-b
monocrotophos-c-b
niclosamide-cna
nicotine
nitrogen, liquid-na
oxamyl-na
oxidemeton methyl-cna
OMPA-b
10,10' oxybisphenoxarsine
oxyfluorfen
parathion-dd
paraquat-dd
PCBs
PCNB
pentachlorophenol-dd-cna
pentachlorophenol-sodium S-dd-cna
permethrin
phenarsazine chloride
phorate-cna
phosacetim-c
phosalone-c
phosphamidon-c
picloram-c
picloram, isooctyl ester-c
picloram, potassium salt-cna
picloram, triisoprpanolamine
polychlorinated terphenyls
potassium pentachlorophenate-c
pronamide
profenphos-na
propanoic acid
safrole-b
silvex-b
simazine
sodium arsenate-s
sodium arsenite-b
sodium cyanide
sodium dichromate
sodium fluoroacetate-cna
sodium fluoride
sodium methyldithiocarbamate
sodium monofluoroacetate
sodium pyroarsenate-c
strobane-b
strychnine
sulfotep-cna
sulfuric acid
sulfuryl fluoride
2,4,5-T-dd-b
2,4,5-TCP-b
tefluthrin
TEPP-c
terbufos-na
tergitol-c
TFM-na
thallium Sulfate-b
TOK (nitrofen)-b
toxaphene-dd-b
tributyltin fluoride-cna
tributyltin methacrylate
tributyltin-s
trifluralin-c
triphenyltin hydroxide
vinyl chloride-b
z-mevinphos-c
zinc phosphide
Wood Preservatives: calcium arsenate-b, creosote, pentachlorophenol-dd, sodium arsenate-b, and sodium arsenite-b

Source: USEPA 2002

na = chemicals with no active registered products
cna = chemicals with cancelled and no active registered products
c = chemicals with all products cancelled
b = chemicals with all products banned
s = chemicals with most uses strictly restricted
dd = "dirty dozen" pesticides as designated by PAN, in Boldface Type

Table 3. Pesticides Classified as "Restricted Use Products" (RUP) by USEPA

Note: This list contains only accepted common generic names; trade names are far more numerous. These products may be used *only* by a certificated pesticide applicator or under the direct supervision of a certified applicator. For detailed information on the RUP classification, consult 40 CFR Subpart I, 152.160. RUP lists are found at http://www.epa.gov/opprd001/rup/ (last updated June 27, 2003). The RUP lists provide information on the status (active or cancelled) of all of the different product names (names under which the products are sold) likely to be encountered for each chemical compound base name in the RUP list. Some compounds have up to 100 different names, so look carefully at this resource. For each compound, the RUP list also provides reasons why each product is so closely regulated, along with formulations, uses, EPA actions, and the last date that each was revised.

Note: All pyrethroid pesticides were classified as "restricted on 07/27/95 due to acute hazards." Pyrethrins, on the other hand, are listed due to chronic eye effects.

Key: DD = A chemical on the PAN "dirty dozen" list; EC = emulsifiable concentrate

Acetamide	Acetic acid	Acetochlor
Acrolein	Acrylonitrile	Alachlor
Aldicarb [DD]	Allyl alcohol	Alpha-clorohydrin
Aluminum phosphide	Amitraz	Amitrole
Arsenic acid	Arsenic pentoxide	Atrazine
Avermectin	Avitrol	Azinphos-methyl
Bendiocarb	Benzoic acid	Biphentrhin
Bis(tributyltin) oxide	Brodifacoum	Butylate
Cadmium chloride	Calcium cyanide	Carbofuran
Carbon dioxide	Carbon tetrachloride	Chlordane [DD]
Chlordane, technical	Chlordimeform [DD]	Chlorfenvinphos
Chlorobenzilate [DD]	Chlorophacinone	Chloropicrin
Chlorothalonil	Chlorothoxyfos	Chlorpyrifos (EC on wheat)
Chromic acid	Clofentezine	Coal tar
Coal tar creosote	Copper oxychloride	Coumaphos
Creosote	Creosote oil	Cube resins
Cupric oxide	Cuprous oxide	Cyanazine

Cycloheximide	Cyfluthrin	Cyhalothrin
Cypermethrin	DBCP [DD]	Deltamethrin
Demeton	Diallate	Diazinon
Dichloenil (2,4,D)	Dichloropropene	Diclofop methyl
Dicrotophos	Diflubenzuron	Dioxathion
Diphacinone	Disulfoton	Dodemorph
E-mevinphos	Emamectin benzoate	Endrin [DD]
EPN	EPTC	Ethion
Ethoprop	Ethyl parathion [DD]	Ethylene dibromide
Fenamiphos	Fenbutatin-oxide	Fenitrothion
Fenpropathrin	Fensulfothion	Fenthion
Fenvalerate	Fipronal	Flucythrinate
Fluoroacetamide	Fluvalinate	Fonofos
Hydrocyanic acid	Hydrogen cyanamide	Imazaquin
Isazofos	Isofenphos	Lambda-cyhalothrin
Lindane [DD]	Magnesium phosphide	Methamidophos
Methidathion	Methiocarb	Methomyl
Methyl bromide	Methyl isothiocyanate	Methyl parathion [DD]
Metolachlor	Mevinphos	Monocrotophos
Niclosamide	Nicotine	Nitrogen, liquid
Oxamyl	Oxidemeton methyl	Paraquat [DD]
Pentachlorophenol [DD]	Pentachlorophenol, Sodium S [DD]	Permethrin
Phorate	Phosacetim	Phosalone
Phosphamidon	Phostebupirim	Picloram
Picloram, isooctyl ester	Picloram, potassium salt	Picloram, triiosopropanolamine
Piperonyl butoxide	Potassium pentachlorophenate	Profenophos

Pronamide	Propanoic acid	Propetamphos
Pyrethrins	Resmethrin	Rotenone
S-Fenvalerate	Simazine	Sodium arsenate
Sodium cyanide	Sodium dichromate	Sodium fluoroacetate
Sodium hydroxide	Sodium methyldithiocarbamate	Sodium pyroarsenate
Starlicide	Strychnine	Sulfotepp
Sulfuric acid	Sulfuryl fluoride	Sulprofos
Tefluthrin	TEPP	Terbufos
Tergitol	TFM	Toxaphene [DD]
Tralomethrin	Tributyltin fluoride	Tributyltin methacrylate
Trifluralin	Triisopropanolamine	Triphenyltin hydroxide
Z-Mevinphos	Zinc phosphide	

Biopesticides

There are three major classes of biopesticides:

- **Microbial pesticides**, which contain micro-organisms as the active ingredient.
- **Plant-incorporated protectants**, such as Bt proteins that are genetically added to a plant
- **Biochemical pesticides**, such as essential oils (lemongrass, eucalyptus) or insect pheromones that control pests by non-toxic means.

Biopesticides have several advantages over synthetic pesticides:

- They are usually inherently less toxic.
- They generally affect only the target pests.
- They are often effective in small quantities and decompose quickly.
- They can be safely used by large- and small-scale farmers.
- They can reduce use of conventional pesticides while preserving high crop yields.

Biopesticides: Microbials, Botanical Pesticides, Repellents and Baits

Lists of biopesticides regulated by USEPA may be found at http://www.epa.gov/pesticides/ biopesticides. These pesticides are derived from such natural materials as animals, plants, bacteria and certain minerals. For example, canola oil and baking soda have pesticidal applications and are considered biopesticides. At the end of 2001, there were approximately 195 registered biopesticide active ingredients and 780 products.

Plant-Derived Pesticides That Are Not Permitted. The use of plant-derived pesticides *not* registered with USEPA, such as nicotine-based commercial products or smallholder farmer concoctions, will not be promoted under a USAID-funded project without completing a pesticide review—for example, an IEE, EA, or PERSUAP. Suggestions for testing and determining the risk of botanical products are listed in these guidelines' IPM chapter. For example, some botanical infusions of ground "rope" tobacco and soap can result in a product that is highly toxic to people and should not be supported or extended to smallholder farmers. Table 4 shows a list of botanical pesticides, repellents and baits regulated and registered by USEPA.

Biopesticides, as outlined by USEPA, fall into three major classes:

1. Microbial pesticides consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient. Microbial pesticides can control many different kinds of pests, although each separate active ingredient is relatively specific for its target pest(s). For example, there are fungi that control certain weeds and other fungi that kill specific insects.

The most widely used microbial pesticides are subspecies and strains of *Bacillus thuringiensis*, or Bt. Each strain of this bacterium produces a different mix of proteins and specifically kills one or a few related species of insect larvae. While some Bts control moth larvae found on plants, others are specific for larvae of flies and mosquitoes. Target insect species are determined by whether the particular Bt produces a protein that can bind to a larval gut receptor, thereby causing the insect larvae to starve.

2. Plant-Incorporated Protectants (PIPs) are pesticidal substances that plants produce from genetic material added to the plant. For example, scientists can take the gene for the Bt pesticidal protein and introduce it into the plant's own genetic material. Then the plant, instead of the Bt bacterium, manufactures the substance that destroys the pest. The protein and its genetic material, but not the plant itself, are regulated by USEPA.

3. Biochemical pesticides are naturally occurring substances that control pests by nontoxic mechanisms. Conventional pesticides, by contrast, are generally synthetic materials that directly kill or inactivate the pest. Biochemical pesticides include substances such as insect sex pheromones that interfere with mating as well as various scented plant extracts that attract insect pests to traps. Because it is sometimes difficult to determine whether a substance meets the criteria for classification as a biochemical pesticide, USEPA has established a special committee to make such decisions.

Examples of scented plant extracts include a relatively long list of **essential oils**, defined as any volatile oil that gives a distinctive odor or flavor to a plant, flower or fruit, that were first registered as pesticide active ingredients in 1947. Twenty-four distinct chemicals are covered under the heading "essential oils." USEPA now requires that registrants identify the particular oil(s) contained in their products, rather than naming "essential oils" as the active ingredient. Approximately 25 pesticide products that contain essential oils as active ingredients are currently registered by USEPA. These products are used as repellants, feeding depressants, insecticides and miticides as well as antimicrobials, and are marketed as liquid sprays, crystals and pellets.

The advantages of using biopesticides are many:

- Biopesticides are usually inherently less toxic than conventional pesticides.
- Biopesticides generally affect only the target pest and closely related organisms, in contrast to broad-spectrum conventional pesticides that may affect organisms as different as birds, insects and mammals.
- Biopesticides often are effective in very small quantities and often decompose quickly, lowering exposures and largely avoiding the pollution caused by conventional pesticides.
- Both larger-holder and smallholder farmers may be able to use biopesticides safely.
- When used in IPM programs, biopesticides can greatly decrease use of conventional pesticides, while crop yields remain high.

The Versatile Bt Protein

The common soil bacterium *Bacillus thuringiensis* (Bt) produces proteins that can poison insect larvae. Each Bt strain kills a specific insect or group of insects. Bt can be used whole to protect maize, cotton and potatoes from insects, or the protein from the appropriate strain of Bt can be engineered directly into each crop so that the plants themselves kill the pests that are eating them.

Table 4. Botanical Pesticides, Repellents and Baits Regulated by USEPA, As Listed by EPA

Anise Oil	*Pimpinella anisum*	Repels vertebrates	Low	004301
Azadirachtin, Dihydroazadirachti	*Azadirachta indica* Neem tree extract	Kills & repels insects	III-IV	121701, 121702
Bergamot	Lemon mint	Repels vertebrates		129029
Canola Oil	*Brassica napus* *B. campestris*	Kills many insects	Low	011332
Capsaicin	*Capsicum frutescans* Red pepper	Repels vertebrates	Low, III	070701
Castor Oil	*Ricinus communis*	Repels vertebrates	Low	031608
Cedarwood Oil	*Juniperus* & *Cedrus* spp	Repels moth larvae	Low	040505
Cinnamaldehyde	Ceylon & Chinese cinnamon oils	Kills insects, fungi & repels vertebrates*	Low	040506
Citronella Oil	*Cymbopogon fardus*	Repels insects & vertebrates	Low	021901
Cloves, Crushed	*Syzygium aromaticum*		Low	128895
Eucalyptus Oil	p-Methane-3,8 diol	Repels insects, mites fleas & mosquitoes	Low	040503
Eugenol	Oil of cloves	Kills insects**	Low	102701
Garlic	*Allium sativum* 'Garlic barrier' etc.	Repels insects	Low	128827
Geraniol	Oil of rose isomeric w/ linalool	Repels vertebrates**	Low	597501
Geranium Oil			Low	597500
Indole	from all plants	Trap bait: corn root-worm beetles	Low	25000-
Jasmine Oil	*Jasminum* sp.		Low	040501
Jojoba Oil	*Simmondsia* spp.	Kills & repels whitefly kils powdery mildew	Low	067200
Lavandin Oil	Lavender	Repels clothes moth	Low	040500
Lemongrass	*Cymbopogon citratus*	Repels vertebrates	Low	040502
Linalool	Oil of Ceylon isomeric w/ geraniol	Repels insects, ticks, mites & spiders	Low	128838
Maple lactone		Roach trap bait	Low	004049
Methyl salicylate	Oil of wintergreen	Repels moths, beetle & vertebrates	May be Toxic in large quantity	76601-
Mint, Mint oil	*Menthus* spp.	Kills aphids	Low	128892, 128800
Mustard Oil	*Brassica nigra* Allyl isothiocyanate	Repels insects, spiders & vertebrates	Low	004901
Neem Oil	[see azadiractin]	Kills whitefly, aphids	Low	025006
1-Octen-3-ol	From clover, alfalfa	Trap bait: mosquitoes	Low	69037-
Orange	*Citrus sinensis*	Repels vertebrates	Low	040517
Pepper, red	Chilli, capsaicin	Repels insects	Low	070703
2-Phenylethyl-propionate	From peanuts	Kills insects, ticks,	Low	102601

Planning and Preparing for Pest Management Operations

There is a detailed discussion of IPM in the chapter on integrated pest management in these guidelines. Refer to it for details. In brief, here are some essentials of IPM.

How Do IPM Programs Work?

IPM is an approach that integrates appropriate existing management methods (cultural, biological, chemical, physical) with mitigating factors, environmental concerns, climatic conditions, and ecosystem inter-relationships to assist in decision-making. IPM is thus not a single pest control method, but rather a series of pest management evaluations, decisions and controls. In practicing IPM, growers will follow an approach that includes the following elements:

1. Prevention: As a first line of pest management, IPM programs work to manage the crop, lawn or indoor space to prevent pests from becoming a threat. On a farm this may mean using methods like rotating between different crops, selecting pest-resistant varieties, and planting pest-free rootstock. These methods can be very effective and cost-efficient and present little or no risk to people or the environment.

2. Monitoring and identifying pests: Not all insects, weeds and other living organisms require control. Many are innocuous, and some even benefit the crop by preying on harmful organisms. IPM programs work to monitor for pests and identify them accurately, so that farmers can make appropriate management decisions using action thresholds (see next item). This monitoring and identification removes the possibility that pesticides will be used when they are not really needed or, worse, that the wrong kind of pesticide will be used.

3. Setting action thresholds: Before taking any pest management action, IPM sets an **action threshold**—a point at which pest populations or environmental conditions indicate that action must be taken. Sighting a single pest does not always mean action is needed. Knowing the level at which pests become an economic threat is critical to pest control decisions.

4. Management: Once monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM programs evaluate possible management methods for both effectiveness and risk. Effective, lower-risk pest controls are chosen first, including highly targeted chemicals (such as pheromones to

Basic Steps for Pest Management

- *Practice prevention first,* by managing crops or households to prevent pest problems before they occur.
- *Monitor and identify pests*. Not all insects, weeds and wild animals around the farm are harmful; some may even help.
- *Set an action threshold*—the point where a pest problem must be dealt with. Sighting a single pest may not justify a campaign.
- *Identify and evaluate proper controls,* once pest management is indicated.

disrupt pest mating) or mechanical controls (such as trapping or weeding). If further monitoring, identification and action thresholds indicate that less-risky controls are not working, then additional pest control methods are used, such as targeted spraying of the least toxic pesticides. Broadcast spraying of nonspecific pesticides is generally a method of last resort.

Many kinds of organisms can be pests, including different species of insects, mites, nematodes, mollusks, plant pathogens, vertebrates and weeds. It is vital to identify a pest correctly—as well as its natural enemies—before deciding whether and how to manage it.

Preparing for Crop Protection Actions

Before the growing season(s), any crop protection service (CPS) field bases supporting village farmers should ensure that farmers are ready, technically and materially, to face the coming season. Farmers should first prepare the farm to face a pest infestation with preventive action. In addition to the methods mentioned in (1) above, examples of prevention include destroying last season's crop refuse and having planting material ready to plant at the optimum time. Farmers should also prepare:

- plans of action or IPM strategies for different pest scenarios;
- working spray equipment;
- clean protective clothing and safety equipment;
- and a basic supply of least-toxic pesticides carefully stored and ready for use.

In addition, if pest problems do develop, it is important to assess the vulnerability of crops threatened by the pest species, the relative importance of the crops, and the crops' stage of development. This information will help the farmer decide when and where a pesticide spray treatment may be needed.

Pest Monitoring and Survey

To help keep pest numbers below levels where economic damage from crop loss can occur and to reduce the environmental impact of pesticide use, it is important for both farmers and extension agents to survey the crops regularly. Pest surveying should begin early in the season and continue on a regular basis throughout the growing season. When necessary, control activities should be carried out promptly and in a carefully targeted way. Knowledge of the pest and crop ecology, along with equipment in good working order, help to accomplish this. *A monitoring-based approach*

typically will reduce the number of pesticide treatments required by 40–60 percent during a regularly scheduled control scheme.

The main elements to be included in pest survey programs are (1) knowledge of pest distribution in time and space and (2) monitoring of environmental conditions and changes that might lead to increased numbers of pest species. This will require some knowledge of pest species' biology, current environmental conditions, and how these conditions can encourage or limit the spread of pests.

Appropriate, well-maintained equipment is critical for safe pesticide use.

Village Brigades

A village brigade is a unit responsible for a village's pest monitoring and control needs. Brigades are being formed in many African countries as self-help units and to decentralize the activities the national CPS often conducts. These brigades are formed with the assistance of rural extension agents and the national CPS. A village brigade typically includes 10 interested and enthusiastic villagers. Brigade activities should include coordination of area-wide rat-baiting programs, removal of pest and pathogen reservoirs (such as crop stubble containing pests), timely hand-picking of egg masses of large pests, and implementation of other useful non-chemical management techniques requiring effective community mobilization.

Village Brigades

A village brigade typically includes 10 interested villagers who can mobilize their neighbors for such anti-pest activities as:

- Baiting rats area-wide
- Removing pest and disease reservoirs
- Hand-picking egg masses of large pests

Ideally the members receive three days of intensive training in pest management. They can then train their entire village during the year.

Ensuring Proper Pesticide Management and Safety

The following list presents the main issues to be understood and remembered when using chemicals to manage pests:

- Use the recommended chemical, rate and application method.
- Good coverage of all plant parts is essential if spraying is done on a "wet to runoff" basis—i.e., the plants are sprayed to the point that the spray just begins to drip from the foliage.
- Some insecticides kill beneficial insects as well as harmful ones, so do not use them indiscriminately.
- Always read the directions on the container.
- Buy and store pesticides in their original container. Keeping pesticides in containers that originally held food or drink has resulted in many accidental poisonings. Likewise, never reuse an empty pesticide container for any purpose, especially for storing food or water.

To the extent that village brigades assume a significant role in pest management, they should be encouraged to understand and promote adoption of non-chemical control options as much as possible and discouraged from becoming overly dependent on pesticides. Participants ideally receive three days of intensive pest and pesticide management training and then are responsible for pest management at the village level, with the help of the other local farmers. Investment in participant training has the potential for a dramatic multiplier effect, as the members of a village brigade can train an entire village during the year.

Pesticides at the User Level

Safer pesticide use involves the following key components, which are discussed in three sections. The first section (below) covers the practical context of pesticide use, including pesticide selection, understanding the pesticide label, pesticide transport, mixing and loading pesticide, pesticide storage, container disposal and obsolete pesticides. The second section covers the actual process of using pesticides, including calibration of application equipment, determining the amount of chemical to use, and applying pesticides. The third section covers pesticide toxicity, human protection, and basic first aid for pesticide overexposure.

Note that many smallholder farmers will not use the methods discussed in these three sections, regardless of the amount of training they receive, while some larger-holder farmers who do understand these principles may not emphasize their importance sufficiently to laborers who use the pesticides. Medium- to larger-holder farmers who do their own crop protection are apt be the most likely to use appropriate precautions. If project monitoring shows that farmers or farm laborers are not using appropriate precautions, a spraying service may need to be provided.

Pesticide Use: The Practical Context

Pesticide selection

Once the decision is made to use a synthetic pesticide, the correct product must be selected.

Here are some factors to consider:

- Is the product registered and recommended for managing the pest on the specific crop being grown? (Do not use a pesticide on a crop for which it is not registered or recommended.)

- What is the cost of the chemical, based not only on the initial unit cost but also on the cost per application and the number of applications required?
- What is the pesticide's availability?
- What is the pesticide's relative toxicity, and how hazardous is its use?
- What are the possible harmful effects of using the product?
- What is one's past experience in using the chemical for the pest and crop in question?

Pesticides can be grouped or classified by several different methods, as seen in the following table.

According to function (action against a specific pest category)	
Pesticide	***Pest Group***
Acaricide/miticide	Mites, ticks
Bactericide	Bacteria
Fungicide	Fungi
Herbicide	Weeds
Insecticide	Insects
Molluscicide	Mollusks
Nematicide	Nematodes
Rodenticide	Rodents
According to chemical makeup	
Groups	***Examples***
Organochlorines	DDT, dieldrin, aldrin, heptachlor, lindane (most of these are banned in most countries)

Organophosphates	actellic, acephate, chlorpyrifos, dimethoate, endosulfan, malathion
Carbamates	carbaryl, methomyl, propoxur
Synthetic pyrethroids	bifenthrin, cyfluthrin, permethrin, cypermethrin, deltamethrin, fenvalerate
Botanicals	pyrethrum, rotenone, nicotine, azadirachtin (neem)
Microbials	*Bacillus thuringiensis*, *Heliothis* nuclear polyhedrosis virus, *Nosema locustae*, *Metarhizium* spp.
Petroleum oils	mineral oil
Insect growth regulators	diflubenzuron, methoprene, fipronil
According to formulation	
Liquid	Emulsifiable concentrates (EC or E) Flowables (F or L) Solutions (S) Ultra low volume concentrates (ULV)
Dry	Dusts (D) Granules (G) Pellets (P) Wettable powders (WP) Soluble powders (SP) Dry flowables (DF)
Other	Aerosols Fumigants Baits

Understanding the Pesticide Label

The label is the printed material attached to the pesticide container. If possible, pesticides without an approved label attached to the container should not be purchased. The ability to read or understand the information on the label is essential, and vendors and farmers should understand the value of an adequate label. Even those who cannot read need to be helped to grasp the information on the label or to understand the pesticides they are selling or using. Users will find the label and other product documentation helpful:

Vendors and farmers need to understand the pesticides they are selling or using. Even those who cannot read must be helped to grasp the information on the label—for safety and for effective use of the product.

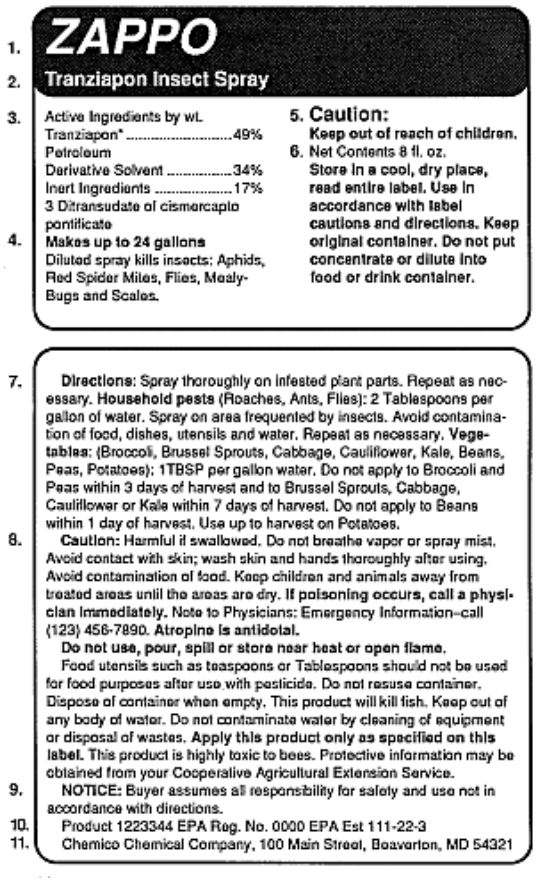
- before purchasing the pesticide, to determine if the chemical will manage the pests on the crop in question and can be used safely for their specific conditions;
- before mixing the pesticide, to determine if users have the necessary protective clothing, how much pesticide to use, and how to mix it;
- before applying the pesticide, to learn the safety measures required, when to apply the pesticide, how to apply it, when it is safe to reenter the treated area, when it is safe to harvest the treated crop, and what restrictions would prohibit its use under current conditions;
- before storing the container, to ensure safe and proper storage; and
- before disposing of the container, to ensure safe and proper disposal.

The pesticide label should include:

- *USEPA or other registration number*
- *Brand name*: Name assigned by the manufacturer
- *Common name*: Short name approved for the chemical's active ingredient (the material that actually kills the pest)
- *Chemical name*: Full name of the active ingredient, presented according to the rules of nomenclature used in *Chemical Abstracts*
- *Ingredient statement*: Lists the active ingredient or ingredients, along with the percentage of inert or inactive ingredients
- *Amount of active ingredient*: For powders, this is listed as a percentage. For instance, "50% WP" means that the powder consists of 50 percent active ingredient and 50 percent inert ingredient. For liquids, it is measured as pounds of active ingredient per gallon. For example, "2 EC" means that the compound contains 2 pounds of active ingredient per gallon of product.

- *Net contents*: Shows the actual amount of product in the container
- *Name and address of the manufacturer*
- *Signal words and symbols*: Quick reference to product's relative toxicity to humans
- *Precautionary statements*: Given to protect users, others, animals, and the environment from damage resulting from using the pesticide
- *Route of entry*: Possible ways the pesticide can harm or enter a handler's body
- *Specific action*: Actions that help the handler protect the routes of entry specified above
- *Protective clothing and equipment*: Lists any that are needed to prevent overexposure to the pesticide
- *Practical treatment*: Specifies the recommended first aid in case of overexposure
- *Environmental hazards*: Explains how misuse of the product can harm the environment

Pesticide Label Example



1.
2. **ZAPPO**
   Tranziapon Insect Spray
3. Active Ingredients by wt.
   Tranziapon* 49%
   Petroleum
   Derivative Solvent 34%
   Inert Ingredients 17%
   3 Ditransudate of cismercapto pontificate
4. **Makes up to 24 gallons**
   Diluted spray kills insects: Aphids, Red Spider Mites, Flies, Mealy-Bugs and Scales.
5. **Caution:**
   Keep out of reach of children.
6. Net Contents 8 fl. oz.
   Store in a cool, dry place, read entire label. Use in accordance with label cautions and directions. Keep original container. Do not put concentrate or dilute into food or drink container.
7. **Directions:** Spray thoroughly on infested plant parts. Repeat as necessary. **Household pests** (Roaches, Ants, Flies): 2 Tablespoons per gallon of water. Spray on area frequented by insects. Avoid contamination of food, dishes, utensils and water. Repeat as necessary. **Vegetables:** (Broccoli, Brussel Sprouts, Cabbage, Cauliflower, Kale, Beans, Peas, Potatoes): 1TBSP per gallon water. Do not apply to Broccoli and Peas within 3 days of harvest and to Brussel Sprouts, Cabbage, Cauliflower or Kale within 7 days of harvest. Do not apply to Beans within 1 day of harvest. Use up to harvest on Potatoes.
8. **Caution:** Harmful if swallowed. Do not breathe vapor or spray mist. Avoid contact with skin; wash skin and hands thoroughly after using. Avoid contamination of food. Keep children and animals away from treated areas until the areas are dry. **If poisoning occurs, call a physician immediately.** Note to Physicians: Emergency Information–call (123) 456-7890. **Atropine is antidotal.**
   Do not use, pour, spill or store near heat or open flame.
   Food utensils such as teaspoons or Tablespoons should not be used for food purposes after use with pesticide. Do not reuse container. Dispose of container when empty. This product will kill fish. Keep out of any body of water. Do not contaminate water by cleaning of equipment or disposal of wastes. **Apply this product only as specified on this label.** This product is highly toxic to bees. Protective information may be obtained from your Cooperative Agricultural Extension Service.
9. **NOTICE:** Buyer assumes all responsibility for safety and use not in accordance with directions.
10. Product 1223344 EPA Reg. No. 0000 EPA Est 111-22-3
11. Chemico Chemical Company, 100 Main Street, Beaverton, MD 54321

Be sure to read and understand the label instructions for each pesticide that is in use.

- *Special toxicity*: Explains how to use the product without harming non-target organisms, such as honeybees, fish, birds, and other wildlife
- *Physical or chemical hazards*: Explains any special fire, explosion or chemical hazards the product can pose during transportation or storage

- *Reentry statement*: Gives the time that must pass between application of the pesticide and when it is safe to reenter the treated area

- *Storage and disposal*: Outlines recommended methods

- *Directions for use*: Occupies a large area of the label. Lists crops, sites and target pests for which the product is registered, along with recommended application rate, method of application, timing, any known compatibility or phytotoxic (plant-poisoning) problems, and other information about use. The period between application and when the crop is safe to eat ("days to withhold") is sometimes listed here.

Signal words, symbols and color codes. A label may display a signal word such as "Danger—poison," "Warning" or "Caution," depending on how toxic the product is. The most poisonous products will also have a skull and crossbones on the label. Various measures are used to find the category to which a pesticide belongs. See the discussion below under "Pesticide Toxicity and Human Protection," including Table 8, as well as Tables 13 and 14 at the end of the chapter.

Pesticide label "color coding" schemes have been developed by the FAO and others. For example, in Zimbabwe the pesticide registration officer of the Plant Protection Research Institute collaborates with the Hazardous Substances and Articles Control Board to assign a color code to a pesticide. The color reflects the size of the pesticide's acute oral lethal dose (LD50), the concentration of its formulation, and the length of time it persists in the ecosystem after application. The colors green, amber, red and purple represent pesticides with LD50 ranges of >2,001; 500–2,000; 101–500; and 0.1–100 mg/kg body weight, respectively. In addition, the color coding system signals the hazards the chemical possesses; who, by law, may handle or use it; and the type of protective clothing a person must wear when handling or using the pesticide. See the Web site http://www.ifgb.uni-hannover.de/ppp/ppp_s01.pdf for more information on this concept.

Reasons It Is Vital to Measure Pesticide Exactly

- Using too little pesticide usually fails to manage the pest.
- Using too much pesticide:
  - wastes money.
  - could harm the user.
  - could harm the environment.
  - could make the crop unsafe to eat because of the toxic residues.

Management System for Pesticide Storage

A good management system is vital for storing pesticides safely. The system should ensure that people:

- Record dates of arrival and use for each pesticide.
- Post and teach storage requirements for each pesticide.
- Have stored pesticides tested periodically.
- Dispose of used/obsolete pesticides safely, as well as their containers.

Pesticide Transport

Pesticides should be transported where people are the least likely to be exposed to them. They should be placed inside another container or bag and kept as far from passengers as possible. Check the transporting surface to be certain that there are no nails, bolts, screws, or other sharp objects that could puncture pesticide containers. Never transport pesticides with persons or animals. Never transport pesticides where they could come into contact with groceries, livestock feed, seed or other products that might become contaminated. Pesticide containers should be well sealed and secured during transport to prevent spillage or loss in case of sudden starts, stops or turns.

Mixing and Loading Pesticide

Most pesticides are sold as concentrates that require dilution with a "carrier" (usually water) before application. Always read the label before mixing a pesticide; it will tell how much to dilute the formulated product and how much of the mixture to apply per unit of area.

It is essential to measure the exact amount of pesticide recommended. Applying smaller amounts usually does not manage the pest. Applying more than is recommended not only needlessly increases production costs but could also be harmful to the applicator and the environment. It could also make the crop unsafe to eat and/or hard to sell abroad due to excessive pesticide residues. Pour the specified quantity of pesticide into the water. If stirring is necessary, use a stick, never hands.

Make sure all the protective clothing specified on the label is available and is used. Soap and water for washing should be accessible as well. **If a pesticide spills or splashes onto the farmer during mixing, the next two minutes are critical.** Immediately remove clothing and wash affected areas thoroughly with soap and water.

Following the mixing process, close the containers securely and return them to storage. Wash all measuring and mixing containers and store. Wash all protective clothing, and store any that is not required for application.

Pesticide Storage

The success of pest management campaigns depends on pesticides being available in the areas that need treatment. Pesticides should be placed in a safe and secure storage area as close as possible to agricultural areas that are likely to need treatment. Pesticide stocks must be securely in place at the crop protection service's bases and in villages before the rainy season, when transportation often becomes much more difficult.

A good storage facility should have a fenced and covered area for the pesticides. (A thorn-branch fence will do if other materials are unavailable or too expensive.) The facility should:

- be secure against illegal entries, as well as children and livestock, and locked when not in use;
- be constructed in a site not exposed to flooding during rainy season;
- be isolated from dwellings, to avoid fire, leakage and water contamination;
- be supplied with water, to clean spills and fight fires;
- be well ventilated (aerated) to avoid concentration of toxic fumes;
- have a current inventory list of pesticide stocks;
- have protection gear such as suits, boots, gloves, goggles and breathing masks;
- have a first aid kit with antidotes; and
- be serviced by trained personnel familiar with measures to take in cases of poisoning.

The following considerations are also of vital importance:

- The pesticides must be kept dry; if they get wet, they lose their power to control pests. Therefore, the roof should be waterproof (zinc sheeting is good), and pesticides should be placed on a shelf or pallet—never directly on the floor or ground.
- Plants should not be allowed to grow around the storage area, because they will attract domestic animals to feed. Animals can be poisoned by eating plants that have been contaminated with pesticides.

A management system is needed to record the date each pesticide arrived at the facility, how long it stays in storage, and when it is removed for use. In addition, storage requirements for each pesticide must be posted and known by the management staff. Stored pesticides must be tested periodically to insure that the active ingredient is as described on the label and that the formulation concentration is correct. Also, disposing of unused and obsolete pesticides, and destroying their containers, must be part of the management system.

If no village storage facility is available, farmers may decide to keep pesticides on their farms for their own use. As far as possible, they should store pesticides in accordance with the principles described above. Place special stress on

keeping the pesticides covered and dry; well ventilated; secure from thieves, children and animals; and isolated from the rest of the farm, with no plants growing around the pesticide area. Smallholder farmers, in particular, are often unaware of these principles, which should be carefully explained to them. Larger-holder farmers may have this information already, and may have a safe building where pesticides are stored.

Safely Disposing of Containers

All empty pesticide containers must be destroyed and never reused.

- Clean the containers first (it is still unsafe to reuse them for any other purpose).
- Break glass containers; puncture or crush plastic ones.
- Bury the destroyed containers in an isolated area at least 50 cm underground.

Container Disposal

All empty pesticide containers must be destroyed and never reused. It is extremely dangerous to use them for anything else. Consult the pesticide label, the manufacturer, or the manufacturer's representative for specific recommendations regarding container cleanup and disposal. The following are general guidelines.

There are two basic methods for cleaning pesticide containers before disposal. Both require that the container be turned upside down and allowed to drain into the spray tank for at least 30 seconds, followed by adding water to the container and rotating it well to wet all surfaces, then draining it again into the spray tank as an additional dilutent.

- *Triple Rinse Method:* Add a measured amount of water or other specified dilutent so the container is one-fifth to one-fourth full. Rinse container thoroughly, pour into a tank, and allow to drain for 30 seconds. Repeat three times. The water rinsate (rinsewater) can be used to mix with or dilute more of the same pesticides, or it can be sprayed on the target crop.

- *Pesticide Neutralization Method:* Empty organophosphate and carbamate containers can be neutralized by washing with alkaline substances, though the wash water and rinsate are still dangerous. The following procedure is recommended for 200-liter barrels; use proportionally less material for smaller containers.

    1. Add 20 liters of water, 250 milliliters of detergent, and one kilogram of flake lye or sodium hydroxide.

    2. Close the barrel and rotate to wet all surfaces.

    3. Let stand for 15 minutes.

    4. Drain completely and rinse twice with water. The rinsate should be drained into a shallow pit in the ground located far away from wells, surface water or inhabited areas.

Containers cleaned by any of the above methods are still not safe to use for any other purpose. Glass containers should be broken; plastic or metal ones should

be punctured or crushed. Containers can then be buried in an isolated area at least 50 cm below ground surface.

Obsolete pesticides

As discussed above, obsolete pesticides are a major problem in most African countries. 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 are sold for use by unscrupulous or unknowing crop protection agents. Pesticides often degrade into chemical compounds even more dangerous and toxic than the original pesticide. Be aware of this and beware of allowing these old pesticides to be used in an IPM program. In fact, strongly discourage their use for any purpose.

Calibration, Product Quantity and Pesticide Application

Calibration of application equipment

Calibration of spray equipment is the process of adjusting the sprayer to deliver the correct amount of pesticide to manage the target pest, according to the rates recommended by the manufacturer. Pesticides are generally mixed with water, and the resulting mixture is applied using some type of sprayer. Water is used to dilute and "carry" the pesticide so the sprayer can deliver it to the plant or other target area. A sprayer *must* be properly equipped, maintained and calibrated for pesticides to be effective.

An adequately equipped, maintained and calibrated sprayer is essential for using pesticides effectively.

***Determining the application rate*:** Three factors determine the rate at which many sprayers deliver the spray mixture to a given area: (1) the size of the orifice (opening) in the nozzle tip through which the spray mixture passes, (2) the pressure used to force the spray mixture through the nozzle, and (3) the speed at which the sprayer travels over the area being sprayed.

Nozzle tips. The nozzle regulates the flow rate, breaking up (atomizing) the mixture into droplets and dispersing them in a specific pattern. Nozzles come in different types and orifice sizes. As orifice size increases, so does the amount of spray mixture that passes through it in a given period. It is important to check the sprayer's calibration before each application involving a different spraying situation. If the orifice becomes badly worn, the nozzle will deliver the wrong amount of pesticide. In this case, the nozzle tip should be replaced.

Cone nozzles are preferred for applying fungicide and insecticide sprays where penetration and complete coverage of the plant foliage is important. These produce small, lightweight droplets that drift readily, so spraying should be

done when the weather is calm. Cone nozzles are named for the spray pattern they produce, some producing a hollow cone, others a solid cone.

Ensuring that a sprayer is working properly helps reduce environmental damage from pesticides and can prevent dangerous accidents.

Pressure. The rate of spray application increases with the pressure. Gauges that measure the pressure created by the spray pump are available for many backpack sprayers, but few such sprayers actually have gauges. Pressure gauges are not as important for insecticide and fungicide application as they are for herbicide use.

Speed of movement. The time the user will need to spray a given area must be determined when calibrating a sprayer. For applying fungicides and insecticides to row crops, this is the time the user will take to spray the crop plants thoroughly for a predetermined length of a row. Usually it is recommended that crops be sprayed to the "wet to runoff" point, when the spray just begins to drip from the foliage. Alternatively, one could determine the time required to spray a certain area, for example, two hectares. This method is useful for crops planted broadcast (i.e., not planted in rows).

***Calibration*:** To calculate how much insecticide or fungicide material should be added to a given amount of water, one must first know how much water will be applied to a given area. Spray volume and pesticide rates are often expressed in terms of amounts required per hectare. In the following example, we will assume we are planning to use a chemical that is in liquid form. We will spray water over a small area to calibrate the sprayer and then convert this to liters per hectare.

To calibrate a sprayer *for crops planted in rows*:

1. Determine the space between rows (in cm) for the crop to be sprayed. Using this distance and Table 5, select the length of row to be used in calibrating the sprayer. For example, if the row spacing is 90 cm, use a row length of 11.1 m.

2. Select a section of a row with plants that best represent the average size of the crop to be sprayed. Then measure and mark off the distance obtained in Table 5.

3. Make sure the sprayer is clean and in good working order. Fill the sprayer with clean water only. Do not use any spray chemicals for the calibration test.

4. Using a watch, determine how long it takes to spray the plants in the section of row that you marked off, working at the same pace you would normally use when spraying a crop.

5. Next, while standing still in a convenient location, spray in the same way as before and for the same length of time, but now collect the

water by spraying it into a suitable container. Then measure the water collected to determine how many ml were sprayed. If a cup to measure ml is not available, you may substitute an empty cold drink (soft drink) can. Measure the amount to the nearest 1/4 can. *Note: For this step, do not use containers that will be used to prepare food, since small amounts of poisonous chemicals may remain in sprayers even after cleaning.*

6. If you measured the water you collected in ml, then the number of ml collected is equal to the number of liters per hectare. Example: If you collected 475 ml, the amount of the total spray you will need to apply (water plus chemical) is 475 liters/ha.

   If you used a cold drink can to measure the water collected, you can use Table 6 to determine the spray volume per hectare. Example: If about 1.5 cans were collected, we can see from Table 6 that the rate per hectare would be approximately 510 liters/ha.

To calibrate *crops not planted in rows*:

1. Select an area that best represents the average topography to be sprayed. Measure and mark a section 2 by 10 meters in size.

2. Follow step 3 above.

3. Determine the time (in seconds) it takes to spray the entire area (see step 4), and follow steps 5 and 6 above.

To calibrate without use of a watch:

1. Follow steps 1 through 3 in the appropriate section above. If the crop to be sprayed is planted in rows, follow section (a). If the crops are not in rows, use section (b).

2. With this method, have the sprayer full when starting so it can be refilled to the same level. Spray the plants in the section marked off, being careful to cover the plant surfaces well just until the spray begins to drip from the leaves.

3. Measure the amount of water you need to use to refill the sprayer to the same level as before.

4. If you measured the water in ml, then the number of ml collected is equal to the number of liters required per treated hectare. If you used a cold drink can to refill the sprayer, go to Table 6 to determine the spray volume per hectare. For examples, see step 6 above.

Table 5. Select Calibration Distance to Use Based on Row Spacing of Crop to Be Sprayed

Row spacing (cm)	Calibration distance (m)
40	25.0
60	16.7
90	11.1
150	6.7

Table 6. Determine Liters per Hectare to Apply Based on Number of Cold Drink Cans of Water Collected

Note: 1 can holds 12 fl. oz. = 355 ml

No. of cans collected	Volume/hectare (liters)
½	170
¾	255
1	340
1¼	425
1½	510
1¾	595
2	680
2¼	765
2½	850

Determining the Amount of Chemical to Use

Adding the correct amount of chemical to each sprayer full of water is as important as correctly calibrating the sprayer. Various extension publications for particular crops list recommended rates of chemical products that should be used to control important diseases and insects. These publications often give the amount of chemical to be added to 5 liters of water or to one spray tank. Some publications list the amount of material to be applied per hectare. In this case, additional calculation is needed to determine the amount to be added to one sprayer tank. Two methods of doing this are given below:

Adding the correct amount of chemical to each sprayer is as important as correctly calibrating the sprayer.

Method 1: To find out what fraction of a hectare can be covered by one tankful of spray, divide the capacity of the sprayer tank by the number of liters needed to cover a hectare, as calculated in step 6 (previous page).

Example: If the sprayer holds 15 liters and it takes 475 liters to cover a hectare, then: 15 liters @ 475 liters/ha = .032 ha per tank (that is, one tankful will cover .032 ha).

Then, find the recommended application rate per hectare for the fungicide or insecticide you are using. If you multiply this by the fraction of a hectare covered by one tankful, you will obtain the amount of chemical to add to one spray tank.

Example: If the recommended rate for the chemical is 2 kg per hectare and one tankful will cover .032 ha, then: 2 kg/ha X .032 ha/tank = .064 kg (or 64 g). In other words, you will add only 64 g of chemical to one sprayer full of water.

Method 2: Table 7 lists the amount of product to add to a 15-liter spray tank for various recommended rates per hectare of chemical product and for several calculated spray volumes. For spray volumes not listed in the table, use the one nearest to your calculated amount.

Table 7. Number of Tablespoons (1 level matchbox) of Chemical to Add to 15-Liter Spray Tank for Recommended Chemical Rates and Spray Volumes

Recommended chemical use (kg/ha and liters/ha)	**Recommended chemical rate for calibrated spray volume (liters/ha)**					
	250	300	400	500	600	700
Kg of powder/ha	**Number of tablespoons or level matchboxes of chemical to be added to a 15-liter spray tank**					
1	6	5	4	3	2.5	2
2	12	10	8	6	5	4
3	18	15	12	9	7.5	6
4	24	20	16	12	10	8
5	30	25	20	15	13	10
Liters of liquid/ha	**Number of tablespoons or level matchboxes of chemical to be added to a 15-liter spray tank**					
1	3	2.5	2	1.5	1	1
2	6	5	4	3	2.5	2
3	9	7.5	6	4.5	4	3
4	12	10	8	6	5	4
5	15	12.5	5	10	7.5	6

Example: Two kg per hectare of chemical are recommended, and in your calibration you have determined that your spray volume is 475 liters per hectare. Using Table 7, you find that 475 liters per hectare is not listed. Since 500 liters is the closest amount, you look under that column and find that to get 2 kg of chemical per hectare, 6 matchboxes (tablespoons) of the chemical should be added to each 15-liter spray tank.

Applying Pesticides: Important Cautions

Avoid applying pesticide spray or dust if you see leaves and small plants continually moving and fluttering in the wind (i.e., when the wind is moving at about 4 meters/second). If too much pesticide drifts away from the treatment area, there is a good chance the pests will not be managed well. In addition, the drifting pesticide can harm the environment in other areas: it can affect human settlements, pollute waterways, and contaminate adjacent crops that are close to being harvested.

Refrain from applying pesticides during the hottest part of the day. As a general rule, do not apply between 10 a.m. and 6 p.m. Avoid applying pesticides if you think it will rain within 12 hours, rain is likely to wash the pesticide away. This wastes the pesticide, and it may run off into bodies of water or other inappropriate places.

Disposing of unwanted pesticides, a potentially dangerous undertaking, is difficult to do safely. Avoid this problem by buying only the amount needed for a single season and mixing only the amount needed to treat the desired area.

Recommended protective clothing must be worn at all times. Do not eat, drink, or smoke or chew tobacco while applying pesticides; tobacco absorbs them. Do not carry tobacco, food or drinks with you while spraying. Keep out of any spray drift and keep all others away from the area. If the nozzle gets plugged, do not try to blow it out with your mouth; use a small brush or soft stick. ***If you or a co-worker show signs of pesticide poisoning, stop spraying immediately and begin first aid.***

After applying pesticides, wash all equipment and protective clothing and store them in a secure area. Wash face, hands and other exposed parts of the body with soap and plenty of water. Wash all contaminated clothing separately from other clothing. As always, do not contaminate streams, ponds or drinking water wells during cleanup. Fish are very susceptible to most pesticides (that is why you should never eat fish found dead).

Toxicity, Human Protection and First Aid

Toxicity is the inherent capacity of a substance to poison living beings. A pesticide's toxicity is measured by performing **oral** (mouth), **dermal** (skin) and **inhalation** studies on test animals. The term *hazard* refers to the risk or danger of intoxication (poisoning) when a toxic substance is used. Pesticides vary in their toxicity to humans and are grouped into three categories. The relative toxicity of a pesticide is noted on its label by a **signal word**, as shown in Table 8. Two more detailed labeling systems are shown in Tables 13 and 14 at the end of the chapter.

DON'Ts for Pesticide Safety

Do NOT:

- ✖ Buy more pesticide than you'll need for a single season.
- ✖ Mix more pesticide than you'll need to treat the desired area.
- ✖ Apply sprays or dusts when leaves and small plants are continually moving because of the wind (this means a wind speed of 4 m/second).
- ✖ Apply pesticides during the hottest part of the day.
- ✖ Apply pesticides if you think it will rain within 12 hours.
- ✖ Eat, drink, smoke, or chew tobacco while applying pesticide.
- ✖ Carry tobacco, food or drinks with you while spraying.
- ✖ Get into the path of any spray drift, or let others get in its path.
- ✖ Try to blow out a plugged nozzle with your mouth.
- ✖ Keep working if anyone shows signs of pesticide poisoning (start first aid immediately).
- ✖ Wash contaminated clothes with any other clothing.
- ✖ Let water from washing contaminated clothes or equipment get into streams, ponds or wells.

Table 8. Relative Pesticide Toxicities Noted by Signal Word on Pesticide Label
Source: U.S. Environmental Protection Agency

Signal word	**Toxicity**	**Lethal oral dose** (for a 70 kg person)*
Danger **	Highly toxic	A few drops to 1 teaspoon (5 ml)
Warning	Moderately toxic	1 teaspoon to 1 tablespoon (15 ml)
Caution	Low toxicity	1 ounce (28 g or ml) to more than1 pint (473 g or ml)

*Lethal doses are less for a child or a person weighing less than 70 kg.
**Skull and crossbones symbol included.

Time spent learning about safer procedures and how to use them is an investment in the health and safety of oneself, one's family, and others.

Farmers who use pesticides are being exposed to poison, and it is crucial to keep such exposure to an absolute minimum. The danger can be reduced by following proper safety procedures. Most pesticide poisonings result from carelessness or a lack of knowledge about the safer handling of pesticides. The time spent learning about safer procedures is an investment in the health and safety of oneself, one's family, and others.

Pesticides can enter the body through four major paths: the skin, the mouth, the nose, and the eyes. The checklist below will help users to avoid these various routes of overexposure to pesticides.

To avoid dermal (skin) exposure:

- Check the label for special instructions or warnings regarding dermal exposure.
- Use recommended protective clothing and other equipment as listed on the label.
- Do not reenter the treated area until the sprayed-on pesticide has dried or the *reentry interval* (waiting period) is past.

To avoid oral (mouth) exposure:

- Check the label for special instructions or warnings about oral exposure.
- Never eat, drink, or smoke or chew tobacco while working with any pesticide.

Basic First Aid for Pesticide Exposure

Get medical advice quickly; provide first aid to victims while medical help is on the way.

Follow the first aid instructions on the pesticide label. Take the pesticide can or label to the doctor or medical practitioner.

For poison on skin:

- Act quickly
- Remove contaminated clothing and drench skin with water
- Cleanse skin and hair thoroughly with detergent and water
- Dry victim and wrap in blanket

For chemical burns:

- Remove contaminated clothing
- Wash with large amounts of running water
- Cover burned area immediately with loose, clean soft cloth
- Do NOT apply ointments, greases, powders or other medications to burn

Poison in Eye:

- Wash eye quickly but gently
- Hold eyelid open and wash with gentle stream of clean running water for 15 minutes or more
- Do NOT use chemicals or medicines in the water; they may worsen the injury

Inhaled Poison:

- Carry victim to fresh air immediately
- Open all windows and doors
- Loosen tight clothing
- Apply artificial respiration if the victim is not breathing or victim's skin is gray or blue. If the victim is in an enclosed area, do not enter without proper protective clothing and equipment. If proper protection is not available, call for emergency equipment from your fire department.

Poison in mouth or swallowed:

- Rinse mouth with plenty of water.
- Give victim large amounts (up to 1 liter) of milk or water to drink.
- Induce vomiting only if the label instructs you to do so. See "Procedure for Inducing Vomiting" on p. 44 (sidebar).

- Wash thoroughly with soap and water before eating, drinking, smoking or chewing tobacco.
- Do not touch lips to contaminated objects (such as nozzles).
- Do not wipe mouth with contaminated hands or clothing.
- Do not expose food, beverages, drinking vessels or cigarettes to pesticides.
- Wear a face shield when handling concentrated pesticides.

To avoid respiratory (breathing) exposure:

- Read the label to find out if respiratory protection is required.
- If respiratory protection is required, use only an approved respiratory device.
- Stay upwind during application.

To avoid eye exposure:

- Read the label to find out if eye protection is required.
- If eye protection is required, use goggles to protect eyes or a face shield to protect eyes and face.
- Keep pesticide container below eye level when pouring.

Table 9 contains a list of recommended protective clothing and equipment based on a product's formulation and the signal word on its label. Table 10 defines different types of toxicity based on how long symptoms take to develop, and Tables 11–12 list symptoms for various types of pesticide poisoning.

Basic First Aid for Pesticide Overexposure

Get medical advice quickly if you or any of your fellow workers have unusual or unexplained symptoms during work or later the same day. Do not let yourself or anyone else get dangerously sick before calling a health care provider or going to a hospital. It is better to be too cautious than too late.

First aid is the initial effort to help a victim while medical help is on the way. If you are alone with the victim, make sure the victim is breathing and is not being exposed further to the poison before you call for emergency help. Apply artificial respiration if the victim is not breathing.

Read the first aid instructions on the pesticide label, if possible, and follow them. The information on page 43 may also be helpful. Do not expose yourself to poisoning while you are trying to help the victim. Take the pesticide container

Procedure for Inducing Vomiting

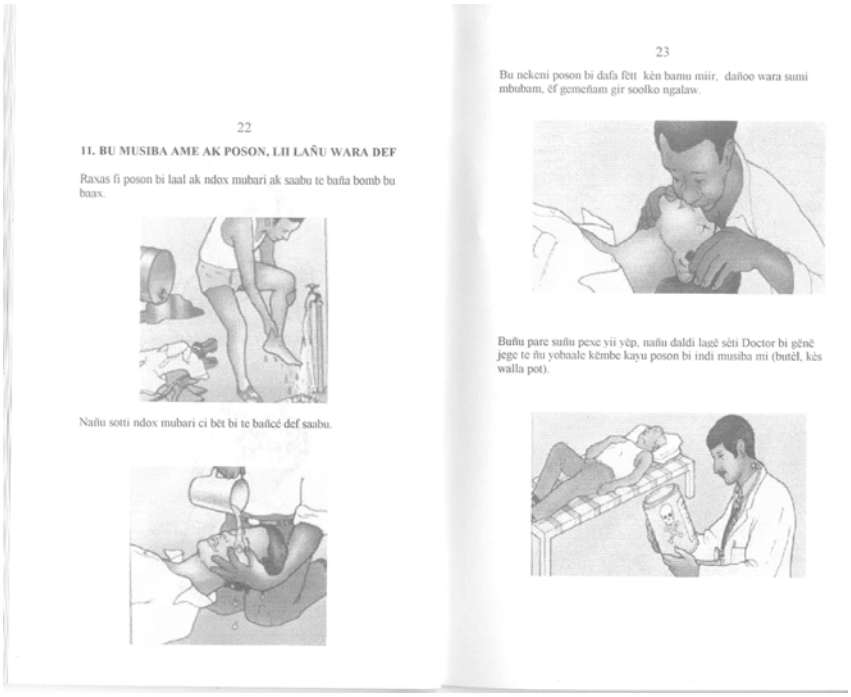
Induce vomiting *only* if the label instructs you to do so.

- Position the victim face down or kneeling forward; do not allow the victim to lie on his or her back, because vomit could enter the lungs and do additional damage.
- Put a finger or the blunt end of a spoon at the back of victim's throat or give syrup of ipecac.
- Collect some of the vomit for the physician if you do not know what the poison is.
- Do not use salt solutions to induce vomiting.

When *Not* to Induce Vomiting

- If the victim is unconscious or is having convulsions.
- If the victim has swallowed a corrosive poison—a strong acid or alkali. Such a poison will burn the throat and mouth as severely coming up as it did going down. It may also get into the lungs and burn them as well.
- If the victim has swallowed an emulsifiable concentrate or oil solution. These may cause severe damage to the lungs if inhaled during vomiting.

(or the label) to the physician. However, do not carry the pesticide container in the passenger space of a car or truck; put it in the trunk (boot), on the truck bed or up on the roof rack.



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11. BU MUSIBA AME AK POSON, LII LAÑU WARA DEF

Raxas fi poson bi laal ak ndox mubari ak saabu te baña bomb bu baax.

Nañu sotti ndox mubari ci bët bi te bañcé def saabu.

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Bu nekeni poson bi dafa fëtt kèn bamu miir, dañoo wara sumi mbubam, éf gemeñam gir soolko ngalaw.

Buñu pare suñu pexe yii yëp, nañu daldi lagë sèti Doctor bi gënë jege te ñu yobaale këmbe kayu poson bi indi musiba mi (butël, kès walla pot).

Get first aid to a victim of pesticide poisoning as fast as possible. Booklets, like this one used by USAID's AELGA program, can help farmers and workers respond quickly to an emergency.

Table 9. Protective Clothing and Equipment Guide

	Signal Words on Pesticide Label		
Formulations	**Caution**	**Warning**	**Danger**
Dry	Long-legged trousers and long-sleeved shirt; shoes and socks	Long-legged trousers and long-sleeved shirt; shoes and socks; wide-brimmed hat; gloves	Long-legged trousers and long-sleeved shirt; shoes and socks; wide-brimmed hat; gloves; cartridge or canister respirator if dust is in air or if precautionary statement on label says: "Poisonous *or fatal* if inhaled"
Liquid	Long-legged trousers and long-sleeved shirt; shoes and socks; wide-brimmed hat	Long-legged trousers and long-sleeved shirt; shoes and socks; wide-brimmed hat; rubber gloves. Goggles if required by label precautionary statement; cartridge or canister respirator if label's precautionary statement says: "Do not breathe vapors or spray mists" or "Poisonous if inhaled"	Long-legged trousers and long-sleeved shirt; rubber boots, wide-brimmed hat; rubber gloves, goggles or face shield. Canister respirator if label's precautionary statement says: "Do not breathe vapors or spray mists" or "Poisonous if inhaled"
Liquid (when mixing)	Long-legged trousers; long-sleeved shirt; shoes and socks; wide-brimmed hat; gloves; rubber apron	Long-legged trousers and long-sleeved shirt; shoes and socks; wide-brimmed hat; rubber gloves; goggles or face shield; rubber apron. Respirator if label's precautionary statement says: "Do not breathe vapors or spray mist" or "Poisonous [*or* fatal *or* harmful] if inhaled"	Long-legged trousers and long-sleeved shirt, rubber boots, wide-brimmed hat, rubber gloves, goggles or face shield. Canister respirator if label's precautionary statement says: "Do not breathe vapors or spray mists" or "Poisonous if inhaled"

Liquid (when mixing the most toxic concentrates)	Long-legged trousers; long-sleeved shirt; boots, rubber gloves, waterproof wide-brimmed hat	Water-repellent, long-legged trousers and long-sleeved shirt; rubber boots, rubber gloves, rubber apron; waterproof wide-brimmed hat; face shield; cartridge or canister respirator	Waterproof suit, rubber gloves, and waterproof hood or wide-brimmed hat.

Table 10. Types of Toxicity

Type	Number of Exposures	Time for Symptoms to Develop
Acute	Usually 1	Immediate (minutes to hours)
Subchronic	A few	2 days to 1 week
Chronic	More than a few	1 week to years
Delayed	1 or more	Long after exposure (often years later)

Table 11: Toxicity Categories with Common Symptoms

Category	System Affected	Common Symptoms
Respiratory	Nose, trachea (windpipe), lungs	Irritation, coughing, choking, tight chest
Gastrointestinal	Stomach, intestine	Nausea, vomiting, diarrhea
Renal	Kidney	Back pain, urinating more or less than usual, discolored urine
Neurological	Brain, spinal cord	Headache, dizziness, confusion, depression, coma, behavior change, convulsions
Hematological	Blood	Anemia (tiredness, weakness)

Dermatological	Skin, eyes	Rashes, itching, redness, swelling of skin (cutaneous swelling)
Reproductive	Ovaries, testes, fetus	Infertility, miscarriage, birth defects

Table 12. Symptoms of Acute Organophosphate Poisoning

Mild Poisoning	Moderate Poisoning	Severe Poisoning
Fatigue	Inability to walk	Unconsciousness
Headache	Weakness	Severe constriction of pupil
Dizziness	Chest discomfort	Muscle twitching
Blurred vision	Constriction of pupil	Secretions from mouth, eyes and nose
Too much sweating and salivation	Earlier symptoms are more severe	Breathing difficulty
Nausea and vomiting		Coma and death

Table 13. USEPA Toxicity Categories for Labels According to Hazard Indicator

Categories	Signal word	Oral Toxicity LD_{50}	Inhalation Toxicity* LD_{50}	Dermal Toxicity LD_{50}	Eye**	Skin
I	DANGER—POISON	Up to and incl. 50 mg/kg	Up to and incl. 0.2 mg/liter	Up to and incl. 200 mg/kg	Corrosion; corneal opacity not reversible within 7 days	Corrosion
II	WARNING	From 50 through 500 mg/kg	From 0.2 through 2 mg/liter	From 200 through 2,000 mg/kg	Corneal opacity reversible within 7 days; persisting for 7 days	Severe irritation at 72 hours
III	CAUTION	From 500 through 5,000 mg/kg	From 2 through 20 mg/liter	From 2,000 through 20,000 mg/kg	No corneal opacity; irritation reversible within 7 days	Moderate irritation at 72 hours
IV	CAUTION	Greater than 5,000 mg/kg	Greater than 20 mg/liter	Greater than 20,000 mg/kg	No irritation	Mild or slight irritation at 72

Categories	Signal word	Oral Toxicity LD_{50}	Inhalation Toxicity* LD_{50}	Dermal Toxicity LD_{50}	Eye**	Skin
						hrs

*Based on 1-hour exposure: divide by 4 to reflect four-hour exposure
**The duration of the eye observation period now routinely extends to 21 days.

Table 14. WHO Classification System According to Acute Toxicity

Class	Hazard Level	Oral Toxicity*		Dermal Toxicity*	
		Solids	***Liquids***	***Solids***	***Liquids***
Ia	Extremely Hazardous	5 or less	20 or less	10 or less	40 or less
Ib	Highly Hazardous	5–50	20–200	10–100	40–400
II	Moderately Hazardous	50–500	200–2,000	100–1,000	400–4,000
III	Slightly Hazardous	over 500	over 2,000	over 1,000	over 4,000

*Mg/kg body weight (based on LD_{50} for a rat)

**The terms “solids” and “liquids” refer to the physical state of the product or formulation being classified.

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Annex 1: Pesticide Use Checklist for PVOs and NGOs

The following checklist is intended to assist in identifying potential environmental problems with pesticide use. It will also help in guiding project management to ensure that pesticides are not used inappropriately. Since pesticide use is mainly an issue with agricultural projects involving trees or food production, livestock projects, and health projects (control of mosquitoes, schistosomiasis pathogens, tsetse fly, etc.), particular care should be taken with those sectors. The same caution should be used any time pesticides are used as part of project activities in any sector.

1. Check off all ways in which pesticides will be used:

	By Project Staff	*By Project Recipient*	*Others (Specify)*
Demonstration	_____	_____	_____
Research	_____	_____	_____
Training	_____	_____	_____
Vector control	_____	_____	_____
Others (list)	_____	_____	_____

2. Check the technical expertise of the people to be handling pesticides:

	Project Staff	*Project Recipient*	*Others (Specify)*
Well-trained	_____	_____	_____
Moderately trained	_____	_____	_____
Not trained	_____	_____	_____
Other (explain)	_____	_____	_____

3. Pesticides are needed to manage pests on (check one or more):

_____ Crops

_____ Livestock

_____ Others; please specify: _____

4. Can your staff identify the main pest organisms?

_____Yes _____No

5. Do you know which pesticides are needed?

_____Yes _____No

6. List pesticides needed, indicating each commodity (crop type, livestock type, tree, etc.) and specify pests (name of specific insects, diseases, weeds, storage pests, etc.) needing control, using the format shown below.

Commodity *Pest* *Pesticide Common Name* *Trade Name*

7. Pesticide Storage Facilities

a. Do you have a storage facility on the project site designated solely for pesticides?

_____Yes. Describe:

_____No

b. Is the storage shed well lit, well ventilated, and safe from flooding?

_____Yes _____No

c. Are pesticides kept away from food, feed and water?

_____Yes _____No

d. Are storage facilities secure and kept locked when not in use?

_____Yes _____No

e. Are all pesticides kept in their original, labeled containers?

_____Yes _____No

f. Are warning signs posted outside the storage sheds?

_____Yes _____No

g. Are pesticides stored away from flammable/combustible materials?

_____Yes _____No

h. Is there a well-established procedure for cleaning up spills?

_____Yes. Describe:

_____No

8. Safe Use of Pesticides

a. Do you have a place to mix the pesticides safely?

_____Yes. Describe:

_____No

b. Do you have protective clothing (e.g., rubber boots, coveralls, gloves, masks, eye protection)?

_____Yes. Describe:

_____No

c. Do you have measuring and mixing equipment?

_____Yes. Describe:

_____No

d. Do you have a supervisor in the project designated to oversee all pesticide operations?

_____Yes. Name:_____

Level of training: _____

_____No

e. Is your staff familiar with appropriate pesticide disposal procedures?

_____Yes _____No

f. Describe how you plan to dispose of pesticide containers:

Metal: _____

Glass: _____

Plastic: _____

Paper: _____

Cardboard: _____

g. Is your staff familiar with first aid procedures for pesticide poisoning?

_____Yes _____No

h. Are emergency procedures in place in case of accidental poisonings?

_____Yes. Briefly describe:

_____No

i. Are there procedures for observing restricted-entry intervals after applications?

_____Yes _____No

9. Application Equipment

a. Describe equipment you will use to apply the pesticide.

b. Is there a trained person on the project whose job is to maintain application equipment, including nozzles and sieves?

_____Yes _____No

c. Are spare parts available in local stores?

_____Yes _____No

10. General Pest Management Concerns

a. Have you identified pesticide-related risks in your project area and analyzed whether pesticide use is justified, is affordable, and can be managed and supervised adequately?

_____Yes _____No

_____N/A

b. Will your staff be training other people in pest management and pesticide use?

_____Yes (whom?)

_____No

c. Are available funds for necessary materials, training methods, and follow-up included in your project paper?

_____Yes. Estimated costs: _____

_____No

11. IPM approach

a. Is the project promoting adoption of preventive, nonchemical management measures?

_____Yes _____No

If yes, indicate which measure (crop rotation, biocontrol, use of resistant cultivars, crop diversification, no-till or reduced tillage, sanitation, manual weed destruction, etc.):_____

_____

b. Are pesticides being applied only as a last resort and based on action threshold criteria? Are pest monitoring procedures being used to determine the need for pesticide treatments?

_____Yes _____No

c. Can farmers and project extensionists readily distinguish pest from nonpest organisms? Can they recognize common beneficial species (pollinators, predators, parasitoids)?

_____Yes _____No

12. Environmental Impact

a. Are there wildlife sanctuaries, preserves or any other protected habitats in or near the project implementation area that might be affected by pesticide use?

_____Yes. Describe:

_____No

b. Are there water bodies (lakes, lagoons, reservoirs, rivers, streams, estuaries, etc.) near the project areas that might be subject to pesticide contamination through drift, runoff or spills?

_____Yes. Describe:

_____No

c. Are wildlife and domestic animals protected from poisoned baits?

_____Yes. Describe how:

_____No

13. Pesticide Monitoring

Is there a system in place for tracking pesticide use activities, including frequency of application, techniques, chemicals used, doses, target pests, effectiveness, criteria for applying, and safe use practices?

_____Yes

_____No

14. Literature Needs

Have you included needed literature on pesticide safety and IPM techniques and technologies in your activity?

_____Yes

_____No

15. Check off areas where additional assistance may be needed:

	Consultancy	*Training*
Pest identification	_____	_____
Pesticide selection	_____	_____
Handling pesticides (transport, mixing, loading, application, equipment cleanup, disposal)	_____	_____
Application equipment	_____	_____
IPM	_____	_____
Pesticide storage	_____	_____
Protective clothing	_____	_____
Measuring & mixing equipment	_____	_____
Training (designate activity)	_____	_____
Literature	_____	_____
Training materials	_____	_____
Other (specify)	_____	_____

Annex 2: Measurement Conversions

English to Metric

Multiply	By	To Get
Acres	0.405	Hectares
Feet	30.48	Centimeters
Feet	0.305	Meters
Inches	2.54	Centimeters
Ounces*	28.35	Grams
Pints	0.473	Liters
Pounds	453.592	Grams
Quarts	0.946	Liters
Tons**	907.185	Kilograms
Yards	0.914	Meters
Pounds per acre	1.121	Kilogram per hectare
Pounds per gallon	119.826	Grams per liter

* Ounces shown here are avoirdupois. Multiply troy ounces by 31.104 to get grams.
**Tons shown here are short tons. Multiply long tons by 1,016.047 to get kilograms. Multiply metric tons by 1,000 to get kilograms.

Metric to English

Multiply	By	To Get
Grams	0.035	Ounces (dry)
Hectares	2.47	Acres

Multiply	By	To Get
Kilograms	2.205	Pounds
Kilometers	3281	Feet
Kilometers	0.621	Miles
Liters	0.264	Gallons
Liters	2.113	Pints
Liters	1.057	Quarts
Meters	3.281	Feet
Meters	39.37	Inches
Meters	1.094	Yards
Kilograms per hectare	0.89	Pounds per acre

English

Multiply	By	To Get
Acres	43,560	Square feet
Acres	4,840	Square yards
Cups	8	Ounces (fluid)
Cups	16	Tablespoons
Feet	12	Inches
Feet	0.333	Yards
Gallons	128	Ounces (fluid)
Gallons	8	Pints

Multiply	By	To Get
Gallons	4	Quarts
Miles	5,280	Feet
Miles	1,760	Yards
Miles per hour	88	Feet per minute
Miles per hour	1.467	Feet per second
Miles per minute	88	Feet per second
Miles per minute	60	Miles per hour
Ounces (dry)	0.063	Pounds
Ounces (fluid)	0.063	Pints
Ounces (fluid)	0.031	Quarts
Pints	0.125	Gallons
Pints	0.5	Quarts
Pints	2	Cups
Pints	16	Ounces (fluid)
Pounds	16	Ounces (dry)
Quarts	2	Pints
Quarts	0.25	Gallons
Quarts	32	Ounces (fluid)
Quarts	2	Pints
Tablespoons	3	Teaspoons
Yards	3	Feet
Yards	36	Inches

Metric

Multiply	**By**	**To Get**
Grams	0.001	Kilograms
Grams	1,000	Milligrams
Kilograms	1,000	Grams
Meters	0.001	Kilometers
Meters	100	Centimeters
Meters	1,000	Millimeters
Square meters	0.0001	Hectares
Hectares	10,000	Square meters
Hectares	0.01	Square kilometers
Square kilometers	100	Hectares