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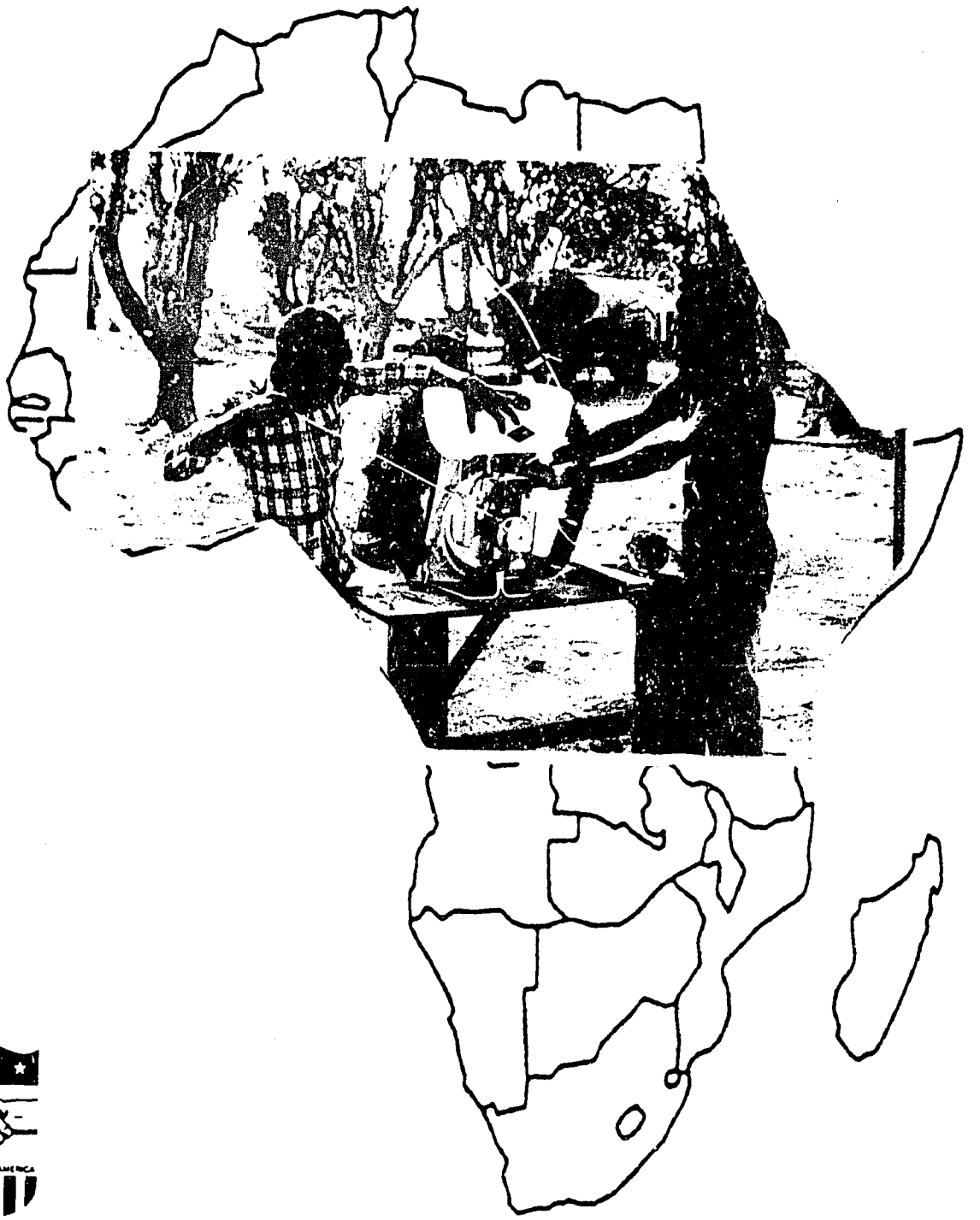
PESTICIDE USER'S GUIDE

A Handbook for African Extension Workers

by

William Overholt and Carl Castleton



African Emergency Locust/Grasshopper Project 698-0517
Africa Bureau Office of Technical Resources
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PREFACE

This guide has been developed as a practical reference for African agricultural extension workers as they strive to improve food production through the reduction of crop loss due to pests. The use of pesticides is expanding greatly in Africa. It is essential that pesticide use be limited to only those instances where it is appropriate and that all applications be done properly and safely.

This guide is **not** a substitute for practical, hands-on training. Agricultural extension workers who routinely handle pesticides should inquire about the availability of pesticide applicator's certification programs. The purpose of this guide is to serve as a convenient field reference. Workers are encouraged to carry it with them to the site of pest outbreaks and consult it as often as necessary to ensure that pesticides are being used properly.

We have attempted to write in a simple and practical manner so that the guide could be of use to the widest possible audience, ranging from government crop protection specialists to village-level extensionists. The reproduction of this guide by national services is not only authorized, it is encouraged. We realize that some of the content and illustrations may have to be redrafted to adapt to national training needs. If the guide is modified or reproduced locally, please send us a courtesy copy and note the number of copies reproduced and distributed. Your suggestions may be incorporated into future editions.

William Overholt
Carl Castleton
1989

INTRODUCTION

Since the time when man began cultivating crops for food, he has contended with organisms which cause damage to his agricultural crops. These organisms have been termed "pests." An agricultural pest can be more closely defined as any organism which enters into competition with man for agricultural crops. When a man plants a field of millet and this field is subsequently attacked by grasshoppers, the grasshoppers are pests in that they are competing with man for food. Agricultural pests are only one of several factors which can limit crop production. Among other factors which will not be considered in this manual are weather conditions and soil fertility.

Every year a significant portion of the potential food crop yield in Africa is lost to pests. These pests include species of insects, birds, rodents, diseases, nematodes, mites, millipedes, snails, and, in some cases, large mammals such as monkeys and elephants. It must be stressed that only a few species from each of these groups are considered pests. The greatest majority have little or no effect on crops or are actually beneficial to man. It is estimated that 90% of all known insect species are not economically important, about 7% are considered beneficial, and only 3% can be called pests. Some species are actually pests at certain times and beneficial at other times. For example, certain species of blister beetles found in Africa eat grasshopper eggs while they are larvae and therefore are beneficial to man since grasshoppers are usually considered pests. As adults, the same blister beetles are pests, because they feed on flowering millet and cowpea plants. Through this example, we can see that the definition of a pest is not always clear.

Considering the chronic shortage of food in Africa, it is essential that efforts be made to reduce losses to agricultural crops caused by pests. Numerous methods are available for reducing losses due to pests, including mechanical control, cultural control, legislative control, resistant varieties, biological control, and chemical control. Chemical control involves the use of toxic substances called pesticides. Because of the potential danger to man and the environment involved in using pesticides, they should only be used as a last resort when other methods are not available or are not feasible for economic or other reasons. Unfortunately, the use of pesticides is often the only practical method available to deal with a given pest problem.

Pesticides for the most part should be treated as dangerous and expensive substances. Because of this, great care must be taken in their utilization. The purpose of this manual is to help people who utilize pesticides for agricultural purposes do an effective and safe job.

Two food crops in Guinea-Bissau susceptible to pest problems are sorghum and cassava.

PEST SURVEY AND REPORTING

The first step in any crop protection control operation is survey. Survey means finding out what, if any, pests are attacking a crop; the density of the pest population; the amount of damage that the pest has caused; and an estimation of the potential for future damage. Only after finding and evaluating this information is it possible to make a rational decision on whether or not control efforts are warranted.

WHY IS SURVEY IMPORTANT?

Pest populations are dynamic. They can double in one day or decrease at a comparable rate. Weather conditions, the presence of natural enemies, and crop growth all affect the density of a pest population. In order to do an effective job of protecting a crop, we must constantly monitor the crop and the pest population. To do this, a well-organized periodic survey effort must be carried out. The method used to conduct a survey will vary depending on the crop, the pest, and the resources available for the operation.

For certain pests, it is difficult to directly estimate their density in a field. In those cases, a survey could be aimed at assessing the damage the pest has caused. An example of this would be grain-eating birds such as the Golden Sparrow (*Passer luteus*). It is not easy or practical in most cases to determine the population density of the birds in the field, but we could conduct a survey to assess the damage that the birds have caused. Another survey method could be to determine the number, location, and size of bird roosting sites in a given area. For this method, you would probably need a considerably greater resource base (vehicles and personnel).

Another example would be a pest like *Raghuva spp.*, the millet spike borer. It is difficult to detect the presence of *reghors* before they have already caused damage and by then it is too late to mount an effective control operation. One possible way would be to use light traps to detect the presence of female *Raghuva* moths before they have laid their eggs. With such a survey method, the implementation of control operations could begin when a certain number of female moths had been trapped during a set time period. For example, 3 moths in one day might mean you should treat in one week.

From the two examples discussed above, you can see that the methods used in survey can vary greatly depending upon the crop, the pest, and the resources available to conduct a survey.

Asking farmers about their crops is an important first step in effective survey (Mauritania)

Survey for cassava mealy bug (Guinea-Bissau)

Survey for sorghum pests (Mauritania)

WHAT SHOULD BE INCLUDED IN A GOOD SURVEY?

- The date and time of the survey.

- The site surveyed. This should be recorded as precisely as possible. Marking the location on a map is an excellent method. At a minimum, you should note the distance and direction from the nearest town or village.

- The type of vegetation growing in the area surveyed (millet, sorghum, cowpeas, pasture, etc.).

- The type of farming system (recession, rainfed, irrigation).

- The developmental stage of the crop (seedling, tillering, flowering, maturity).

- The names of the pests observed. The scientific name is always the best. Common names can vary from one region to another and therefore cause confusion. If the scientific name is not known, record the common name and collect specimens of the pest for later identification by experts. If you always do this, before long you will find that you know the scientific names of all the common pests.

- The developmental stage of the pest. For example, with grasshoppers you should always note whether the population was mostly early instar nymphs, later instar nymphs, adults, or a mixture of stages.

- The density of the pest and the method used to determine the density. For example, were the pests counted per plant, per square meter, or was another method used?

- Part of the plant damaged (roots, leaves, stem, grain).

- An estimation of the damage caused and the method used to assess damage (percentage of plants damaged or average percentage of damage/plant).

- An estimation of the area infested with the pest.

- Observations. This should include anything else you might think is important in determining whether or not to begin control operations.

  For example, you have surveyed a millet field and the surrounding pasture areas. You find very few grasshoppers in the millet field, but the surrounding area has a high population. This should be noted in your survey along with the developmental stage of the pasture and the millet.

  In Appendix II, you will find survey forms which could be used for use in grasshopper and locust surveys in African countries.

SURVEY METHODS

As was mentioned earlier, survey methods must be designed with a specific crop, pest, and resource base in mind. In designing a survey, it is important to decide in advance over what area the results of the survey will be applied, and to determine the characteristics of the area, so the survey areas chosen will be representative of the area as a whole. It should be stressed that samples taken during a survey must be chosen as randomly as possible. Many people have a tendency to take samples from the most heavily infested plants or parts of a field. This will give an exaggerated survey result which is much higher than the actual pest density. If this exaggerated estimate was used to determine whether or not to treat, pesticides might be applied where they are not actually needed. Be sure to take samples from the entire area being surveyed. Pest populations are often higher at the edges of a field than they are in the center. Take samples from both the edges and the center. It is also helpful, if resources allow, to have people work in teams, because people differ in their counts, and comparing the results from different observers may remove the effects of a single individual whose counts tends to be consistently higher or lower than others.

Below you will find descriptions of three methods commonly used to survey for grasshoppers in rangeland.

Method I

1. Begin at the edge of the area to be surveyed.

2. Determine a straight line which traverses the area through the center. This is the path you will follow.

3. Imagine an area of 1 m^2 approximately 5 meters in front of you and begin walking towards it.

4. As you are walking, count the number of grasshoppers which leave the 1 m^2 area.

5. When you arrive at the 1 m^2 area, count any grasshoppers which remain in the area.

6. Record the total number of grasshoppers that you observed in the 1 m^2 area on your survey form.

7. Imagine a second 1 m^2 area approximately 5 meters in front of you and repeat the counting process. Record the number.

8. Continue taking samples in the same fashion until you have traversed the area. If you have recorded 20 samples, then the survey has been completed. If not, walk back across the field following a different line and continue taking samples until you have a total of 20.

9. Add up the total number of grasshoppers observed in the 20 samples, divide that number by 20, and you will have the average number of grasshoppers per m^2 for the area surveyed.

Method II

1. Determine the area to be surveyed.

2. Slowly walk in a straight line for 10 meters counting all the grasshoppers in a one meter wide area directly in front of you (including those that jump out but not those that jump into the area).

3. The total number of grasshoppers you have counted is the number of individuals in 10 m^2.

4. Divide this number by 10 to arrive at the density/m^2.

5. Repeat this procedure in several different locations in the area and take the average of these estimates.

Method III

1. Estimate the average distance in centimeters between individuals at one location in the area to be surveyed.

2. Divide this number into 100 and square the result.

   Example: average distance between individuals = 20 cm

   100/20 = 5 5 x 5 = 25

   Therefore there are approximately 25/m^2

3. Repeat this procedure at several locations in the area and take an average to aim at an estimate of the density.

REPORTING SURVEY RESULTS

After completing a survey and filling out a survey form, what do you do with the information?

The answer to this question depends upon the situation. If you are the leader of a crop protection team which has the means necessary to intervene against crop pests, then from the results of the survey, you have to decide whether or not to treat. Regardless, you should always keep your superiors informed of the results of your surveys so that they can direct control operations on a national scale.

If you are an extension agent who does not have the equipment or personnel necessary to intervene against pests, the results of your survey must be transmitted to the people who have the means to intervene.

Written communication is usually slow. If you were to send your survey form by post to the capital city and wait for the Crop Protection Service (or some other agency) to send a team to begin control operations, it would probably be too late to do any good by the time they arrived. Pests will not wait until intervention means are mobilized before causing further damage to crops.

You must use the quickest method available to communicate the message. Many extension agencies and crop protection services in Africa are equipped with Single Sideband 2-way radios; others rely on telephone systems. Whichever method you use to transmit survey results, you must be sure to include all pertinent information in your messages. If you neglect to do so, the people receiving the message will not know whether or not to send assistance.

For example, if you send a message to the Crop Protection Service which states "SITUATION URGENT STOP 15 GRASSHOPPERS/M^2 STOP SEND HELP STOP," the Crop Protection Service will not have sufficient information to accurately assess the situation. Are the grasshoppers in cultivated fields or pasture? Has there been any damage to crops? What is the surface area infested, one hectare or 1,000 hectares? The Crop Protection Service would have a hard time justifying action on the basis of the above message. They would have to request additional information or send an agent to assess the situation. This could delay eventual assistance and result in a higher level of crop loss than was necessary.

BE CLEAR, CONCISE, AND INCLUDE ALL PERTINENT INFORMATION WHEN REPORTING SURVEY RESULTS.

A checklist which will help you decide what information should be included in messages is found in the previous section of this manual titled "What Should Be Included in a Good Survey?"

Although sending the actual survey form by mail to the Crop Protection Service headquarters is usually too slow to expect action in time to mobilize intervention efforts, survey forms should, nevertheless, be sent to headquarters and kept on file.

At the end of the growing season all the survey forms for that year can be analyzed to determine what locations experienced the most serious pest outbreaks and at what period the outbreaks occurred. This information can be extremely useful in deciding where and when to mobilize equipment, pesticides, and personnel in future years. The more years of survey data that you have in a data base, the greater the reliability of your analysis.

For example, from analyzing survey forms from the past three years, you may be able to determine that the grasshopper, *Oedaleus senegalensis*, was first observed in significant numbers in three locations of your country at approximately the same time. This information could be extremely valuable in deciding when and where to mobilize intervention efforts in coming years. The three areas could also be analyzed to determine what characteristics they have in common (soil type, vegetation, rainfall). If the three areas prove to have common characteristics, you might want to determine whether there are other areas of the country with similar characteristics. If so, these areas might also have a high potential for outbreaks of *Oedaleus senegalensis*.

END OF SEASON SURVEY FOR GRASSHOPPERS

At the end of the rainy season certain grasshopper species, such as *Oedaleus senegalensis*, lay eggs which will remain in the soil until the next rainy season. The major areas where the eggs are laid may not be the same each year. For this reason, it is very useful to map out the major areas of

oviposition at the end of each rainy season. These are the areas where the first grasshoppers will appear when the rains commence the following year. If the areas are known to the Crop Protection Service, they can take steps to properly organize an early control effort by distributing pesticide and mobilizing farmers.

Additionally, egg-pod surveys can be documented in these areas to determine the amount of natural mortality that occurs during the dry season. For example, egg pods could be collected and dissected once a month and the number of live and dead eggs can be counted to estimate the proportion of the population surviving the dry season.

TO TREAT OR NOT TO TREAT?

The decision of whether or not control measures are necessary can be very complicated. Presently, the decision is often more subjective than objective. This is due to the lack of concrete research results telling us when it is necessary to treat and when it is not. We have to make the decisions as best we can with the information currently available.

When making pest control decisions, it is important to remember that pests will cause a certain amount of damage regardless of what we do. What we have to decide is how much damage is acceptable. This should be the basis of all decisions on whether or not to apply pesticides.

To determine the level of acceptable damage, we usually turn to economics. If it will cost more to treat a crop than the value of crop that would be lost if we did not treat, we would incur a net loss. In this case, we are losing more than we are saving, and it would not make sense to treat.

COST OF TREATMENT - time - pesticide - gasoline - personnel	>	VALUE OF CROP THAT WILL BE LOST TO PESTS IF NO TREATMENT IS MADE

On the other hand, if the cost of treatment is expected to be less than the monetary value of the crop we could save if we do treat, it would make sense to treat.

COST OF TREATMENT	<	VALUE OF CROP WE EXPECT TO SAVE IF WE TREAT	=	TREAT

The point at which the cost of treatment equals the value of the crop saved is called the "**economic threshold.**" Economic thresholds are usually expressed in densities of pest populations or estimations of damage caused. Some examples of economic threshold calculations are in the Appendix.

Thresholds must be set in relation to the growth stage of the crop. For example, the threshold for grasshoppers in a millet field at the seedling stage might be 5 grasshoppers/m^2. When the crop reaches the flowering stage, the plants can tolerate more grasshoppers and, therefore, the threshold might increase to 10 grasshoppers/m^2. In general, the two growth stages least tolerant to pest damage are the young seedling stage and initial grain formation after flowering.

The idea of economic thresholds in Africa is somewhat complicated because in many cases the farmer does not pay for pesticide treatments or for pesticides. It is often a free service provided by the government. This is especially true for staple crops. In cases such as these, it is the government which must decide what the acceptable levels of damage are, based on the amount of money it must spend to replace the food lost to pests, versus the amount of money it would need to spend to control the pests. However, these levels are not always based solely on economics and, therefore, we can call these levels "**intervention thresholds.**" The intervention threshold is the level at which control actions should be taken.

Even though further research is necessary to arrive at refined, scientifically based intervention thresholds, crop protection services, which have several years experience, should begin to set preliminary thresholds for the major pests on food crops. The more experience a person has working in crop protection, the better he will be able to answer the question "To treat or not to treat?"

PLANNING A PESTICIDE APPLICATION

After deciding that a field needs to be treated with pesticide, you must decide what kind of pesticide and equipment to use, and how much pesticide is needed for effective control. The various factors which you should consider in order to make these decisions are discussed in this chapter.

CHOOSING A PESTICIDE

Types of Pesticides

Thousands of pesticides have been developed over the years. In order to better understand these substances, man has classified pesticides into many different groups using various criteria. These include classification by target pest group, by chemical group, by formulation, and by toxicity.

1. **Target pest group classification.** This is by far the easiest classification method to understand. Pesticides are divided into categories depending on what organisms they are designed to control. Below is a list indicating the target pest group and the name of the corresponding pesticide group:

Target Pest	Name of Pesticide Group
Insects	Insecticides
Nematodes	Nematocides
Fungi	Fungicides
Weeds	Herbicides
Birds	Avicides
Mites	Miticides
Rodents	Rodenticides
Snails	Molluscicides

Some pesticides belong to more than one category because they control more than one category of pests. An example of this would be the pesticide Carbofuran which is both an insecticide and a nematocide.

2. **Chemical group classification.** This is probably a less important classification method to the agricultural extension worker. It suffices to say that most pesticides can be divided into two main categories: inorganic and organic. The organic, which are by far the most commonly used, can be further broken down into 4 major groups. These are the chlorinated hydrocarbons, the organophosphates, the carbamates, and the synthetic pyrethroids. Additionally, there is a new group of chemicals which are called "insect growth regulators." Many other chemical groups exist, but it is not necessary to know all the names.

Inorganic pesticides:

These are pesticides that are derived from mineral ores and contain no carbon. Most of the compounds in this category are heavy metals. Compounds derived from copper, arsenic, mercury, lead, and sulphur are included in this group. This is the oldest group of pesticides and many of them are **very toxic** and **very persistent.**

Organic pesticides:

Chlorinated hydrocarbons (also referred to as organochlorines). Most pesticides in this group are very persistent in the environment, are not readily metabolized by most living organisms, and are fat soluble. This means that they can build up in the bodies of animals after repeated exposures. Because of these properties, they have caused serious environmental problems and their use is being phased out in most African countries. Developed countries have prohibited the use of most chlorinated hydrocarbons for agricultural purposes, including grasshopper control, for a number of years. Examples of chlorinated hydrocarbons still used in some African countries include BHC, DDT, and Dieldrin.

Organophosphates. These pesticides vary from highly toxic to relatively nontoxic. They are not persistent, lasting less than one month before breaking down into nontoxic substances. Examples of organophosphate pesticides used in Africa include Malathion, Fenitrothion, and Diazinon.

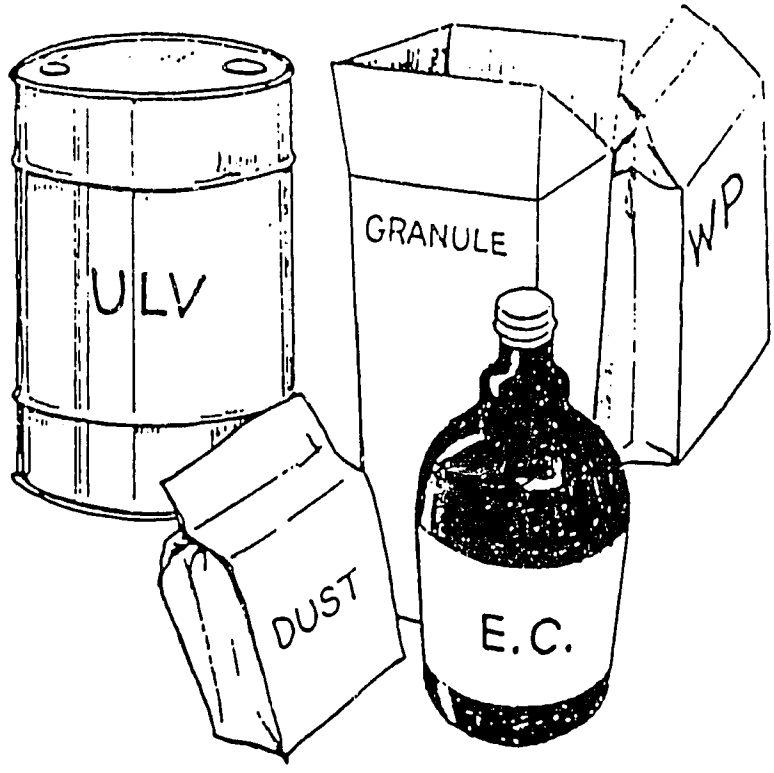
Carbamates. These pesticides have properties similar to the organophosphates. They tend to break down rapidly in the environment. The toxicity of carbamate pesticides varies from highly toxic to relatively nontoxic. Examples of some of the less toxic carbamates used in Africa are Carbaryl and Propoxur.

Synthetic pyrethroids. This is one of the newest categories of pesticides and their use is increasing in popularity. They are chemicals synthesized by man to resemble a naturally occurring substance called pyrethrum, which is found in plants of the genus Chrysanthemum.

Synthetic pyrethroids are toxic to many insects, but generally have low toxicity to mammals. Some synthetic pyrethroids are quite toxic to fish and should not be used around aquatic areas. Usually much smaller doses are used than with the other pesticide groups. Examples of synthetic pyrethroids used in Africa are Deltamethrin (Decis), and Lambdacyhalothrin (karate).

Insect growth regulators. This is also a fairly new group of insecticides which have been recently tested for use against grasshoppers in Africa. These compounds interrupt the normal growth patterns of insects. Some mimic a hormone found in all insects which is essential for growth and development. Others inhibit the production of chitin which is a major component in the exoskeleton of insects and other arthropods. The major advantage of insect growth regulators is their specificity to arthropods and low toxicity to man and other nontarget organisms. Examples of insect growth regulators which are being tested against grasshoppers are Diflubenzuron and Teflubenzuron.

Formulations



Pesticides are very rarely used in their pure form as originally manufactured. They are almost always altered in some way to facilitate their application and improve their effectiveness. The pesticide product which is sold in the market is called a "**pesticide formulation.**"

A formulation is made up of the active ingredient and one or more inert ingredients. The active ingredient is the chemical which is poisonous. The term "active ingredient" is commonly abbreviated "a.i." The inert ingredients in a pesticide formulation are not usually poisonous, but nevertheless have a specific purpose. Inert ingredients are added to dilute, emulsify, or increase the sticking ability of the active ingredient. It may also improve the dispersion of the active ingredient over the target area.

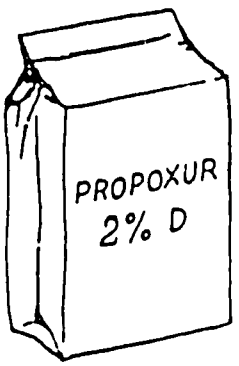
PESTICIDE FORMULATION

- **Active Ingredient**
- **Inert Ingredients**
  - Diluents
  - Solvents
  - Emulsifiers
  - Sticking agents
  - Dispersing agents

CHOOSING A PESTICIDE FORMULATION

Descriptions of Formulations

The most common types of formulation used in Africa for agricultural purposes are dusts, granules, wettable powders, baits, emulsifiable concentrates, oil solutions, and ultra low volume (ULV). The first four are sold as dry formulations and the last three are liquid formulations.



DUSTS

Abbreviation: D

Dusts are an active ingredient combined with an inert powder such as clay, talc, or volcanic ash. The percentage of active ingredient in the mixture is usually between 0.1% and 10%.

Advantages

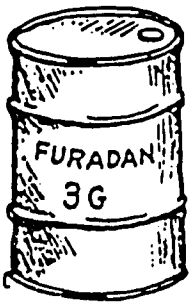
- Ready to use as purchased; no mixing is necessary.
- Simple to apply.
- Safer to use than most liquid formulations.

Disadvantages

- The particles are very small and, because of this, can drift long distances from the target site.
- They do not stick well to plant surfaces and are readily removed by wind and rain.
- They do not allow good coverage of the undersides of leaves, and thus are not effective against many sucking bugs.
- Dusts are bulky and therefore expensive to transport.
- They can cause intoxication through inhalation of the dust particles and irritation to the eyes.

An example of a dust formulation widely used in Africa is Propoxur 2% dust used in grasshopper control operations.

GRANULES



Abbreviation: G

Granular formulations are much like dusts except the particle size is much larger. Particles in a granular formulation are approximately the same size as granulated sugar. Granules are produced by mixing or coating granules of sand, clay, carbon, or other inert substances with the active ingredient. Granular formulations are usually applied directly to the soil or to water in irrigated perimeters.

Some granular formulations are **systemic**, meaning that the pesticide is transported through the vascular system of plants. Systemic granular pesticides can be applied to the soil for the control of pests attacking the stem or foliage of plants.

Advantages

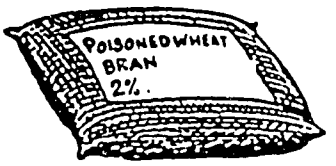
- They are ready to use as purchased, no mixing is necessary.
- They are simple to apply.
- There is little drift from the target area.
- Most are relatively safe to handle, if the formulation is not classified as "Extremely hazardous" or "Highly hazardous" (Ia or Ib) by WHO (see chart on p. 27).

Disadvantages

- They are bulky and therefore expensive to transport.
- They have a limited spectrum of use.

An example of a granular formulation commonly used in Africa is Diazinon 10G. The 10 means it has 10% active ingredient by weight. The G means that it is a granular formulation. This formulation is commonly used to control stemborers in rice and millet.

BAITS



Abbreviation: None.

A bait is a mixture of a pesticide with a food substance that will attract and be eaten by the target pest.

Advantages

- They are ready to use as formulated.
- Easy to apply especially for the small farmer.
- In general, they have less impact on nontarget organisms than other formulations.
- Are relatively safe to use for the applicator.
- There is little or no drift from the target area.

Disadvantages

- They are bulky and therefore expensive to transport.
- Can cause problems in storage as they sometimes resemble animal feed.
- Have a limited spectrum of use.

WETTABLE POWDERS

Abbreviation: WP

Wettable powders are very similar in appearance to dusts, but should never be confused. They are meant to be mixed with water before application. Wettable powders have a higher concentration of active ingredient than dusts. They are prepared by diluting the active ingredient with a material such as clay. A wetting agent, which is an additive that helps the pesticide to spread out and coat the target surface, is added to this mixture.

Advantages

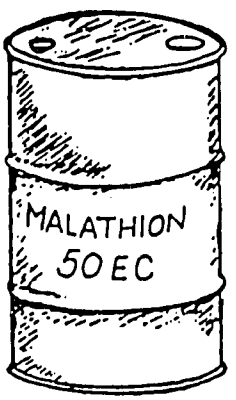
- Due to the high concentration of active ingredient, they are less expensive per application than dusts, baits, and granules.
- They are reasonably safe to use as they are not readily absorbed by the skin.
- They stick to plants better than dusts.

Disadvantages

- They must be mixed with water; **they cannot be used as purchased.**
- There is a risk of intoxication by inhalation of the fine particles, especially during mixing operations.
- In storage they must be well protected from moisture.
- In order to use them you must have some type of spray application equipment.
- They must be agitated after being mixed with water or the powder will settle out.

An example of a wettable powder used in Africa is Carbaryl (Sevin) 75 WP.

EMULSIFIABLE CONCENTRATES



Abbreviation: EC

Emulsifiable concentrates are liquid formulations which consist of the active ingredient, a solvent, and an emulsifying agent. Emulsifiable concentrates are meant to be mixed with water before application. This characteristic makes it possible to determine if an unknown liquid formulation is an EC or some other formulations, such as an ULV or an oil solution. When ULV or oil solutions are mixed with water, the mixture quickly separates into two layers: the water and the pesticide. However, when ECs are mixed with water, they form a white, milky solution which does not separate. The solvent, a petroleum-based substance, evaporates soon after application, leaving the active ingredient on the target. The concentration of active ingredient is similar to that of wettable powders.

Advantages

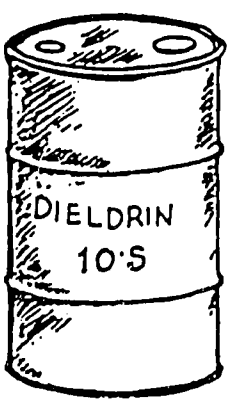
- Are usually less expensive per application than dusts, granules, and baits because of the higher concentration of active ingredient.
- Are versatile; they can be used in many different situations.

Disadvantages

- They are more dangerous to manipulate than dry formulations due to the high concentration of active ingredient, and the fact that they are more easily absorbed through the skin.
- They must be mixed with water before applying; can be used only in areas where adequate quantities of water are available.
- You must have some type of spray application equipment to use.
- They tend to be corrosive to metals and, therefore, can cause damage to the metal parts in a sprayer.
- When stored for a long period of time or incorrectly, they lose their "emulsifiability," that is, they no longer mix with water.

An example of an emulsifiable concentrate commonly used in Africa is Malathion EC.

OIL SOLUTIONS



Abbreviations: S

Oil solutions consist of an active ingredient dissolved in an organic solvent such as kerosene. Oil solutions usually have lower concentrations of active ingredient than emulsifiable concentrates. The use of oil solutions is less common than the other formulations, because the solvents can cause damage to plants. When a pesticide causes damage to a plant it is called a "**phytotoxic effect.**" As discussed under "Emulsifiable Concentrates," oil solutions can be distinguished from ECs in that oil solutions are **not** soluble in water.

Advantages

- They are used as is; no mixing is necessary.
- They are effective, because the solvents used are absorbed rapidly through the skin of the pests.

Disadvantages

- As mentioned earlier, oil solutions have a tendency to be phytotoxic.
- They are rapidly absorbed through the skin, and, therefore, there is a risk of dermal intoxication to the pesticide user.

ULV

Abbreviation: ULV is the abbreviation for **Ultra Low Volume.** This formulation is commonly referred to by its abbreviation. ULV formulations are typically applied at less than 2 liters/ha.

ULV formulations are very much like oil solutions except that the concentration of active ingredient is **much** higher. ULV formulations are usually between 50-100% active ingredient. An exception to this is ULV formulations of synthetic pyrethroid insecticides. These products are so toxic to insects that the dosages required are extremely low, and therefore the percentage of active ingredient in the formulation is low (less than 5%). Because of the high concentration of active ingredient in ULV formulations, the dosages used per hectare are very low. To achieve these low dosages, special equipment is required, which applies a very fine spray of very small droplets. Most ULV formulations are not meant to be diluted before use. They are applied as very fine sprays. As discussed under "Emulsifiable Concentrates," ULV formulations can be distinguished from ECs in that ULVs are not normally soluble in water.

Advantages

- They are to be used as is with no mixing.
- They are usually very effective, because the fine spray penetrates well into crop foliage.
- In general, the lowest-cost formulation due to the high concentration of active ingredient.

Disadvantages

- They are the most dangerous of the pesticide formulations due to the high concentration of active ingredient, and the fact that they are absorbed very quickly through the skin.

- You need a special type of sprayer that applies a very small amount of pesticide per surface area. Dosages are usually less than 2 liters/hectare.

- There is a risk of phytotoxicity, if the recommended dosage is surpassed.

An example of a ULV formulation widely used in Africa is Fenitrothion ULV 100%. This pesticide is commonly used by crop protection services in large-scale grasshopper control operations.

The following chart outlines the characteristics of different types of formulations. It includes certain formulations which are not discussed in this chapter because they are not commonly used in Africa for agricultural purposes.

Characteristics of Different Types of Formulations

FORMULATION	DEFINITIONS	CHARACTERISTICS
DUSTS (D)	Fine, dry powder containing active ingredient. Use as formulated.	Drift problem. Respiratory risk.
GRANULES (G)	Coarse particles with active ingredient inside or coating outside. Use as formulated.	No drift problem. Relatively safe to apply (depending on toxicity of formulation). Limited use.
BAITS	Pesticide mixed with food attractant. Use as formulated.	Less effect on non-target organisms than other formulations. Low content of active ingredient.
WETTABLE POWDERS (WP)	Dry active ingredient with wetting agents. Must be mixed with water, forms suspension.	Problem with separation from water, must be agitated. Respiratory risk during mixing.
EMULSIFIABLE CONCENTRATES (EC)	Active ingredient dissolved in liquid and mixed with emulsifier. Must be mixed with water before use.	Can be used in many situations. Tendency to lose emulsifiability if stored too long.
OIL SOLUTIONS (S)	An active ingredient that is dissolved completely in an organic solvent. Use as formulated.	Spread and stick well. Problem with phytotoxicity.
ULTRA LOW VOLUME (ULV)	An active ingredient that is dissolved completely in an organic solvent. Usually a very high percentage of active ingredient. Use as formulated.	Most dangerous formulation for applicator. Risk of phytotoxicity.
SOLUBLE POWDERS (SP)	Dry active ingredient. Mixed with water to form a solution.	Similar to WPs but no agitation is needed.

Characteristics of Different Types of Formulations (continued)

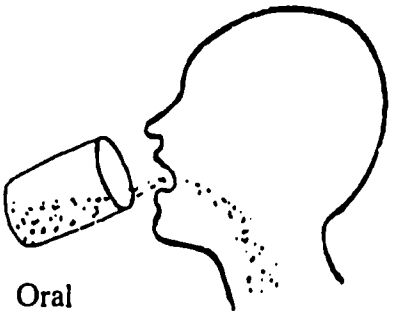
FORMULATION	DEFINITIONS	CHARACTERISTICS
FLOWABLES (F) or (L)	Finely ground solid active ingredient which is suspended in liquid. Must be mixed with water.	Similar in use to ECs. Slight agitation needed.
AEROSOLS (A)	Small amount of pesticide(s) in chemically inert gas under pressure contained in a can.	For small areas. Expensive. Risk of puncture or explosion if overheated.
LIQUIFIED GAS FUMIGANTS	Poisonous gases that kill when absorbed or inhaled. Stored under pressure.	Limited use. Agricultural uses include soil fumigation and fumigation of stored products. Are usually extremely dangerous, and **should not** be used by small farmers.
DRY FUMIGANTS	Aluminum phosphide compressed in small tablets with ammonium carbonate. When in contact with moisture, toxic gas is released.	Safer to use than liquified gas fumigants. Used in fumigation of stored products. Must be stored in airtight containers. Should be used only by people who have been thoroughly trained in the technique.

Toxicity to Man

Pesticides are designed to control pests by killing them. Most pesticides are not only toxic to the pests that they are meant to control, but also to other organisms, including man. Some pesticides are extremely poisonous to man while others are fairly safe, if properly handled. A system has been developed to measure the relative toxicity of various pesticides. Before using any pesticide, you should be aware of its toxicity rating. The toxicity rating will help you decide what precautionary measures are necessary when working with that pesticide.

Routes of entry into man's body

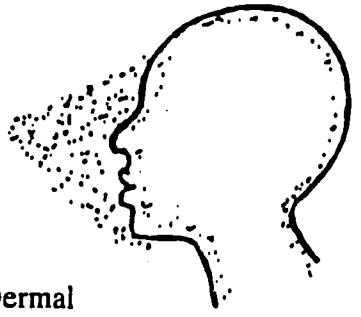
Pesticides can enter your body in three ways: through your mouth, through your skin, and through your lungs. You can be poisoned no matter which way they enter your body.



Oral

Oral

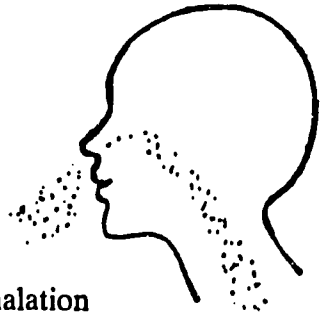
Pesticides can enter your body through your mouth. This can happen by eating contaminated food, by smoking or eating while working with pesticides, or by mistakenly eating or drinking a pesticide that has been incorrectly stored in a used food container. Once a pesticide is in your stomach, it is absorbed rapidly into your body.



Dermal

Dermal

Absorption through the skin is probably the most common way pesticides enter the bodies of people who work with pesticides. Pesticides which are in contact with the skin can be absorbed directly into the body through the skin. Some pesticides are absorbed rapidly while others do not pass quickly through the skin. Care must be taken to avoid pesticide contact with the skin by wearing the proper protective clothing.



Inhalation

Inhalation

Pesticides can also enter your body when you breath. Dust, fine sprays, and gases can be sucked into your lungs while working with pesticides. Most pesticides are absorbed very rapidly through the lining of the lungs. Care must be taken to avoid inhaling any amount of pesticide. When recommended, always wear a protective mask.

Which route of entry is the most common?

The most common route of exposure is through the skin (dermal). This exposure can be quite high, especially during mixing and filling when concentrated pesticides are involved. Leaking backpack sprayers can also cause excessive dermal exposure.

If care is taken to thoroughly wash your hands before eating, drinking, or smoking, oral exposure will be minimal. However, if this precaution is not followed, the exposure level from this route can be high. Inhalation exposure is not an important factor if the worker takes care to stand upwind from the application device in order to minimize exposure to dusts or mists. This precaution is not enough for the more toxic pesticides. Face masks should **always** be worn when highly toxic pesticides are applied.

Acute and chronic toxicity

The toxicity of pesticides is divided into two categories depending on the amount of time an organism is exposed to the pesticide. These are called "acute" and "chronic" toxicity.

> **Acute toxicity**: This refers to how poisonous a pesticide is after a single exposure. When comparing the toxicity of two pesticides, the acute toxicity is usually the one referred to. Acute toxicity may be measured as acute oral, acute dermal, or acute inhalation toxicity. Acute toxicities are measured with a value called to LD50. This is explained later in this section.
>
> **Chronic toxicity**: Chronic toxicity is how poisonous a pesticide is after many small repeated exposures. Chronic toxicity is very important because certain pesticides can remain and build up in the body over a long period of time. With pesticides that build up in your body, you can be poisoned without receiving an acutely poisonous dose, if you have been exposed to this pesticide many times.

Farmers and pesticide applicators in Africa often think that the dangers of pesticides are exaggerated. They say, "I've been using pesticides for years, and I'm not dead yet." They may think that safety precautions are unnecessary. What they may not understand is that pesticides also have **chronic** toxicity, toxicity which is cumulative and takes a long time to produce any symptoms. Even if a pesticide does not make you sick while you are using it, repeated exposure to the pesticide might make you sick after several years, might cause cancer, and may even cause birth defects in the children that you will have in the future.

There is no standard measure of chronic toxicity as there is for acute toxicity. An example of a chronic toxicity measurement might be "rats were exposed to Pesticide A at a rate of 8 milligrams per day for one year. The rats showed no adverse effects after six months, but after one year they showed symptoms of nerve damage."

For many pesticides, an "acceptable daily intake" (a maximum permissible daily exposure over a lifetime) has been established by the FAO/WHO. This is expressed as the maximum permitted daily exposure in milligrams of pesticide per kilogram of body weight. These "ADIs" are established by the Joint FAO/WHO Meeting on Pesticide Residues (JMPR) and are very useful in determining the relative safety of various patterns of pesticide use.

How is the acute toxicity of pesticides measured?

With values that we call the lethal dose 50 and the lethal concentration 50. These are abbreviated LD50 and LC50.

What do acute LD50 and LC50 values mean?

The acute LD50 is the quantity of the active ingredient of a solid or liquid pesticide given in a single exposure that is necessary to kill 50% of a population of test animals in a specified time,

often 24 hours. The LD50 is measured in milligrams of active ingredient per kilogram of test animals.

The LC50 is the concentration of an active ingredient of a pesticide in the air that will kill 50% of a population of test animals. LC50 values are measured in micrograms of active ingredient per liter of air (this is the same as parts per million). LC50 values are used mainly for gaseous pesticides (fumigants).

How are LD50 and LC50 values determined?

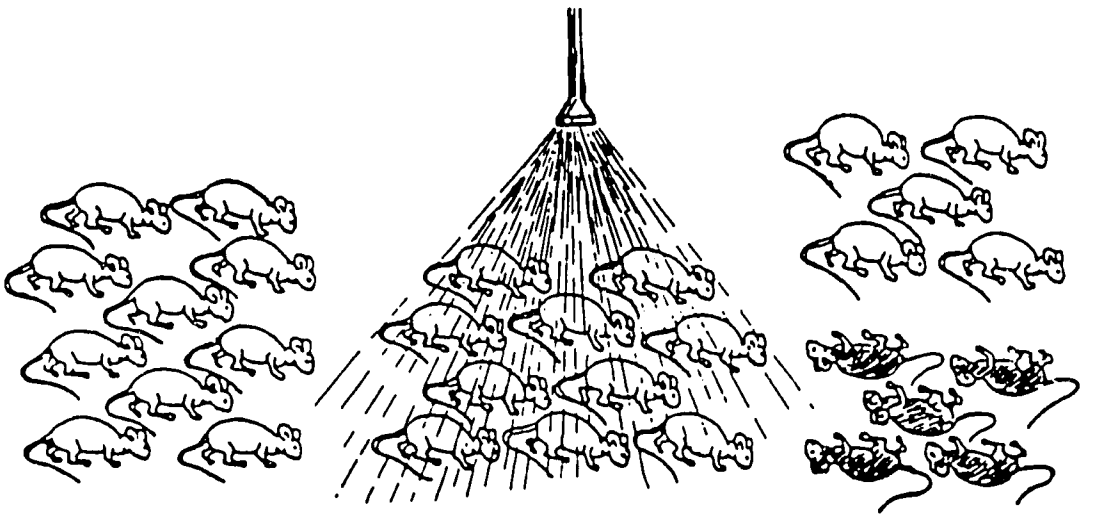
Since man cannot be used as a test animal, tests are made on mice, rats, rabbits, and other small mammals to determine what quantity of active ingredient of a pesticide will kill 50% of the animals tested. For example, after testing pesticide A, it is found that 500 milligrams of the active ingredient will kill 5 out of 10 rats that weigh 1 kilogram each. The LD50 of this pesticide is therefore 500. If it only took 250 milligrams to kill 50% of the test animals, then the LD50 value would be 250. We assume that the toxicity values found by testing small mammals are directly related to the toxicity of pesticides to man.

10 healthy rats	Exposure to pesticide applied at the LD50 dosage.	5 live rats 5 dead rats

IMPORTANT

REMEMBER THAT THE LOWER THE LD50 VALUE, THE HIGHER THE TOXICITY OF THE PESTICIDE.

A pesticide with an LD50 value of 50 is ten times more toxic than a pesticide with an LD50 value of 500.



Dermal/Oral/Inhalation toxicity

As you will recall, there are three ways a pesticide can enter your body: through the (1) mouth, (2) skin, and (3) lungs. The toxicity of a pesticide can vary greatly depending on how it enters your body.

On pesticide labels and in pesticide literature you will usually find two and sometimes three LD50 values for the same pesticide. Each value is for a different route of entry into your body.

- **ORAL LD50** is the toxicity rating if the pesticide is swallowed.
- **DERMAL LD50** is the toxicity rating if the pesticide is applied to the skin.
- **LC50 for INHALATION** is the toxicity rating if the pesticide is inhaled into the lungs.

A given pesticide can be very toxic orally, but relatively nontoxic if applied to the skin. The reverse is rarely true. Pesticides that are highly toxic dermally are also highly toxic orally.

Classification of pesticides according to toxicity

A very useful method of classifying pesticides is according to their acute toxicity. The World Health Organization (WHO) has divided pesticides into four categories depending on their acute oral and dermal LD50 values. These categories are: EXTREMELY HAZARDOUS, HIGHLY HAZARDOUS, MODERATELY HAZARDOUS, and SLIGHTLY HAZARDOUS. Before using any pesticide formulation you should beware of its toxicity rating. The toxicity rating is used to determine what safety precautions must be used in the storage, handling, and application of the pesticide. The absolute toxicity of the pesticide active ingredient is not what is most important in terms of human safety. Instead, it is the toxicity of the formulated product which is to be used.

The method of calculating the hazard level of formulated products is given below. It should be noted that neither the World Bank nor the Agency for International Development allow the use of any formulation classified as "Extremely hazardous" (Ia) or "Highly hazardous" (Ib) for small farmers in less developed countries.

WHO Classification System According to Acute Toxicity

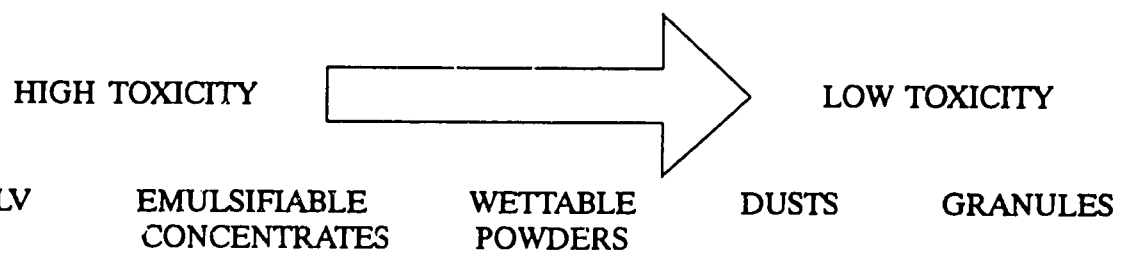
CLASS	HAZARD LEVEL	ORAL TOXICITY* SOLIDS**	ORAL TOXICITY* LIQUIDS**	DERMAL TOXICITY* SOLIDS**	DERMAL TOXICITY* LIQUIDS**
Ia	Extremely hazardous	5 or less	20 or less	10 or less	40 or less
Ib	Highly hazardous	5-50	20-200	10-100	40-400
II	Moderately hazardous	50-500	200-2,000	100-1,000	400-4,000
III	Slightly hazardous	over 500	over 2,000	over 1,000	over 4,000

* Based on LD50 for the rat (mg/kg body weight).

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

Toxicity Varies with Formulations

The toxicity rating of a pesticide as given in pesticide literature is usually the LD50 value for the ACTIVE INGREDIENT, not the pesticide as formulated. In general, the toxicity of a pesticide varies according to the type of formulation and the concentration of active ingredient in the formulation. The scheme below relates toxicity to formulation.



There are two reasons why toxicity varies with formulation:

1. As was stated in the first part of this chapter, a pesticide is made up of the active ingredient plus other ingredients which are inert (nonpoisonous). If a pesticide is formulated as a 50% emulsifiable concentrate, then only 1/2 of the formulation is toxic, the other 1/2 is non-poisonous. Therefore, it would take twice as much of the 50% formulation to have the same effect as an equal amount of the active ingredient. A useful formula which can be used to find the relative toxicity of a pesticide formulation is:

$$\frac{\text{LD50 of the a.i. x 100}}{\text{\% Concentration of a.i. in the formulation.}} = \text{LD50 of the formulation}$$

For example: if you have a pesticide with an LD50 of 200 which is formulated as a 2% dust, then you can use the formula to determine the LD50 of the formulation:

$$\frac{200 \times 100}{2\%} = 10{,}000 \text{ mg/kilogram}$$

More examples of these calculations are given in the Appendix. Also, further information is given in *The WHO Recommended Classifications of Pesticides by Hazard, Guidelines to Classification 1984-1985.* Ref. VBC/84.2, World Health Organization, Geneva, 1984.

In general, ULV and emulsifiable concentrate formulations have the highest concentrations of active ingredient.

Dry formulations such as dusts and granules have the lowest concentration of active ingredient. Therefore, ULV and emulsifiable concentrates are usually more toxic than dry formulations.

2. The rate of absorption of the formulation varies greatly. Liquid formulations are absorbed much more rapidly through the stomach, lungs, and skin than dry formulations. Therefore, ULV and emulsifiable concentrates are usually more hazardous for the user than dry formulations such as dusts, granules, and baits.

REMEMBER: TOXICITY RATINGS IN PESTICIDE LITERATURE REFER TO THE ACTIVE INGREDIENT, NOT THE PESTICIDE AS FORMULATED. The relative toxicity of a pesticide product can vary greatly depending on the concentration of active ingredient and the type of formulation.

FACTORS TO CONSIDER IN CHOOSING A PESTICIDE
(Active Ingredient + Formulation)

When choosing a pesticide for a particular control operation, several factors must be considered before arriving at the best choice. Some of these factors are discussed below, both for choosing the appropriate active ingredient and for choosing the right formulation.

1. **What pest do you want to control?** Identification of the pest is essential before you can decide on how to control it. Once you've identified the pest, you might find it can be controlled without using pesticides. If you determine that pesticides are the only effective method of control, you must then choose a pesticide that will be effective against the pest which is causing damage. You would not use a rodenticide to control an insect problem. Not all insecticides will control all insects. Make sure the pesticide you choose is recommended

for control of the target pest. Sources of recommendations are pesticide labels, research reports, pest control handbooks, and crop protection experts.

2. **Location of the pest.** Where is the pest causing damage? On a plant's roots, the leaves, or the stem? It is very important to answer this question before choosing a pesticide. If the pest is in the ground, you probably would not choose a pesticide which is sprayed; a granular formulation which is mixed with the soil would probably be more effective.

3. **Availability of application equipment.** This can be a key factor in choosing a pesticide. In many cases the types of equipment at your disposal might be very limited. If you only have a high-volume backpack sprayer, you would not choose a ULV formulation. For certain formulations, you do not need any application equipment. Granules and baits can be applied by hand if you are treating only a small area (although gloves should be worn). Shortage of water in some areas might mean that you would choose a formulation which does not need to be diluted with water before application.

4. **Persistence.** Some pesticides are effective for only a few hours after treatment while others can last years. To minimize adverse effects to the environment, the pesticides which are commonly used today have low persistence. Once applied, most pesticides last from a few days to a few weeks. A situation where you definitely would not want to use a persistent pesticide would be when treating a crop close to harvest time.

5. **Safety to applicator.** Always choose the safest pesticide and formulation which will be effective against the target pest. If you have a choice between two pesticides which are both effective against the target pest, then choose the one which is safer to use. Evaluate both the LD50 and the formulation for safety risk to the applicator. Do not forget that the toxicity of a pesticide depends not only on the LD50 (oral and dermal) of the active ingredient, but also on the type of formulation and the concentration of active ingredient. Dry formulations are usually safer to use than liquid formulations. Formulations with low concentrations of active ingredient are usually safer to use than those with high concentrations of active ingredient.

6. **Safety to the environment.** Not only should you be concerned with safety to the applicator but also to the environment. Choose the most pest-specific pesticide available rather than a broad-spectrum pesticide which will affect many nontarget organisms. In control operations you want to have as little adverse effect on nontarget organisms as possible. For example, if you are treating with a pesticide near a river, you would want to choose a pesticide which has low toxicity to fish. If you are treating in a location where bees are kept, you would choose a pesticide that has low toxicity to bees.

7. **Phytotoxicity.** Some pesticides can cause damage to plants. This is called phytotoxicity. Certain formulations tend to be more phytotoxic than others. Choose a formulation that has low phytotoxicity to the plants that you are protecting. ULV and oil solution formulations can be very phytotoxic to some plants and should be used with great care.

8. **Shelf life.** Shelf life refers to how long pesticides can be stored without losing their effectiveness. Some pesticides deteriorate quickly while others will last many years if properly stored. Since we cannot always predict when it will be necessary to use a pesticide, it is advantageous to have pesticides with long shelf lives. Some formulations have longer shelf lives

than others. If stored correctly, wettable powders usually have longer shelf lives than emulsifiable concentrates.

9. **Cost.** Cost is one factor everyone considers before buying a pesticide, but it should not be the only consideration. The other factors such as safety to the applicator, safety to the environment, etc., should be given equal consideration. In general, formulations with a high percentage of active ingredient are less expensive per area treated than formulations with a low percentage of active ingredient. This is due to the increased costs of transportation of pesticides with a low concentration of active ingredient.

   For example, a 50 kilogram sack of Malathion 2% dust would contain only 1 kilogram of active ingredient, whereas a 50 kilogram drum of Malathion ULV 100% would contain nearly 50 kilograms of active ingredient. The transportation costs would be approximately the same for both formulations, but the area which could be treated would be about 50 times greater for the ULV formulation.

CHOOSING PESTICIDE APPLICATION EQUIPMENT

Types of Application Equipment

A wide variety of equipment exists for the application of pesticides ranging from simple burlap sacks used for the application of pesticide dusts to elaborate machinery used in both ground and aerial application. This section of the manual is not intended to be an exhaustive survey of pesticide application equipment, but rather a series of descriptions of the types of ground equipment most commonly found in Africa.

The best source of information on any particular piece of equipment is the literature provided with a new piece of equipment when it is purchased. This literature should be read thoroughly before attempting to use the equipment. If it is written in a language that you are not familiar with, it should be translated and read before the equipment is used. Any equipment being distributed to the field should be accompanied by the pamphlets and brochures provided by the company. Copies of all literature should be made and kept on file so that additional copies can be made as needed.

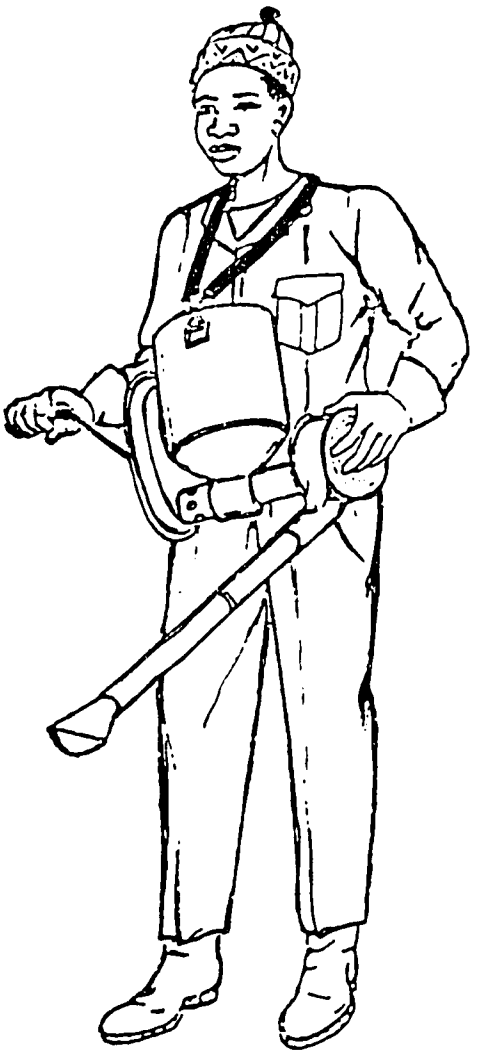
Application by hand

Dusts, granular, and bait formulations can be applied by hand if no other application method is available. The applicator should always wear gloves, if possible. When pesticides are applied by hand, it is especially important to wash hands and face thoroughly after the treatment.

SACK DUSTERS

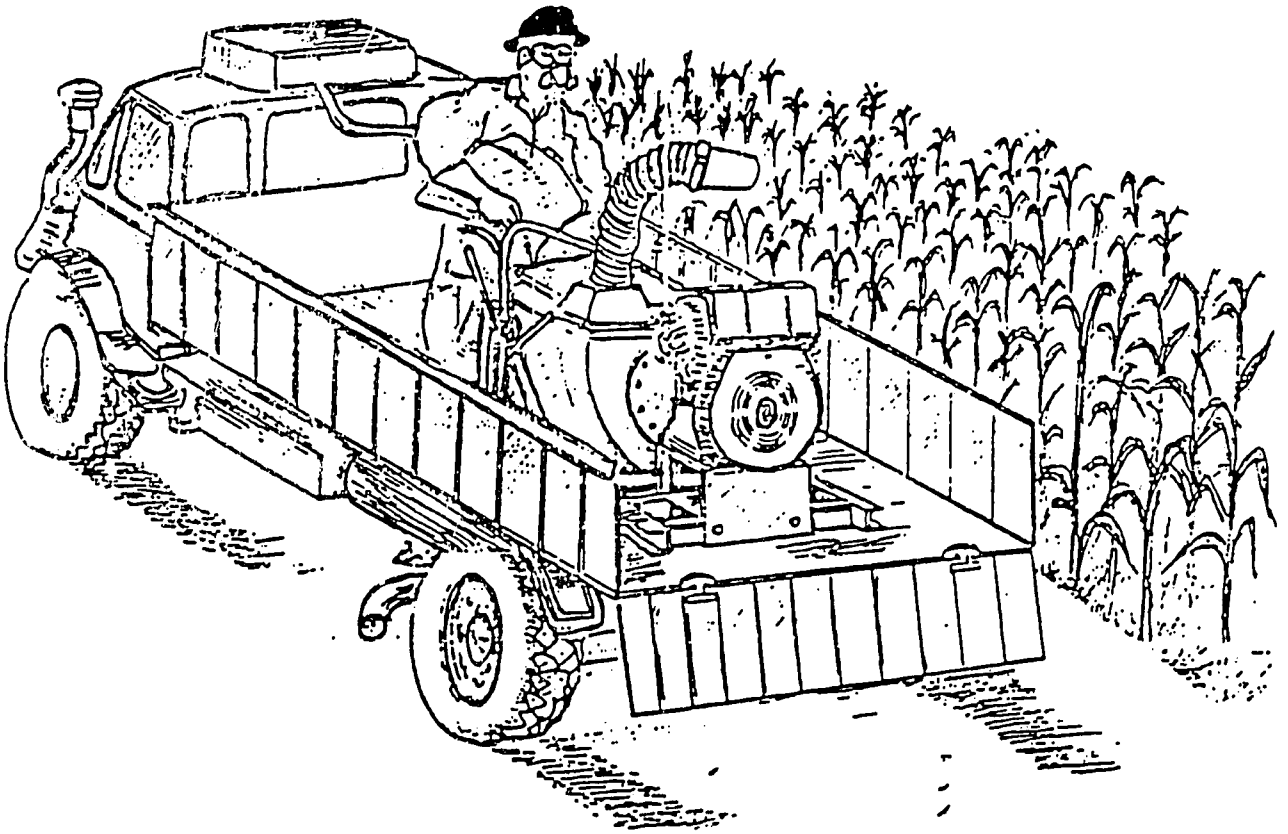
The use of small burlap sacks is a simple and inexpensive method of applying pesticide dusts. In Africa they are often distributed to farmers along with pesticide dust for village-level insect control operations. The sacks should be about 20 cm wide and 50 cm long. A sack this size will hold 2-3 kg of pesticide dust. The sacks are filled about 3/4 full with the pesticide dust and then shaken over the plants or area to be treated. This method should not be used unless there is a breeze of 1-2 meters/second (see Wind Force Chart in the section of the manual titled "Weather Considerations"). The breeze will carry the dust away from the applicator and therefore decrease his exposure to the pesticide. Sack dusting should not be used for treating plants taller than waist-high. Sack dusters should not be used for any purpose other than applying pesticide dusts. When sack dusters are distributed to farmers it should be explained to them that the sack is only to be used for pesticide application and that the sacks should not be stored where children and other unauthorized persons might have access to them.

CRANK DUSTERS



Crank dusters are simple and inexpensive hand-operated machines used for the application of pesticide dusts. They consist of a pesticide hopper holding about 5 kg of dust and a blower which is driven by a crank rotated by the applicator. Most crank dusters are also equipped with an agitator which turns inside the hopper to assure an even flow of dust to the blower. The flow rate is regulated by adjusting the size of the opening between the hopper and the blower. Crank dusters are carried in front of the body using shoulder straps. Some crank dusters can also be used for the application of granular and bait formulations. Check the manufacturer's recommendations.

VEHICLE-MOUNTED DUSTERS



Large vehicle-mounted dusters work on the same principle as small hand crank dusters. The only difference is their size and the power source. Vehicle-mounted dusters are driven by a power take off from the lorry or by a separate engine. The flow rate is regulated by a lever which controls the size of the opening between the hopper and the blower. Some models have one outlet while others have two. Vehicle-mounted dusters are not generally recommended because the large quantities of dust applied tend to drift away from target areas and pile up against the sides of buildings, plants, and other windbreaks.

MANUAL BACKPACK SPRAYERS (Knapsack Sprayers)

Trombone Type:

Trombone manual backpack sprayers are the simplest and least expensive of the manual backpack type. They consist of a tank with a capacity of 10-20 liters and a pump which is built into the spray lance. The pump is either single-action or double-action. Single-action pumps discharge liquid only on the backward stroke while double-action pumps discharge liquid on both the forward and backward strokes. Pumping has to be continuous and rapid to assure an even spray. Both hands are needed to operate this type of sprayer. The operation of trombone sprayers can be very tiring for the applicator.

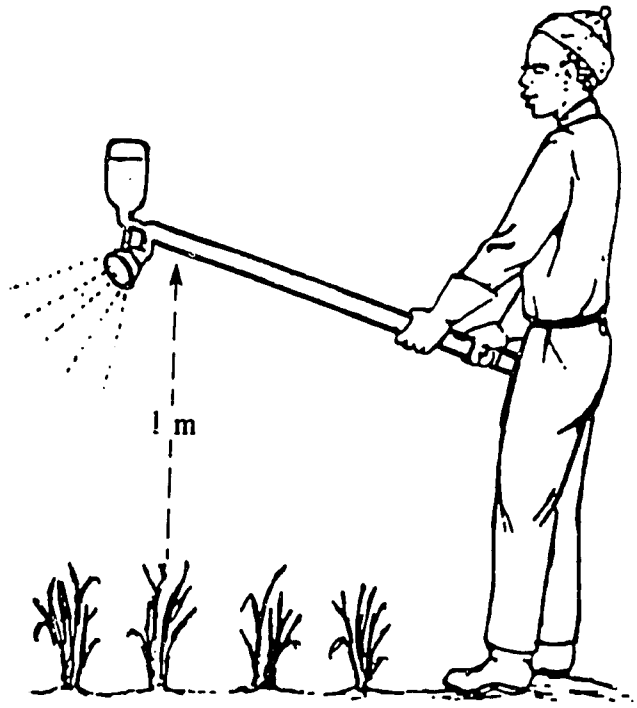
Lever-operated:

Lever-operated manual backpack sprayers are very similar to the trombone type except that the pump is either inside the spray tank or mounted on the outside of the spray tank. They are usually more expensive than the trombone type. Tanks are made of steel, brass, or plastic (most of the newer models are plastic due to weight and cost factors) and hold 10-20 liters. The pump is operated by means of a lever which is mounted on the side of the tank. Many models are made so that the lever can be mounted on either side of the spray tank so that when one arm gets tired the lever can be moved to the other side. The lever must be continually pumped to assure an even discharge of spray. Lever-operated sprayers are less tiring than the trombone type.

Compression Sprayers:

Manual compression sprayers consist of an airtight tank with a capacity of 5-12 liters, a pump built into the spray tank, and a spray lance. The pump is used to pressurize the tank so that continuous pumping during treatments is not necessary. Some models are equipped with a pressure gauge while others are not. Models with a pressure gauge are pumped until the recommended pressure is reached. For models without a pressure gauge, the manufacturer will indicate how many pumping strokes are needed to reach operating pressure. Compression sprayers should only be filled about 3/4 full in order to allow space for the compressed air. You will usually find a mark on the side of the tank indicating the maximum liquid capacity of the sprayer. Some compression sprayers are backpack types with two carrying straps while others have only one strap and are carried under the arm. After completing a spraying operation, be sure to release all the pressure from the sprayer before opening it. This will avoid accidental exposure due to pesticide being discharged from the tank under pressure.

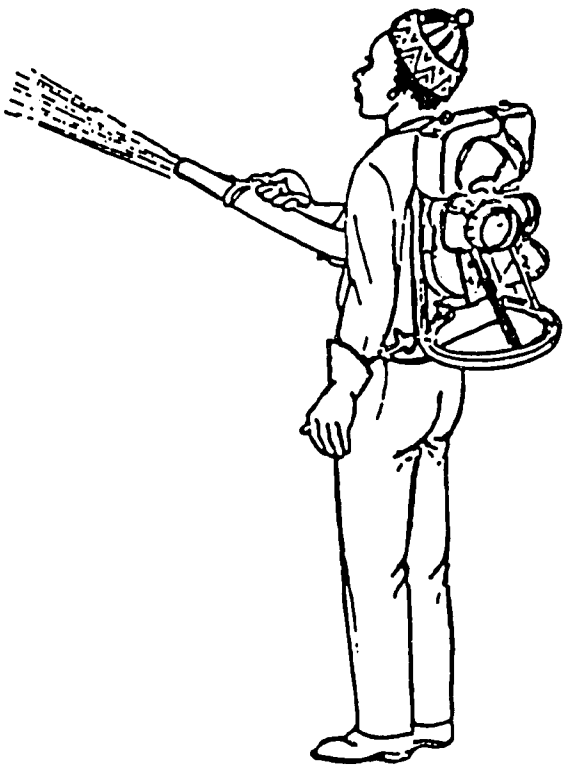
HAND-CARRIED SPINNING DISC SPRAYERS



Hand-carried spinning disc sprayers are small battery-powered ULV sprayers. They consist of a plastic screw-on bottle which serves as a spray tank, a small D.C. electric motor, a rotating disc, and a plastic tube handle which also serves as battery compartment. Liquid is fed from the plastic bottle to the rotating disc by gravity. The liquid is then thrown off the disc by centrifugal force through small notches cut in the edge of the disc. The liquid being forced through the notches is broken up into small droplets (less than 100 microns in diameter). The disc is rotated at very high RPMs (9,000-15,000) by the electric motor. D-cell batteries power the motor. Most models have either 8 or 16 D-cell batteries. The flow rate of these sprayers ranges from 4 to 60 ml/minute. The flow rate is controlled by the diameter of a tube (restrictor) which carries the liquid from the bottle to the rotating disc. Most models come with several tubes of different diameters which can be changed to increase or decrease the flow rate. Spinning disc sprayers that use 16 batteries will operate for about 14 hours before the batteries have to be replaced. Models with fewer batteries will not run as long. The width of the swath treated by a spinning disc sprayer depends upon the speed of the wind. A wind speed of 1-2 meters/second can carry the spray as far as 10 meters.

MOTORIZED BACKPACK SPRAYERS

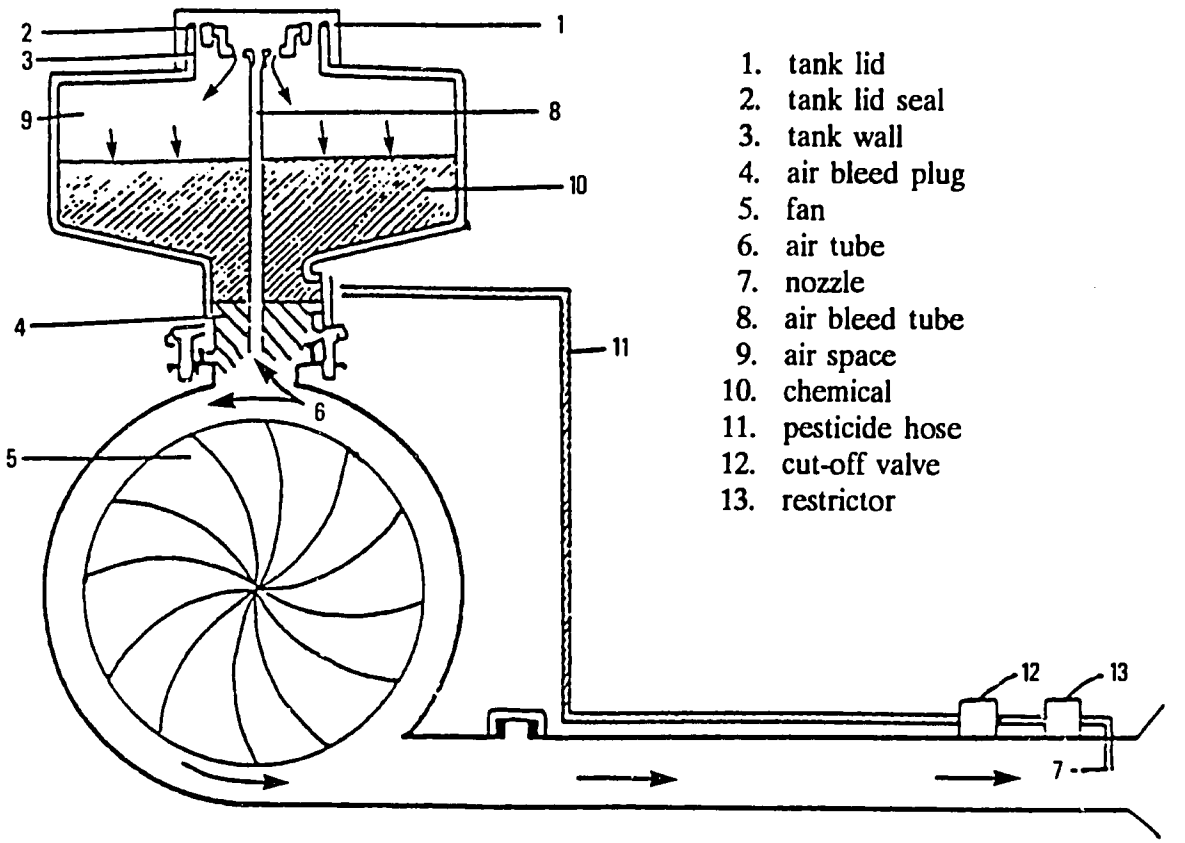
Mistblowers:



Backpack mistblowers consist of a small gasoline engine, a fan (blower), and spray tank. The engine drives the fan which creates an air stream. Pesticide is introduced into the air stream which breaks the pesticide into very small particles (50-100 microns in diameter). The pesticide is then blown out of the sprayer to the target area. Most mistblowers have a spray tank capacity of 10 liters. The tank is slightly pressurized by the blower to force the pesticide to the nozzle. The gasoline engine is a 2-stroke with 35 cc displacement. The width of the swath treated by a mistblower is 10-15 meters. Flow rates range from 0.5 liters/minute to 3 liters/minute. A mistblower with a flow rate of 1 liter/minute would apply 15 liters/hectare if the applicator walked at a speed of 4 km/hour and the swath width was 10 meters. Emulsifiable concentrate and wettable powder formulations are used with mistblowers, but they are diluted much less than when the same formulations are used in manual backpack sprayers. This is because of the greatly decreased flow rate. Some mistblowers can be adapted for the application of dusts and granules (see manufacturers' operating instructions).

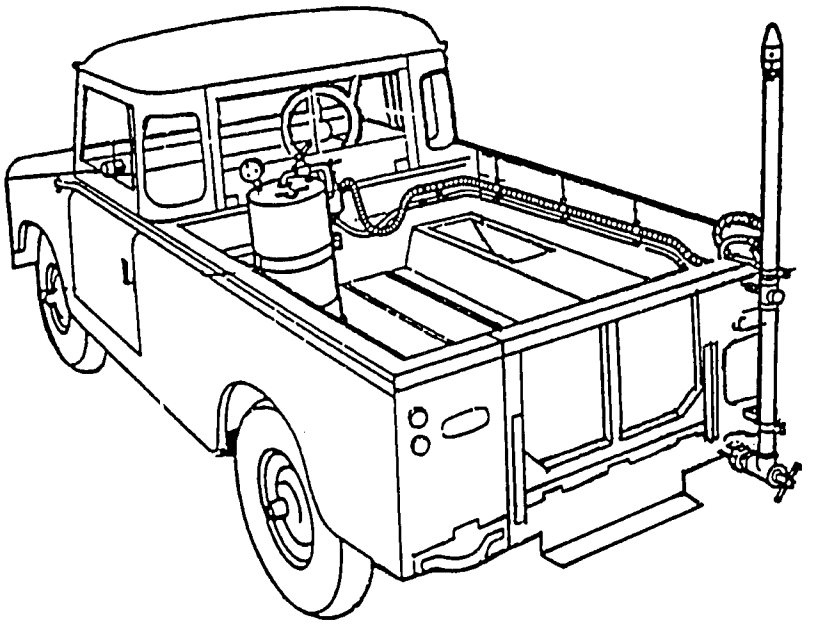
ULV Backpack Sprayers:

Sprayers are almost identical to mistblowers except the flow rates are much lower. Flow rates for ULV backpack sprayers are typically 30-100 ml/minute. A ULV sprayer with a flow rate of 60 ml/minute which treats a 15-meter swath would apply 0.6 liters/hectare if the applicator walked at a speed of 4 km/hour. These sprayers are usually sold with several different sized nozzles. The nozzles can be changed to increase or decrease the flow rate.



Generalized diagram of a backpack mistblower or a ULV backpack sprayer (from Oudejans, 1982).

EXHAUST NOZZLE SPRAYERS



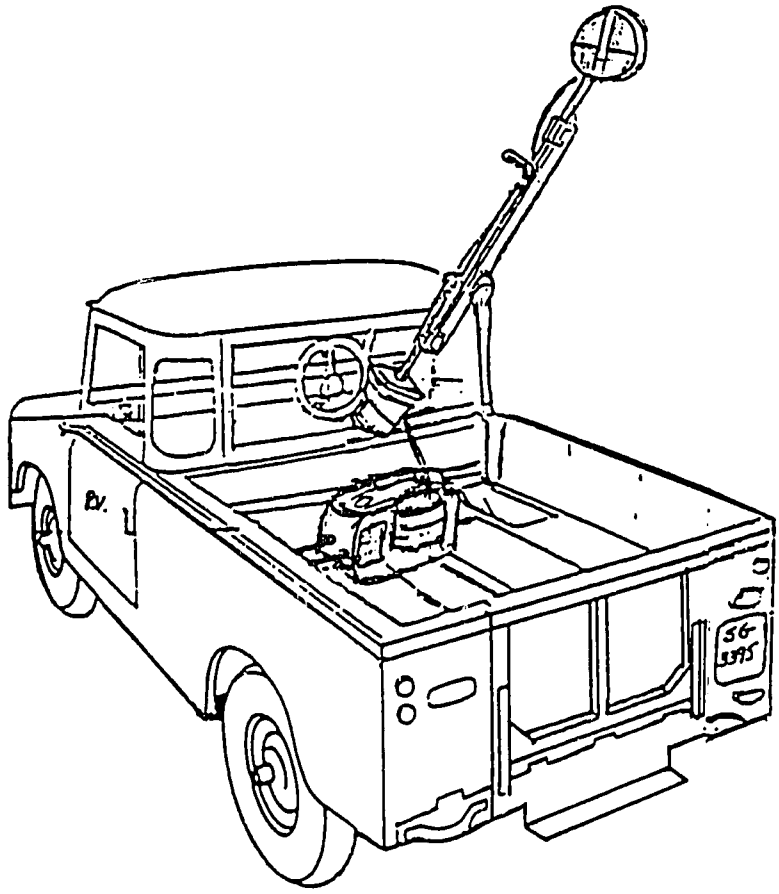
The Exhaust Nozzle Sprayer (ENS) is a large truck-mounted ULV sprayer. The ENS works on the same principle as backpack mistblowers except that the air stream which breaks up the pesticide and ejects it from the sprayer is created by the exhaust gases of the vehicles rather than an engine-driven fan. The ENS is primarily used for large-scale grasshopper and locust control operations. The exhaust system of the vehicle is modified so that the exhaust pipe can be capped off, forcing the exhaust gases to the sprayer. The exhaust pipe is uncapped when the sprayer is not in use. The ENS, as manufactured, has two 50-liter tanks. OCLALAV modifies their ENS to have one 400-liter tank. This allows one tank to treat a much larger area without refilling the sprayer. An ENS with a 400-liter tank will treat 800 hectares if the dosage applied is 0.5 liters/hectare.

The ENS depends on the wind to carry the pesticide to the target area. The width of the swath treated by the ENS depends on the speed of the wind. OCLALAV recommends treating when wind speed is 1-6 meters/second. A wind of 1 meter/second will carry the pesticide 50-100 meters. A stronger wind of 6 meters/second will carry the pesticide up to 1,000 meters.

For specific recommendations on the use of the ENS, see *Utilisation du Pulvérisateur Monte sur Pot D'Echappement* by Jean-Marie Castel of OCLALAV, 1981. This reference provides information on nozzle size, exhaust pressure, swath width, dosages, wind speed, and vehicle speed.

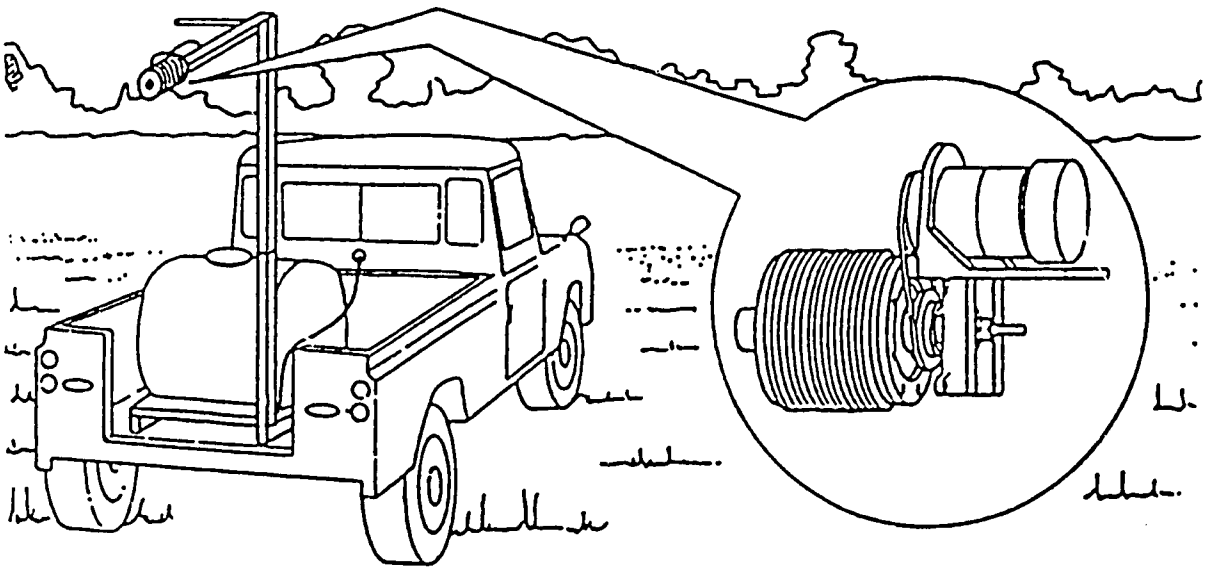
REMINDER: The performance and longevity of pesticide application equipment depends greatly on the care and maintenance it receives. **Thoroughly read and follow the manufacturer's recommendations on utilisation, care, and maintenance of your equipment.** Before distributing equipment to the field, make certain that the personnel who will be receiving the equipment have been fully trained in the use, care, and maintenance of the equipment. Most pesticide application equipment will last many years if properly cared for.

ROTARY ATOMIZERS



Rotary atomizers are ULV sprayers originally developed for pesticide application from aircraft. Recently one manufacturer, Micron Sprayers Ltd., has modified one of their rotary atomizer models (the AU7000) for vehicle mounting. The principle of operation of rotary atomizers is that liquid is dripped onto a spinning metal gauze sleeve which spins at 2,000-12,000 RPM. The spinning action breaks the pesticide into very small droplets. The size of the droplets depends on the speed of the rotating gauze sleeve, the mesh of the gauze, and the viscosity of the pesticide. The faster the gauze sleeve rotates, the smaller the droplets produced. The flow rate of the pesticide is determined by the pressure in the tank and the size of the opening in the variable restrictor unit. Vehicle-mounted rotary atomizers are powered either by an electric motor or small 2-stroke gasoline engine. For those using electric motors, a small auxiliary generator is necessary.

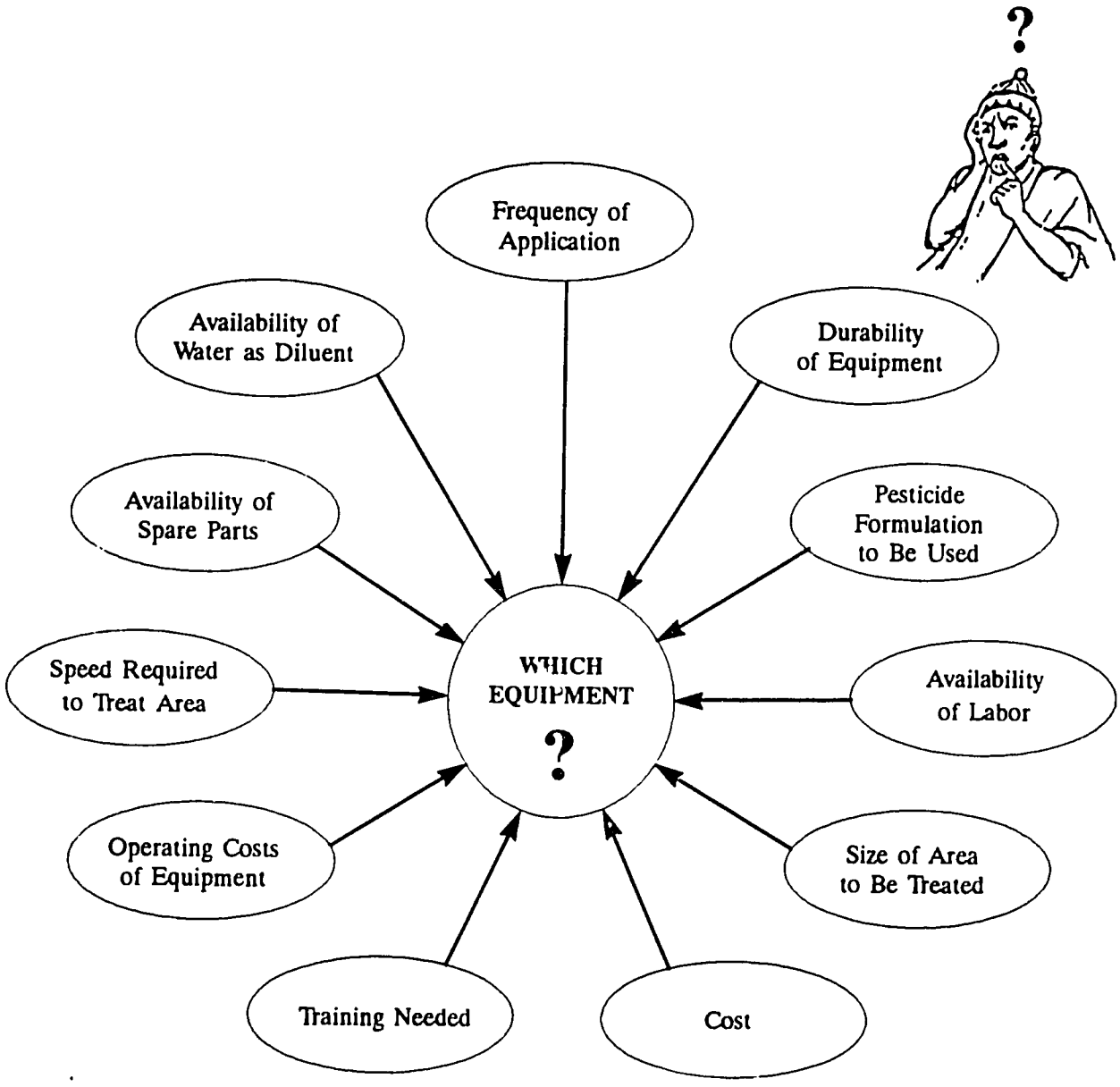
VEHICLE-MOUNTED SPINNING DISK SPRAYERS



Vehicle-mounted spinning disk sprayers work on exactly the same principle as the hand-held spinning disk sprayers. The only major difference is the number of disks. Liquid ULV pesticide is dripped onto the disks and the centrifugal force breaks the pesticide into small droplets. The vehicle-mounted models are powered by a small electric 12-volt motor which is run off the vehicle battery. An example is the Ulvamast apparatus manufactured by Micron Sprayers Ltd.

Factors to Consider in Choosing Application Equipment

The previous section of this manual discussed some of the types of equipment available for the application of pesticides. The choice of the type of application equipment that will best suit your needs depends on several factors. Some of these are discussed below.



1. **Pesticide formulation to be used.** The first factor to consider is what type of formulation is to be employed. If you have chosen a granular formulation, then, of course, you must use granular application equipment. If you will be using dusts, sprays, and granules, you might want to consider procuring application equipment that can be adapted to apply all three types of formulations, such as a combination backpack mistblower/duster/granular applicator. For factors to be considered in choosing a pesticide, see the section of this manual titled "Choosing a Pesticide."

2. **Availability of personnel/size of the area to be treated/frequency of application.** All three of these factors are interrelated. Is the control program to be carried out by the Crop Protection Service or by farmers? Will there be 200 people available for the operation or 10? Is the area which needs to be treated 2 hectares or 2,000? How much time do you have to carry out the control operation? All of these questions must be considered when choosing the appropriate type of application equipment. If farmers are to be applying the pesticide and availability of manpower is no restraint, then maybe sack dusters or baits could be used for the application. If the Crop Protection Service is to be treating large areas with few people, then possibly a more elaborate type of equipment is needed.

3. **Characteristics of the area to be treated.** The physical characteristics of the area to be treated need to be considered before choosing the best application method. Is the area to be treated a rice perimeter, pasture, vegetable crops, field crops, or other type of area? Some areas such as flooded rice perimeters can not be entered by vehicles so you would not choose vehicle-mounted application equipment. If you want to treat the foliage of fruit trees, then you would need application machinery that will reach the tops of the trees.

4. **Availability of water.** Will water be readily available at the treatment site to dilute the pesticide? If not, do not choose application equipment designed to apply pesticides which must be diluted with water, such as emulsifiable concentrates and wettable powders. Where water is not available, it would be more appropriate to apply dusts, granules, baits, or ULV. Low-volume application with mistblowers uses only about 1/10 the amount of water as applications with high-volume spray equipment.

5. **Availability of spare parts.** Be sure that spare parts are readily available for the type and brand of application equipment you choose. Check to see if there is a manufacturer's representative in your country. If spare parts are not available on the local market, make certain that when the application equipment is ordered, a sufficient quantity of spare parts are ordered at the same time.

6. **Durability.** How long can you expect a particular piece of application equipment to last? Does the manufacturer provide a warranty with the equipment when purchased? In general, it can be said that the fewer moving parts an application machine has, the longer it will last. The lifetime of any particular application machine greatly depends on the care and maintenance it receives. Be sure to follow the manufacturer's recommendations concerning the care and maintenance of your application equipment.

7. **Ease of use.** This factor should be considered from both physical and mental aspects. Is the application equipment physically easy to use? Lever-operated backpack sprayers are generally less physically tiring than trombone-type backpack sprayers. Motorized backpack sprayers are even easier to use if they are not too heavy. The less physically demanding the equipment, the greater the chance the operator will do a good job. Also consider the mental aspect. How complicated is the piece of machinery to use? How much training will be necessary to teach the operators to properly use and maintain the equipment? In general, the simpler the equipment the better.

8. **Initial cost.** The cost of application equipment varies tremendously. How much money do you have to spend on application equipment? How many units do you need? After deciding

on the type of equipment you need, compare the prices of several manufacturers of this type of equipment. But remember, the least expensive is not always the best choice. Check for availability of spare parts, compare the warranties offered by various manufacturers, and, if possible, compare the reliability of different machines by checking the literature and consulting with colleagues.

9. **Operating costs.** Consider what resources will be needed to operate a piece of application equipment. How many people will be needed, how much fuel does the machine consume, what are the maintenance requirements? Compare the operating costs of different types of application equipment by calculating the average cost to treat one hectare.

DECIDING HOW MUCH PESTICIDE TO USE

Calculating Surface Area to Be Treated

In order to determine how much pesticide is required to treat an area, you must first determine the size of the area to be treated. In some cases, you will want to determine the size of an area treated after you have completed a pesticide application. Below you will find two methods which can be used to determine the size of an area. Examples of calculations using both of these methods can be found in the Appendix.

Method I. Pacing off: This is a simple method which can be used to measure small areas when you are on foot.

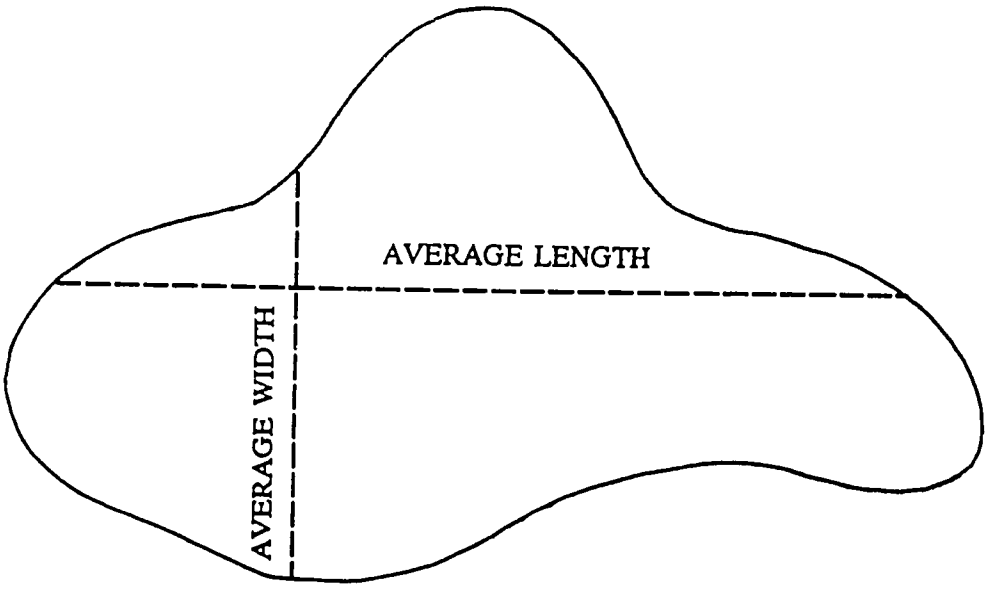
Before beginning, you must know the length of your step. Most adult males have steps 60-80 cm long. To find the length of your step, walk as you normally do for 10 paces, measure the distance that you have gone with a tape measure, and then divide this distance by 10. This will give you the average length of your step. For example, after walking 10 steps, you measure the distance you have walked and find it to be 7 meters. Therefore, the length of your step is 70 cm.

$$\frac{\text{7 meters}}{\text{10 steps}} = \text{70 cm/step}$$

You then pace off the length and width of the area in question, convert the steps to meters, and multiply the length by the width to find the surface area.

$$\text{AREA} = \text{LENGTH} \times \text{WIDTH}$$

The only problem with this system is that the areas that you want to measure are not always square. When you are measuring an area that is not square, you must take the best estimate you can of the **average width** and the **average length** of the area and use these figures to calculate the surface area.



Method II. Using a vehicle with an odometer: This method is commonly used to determine the size of a large area that you have treated with a vehicle. If you are treating with an Exhaust Nozzle Sprayer, this is a good method to calculate the area you have treated.

1. Note the kilometer reading on the vehicle odometer before beginning the treatment. Write it down somewhere so you do not forget it.

2. Treat the area noting **how many passes** you make through the area and **the distance between the passes.**

3. When the treatment is completed note the kilometer reading on the odometer and write it down.

4. Using the formula below, calculate the surface area you have treated.

$$\left(D - [(n - 1) \times L]\right) \times L = \text{area treated in hectares.}$$

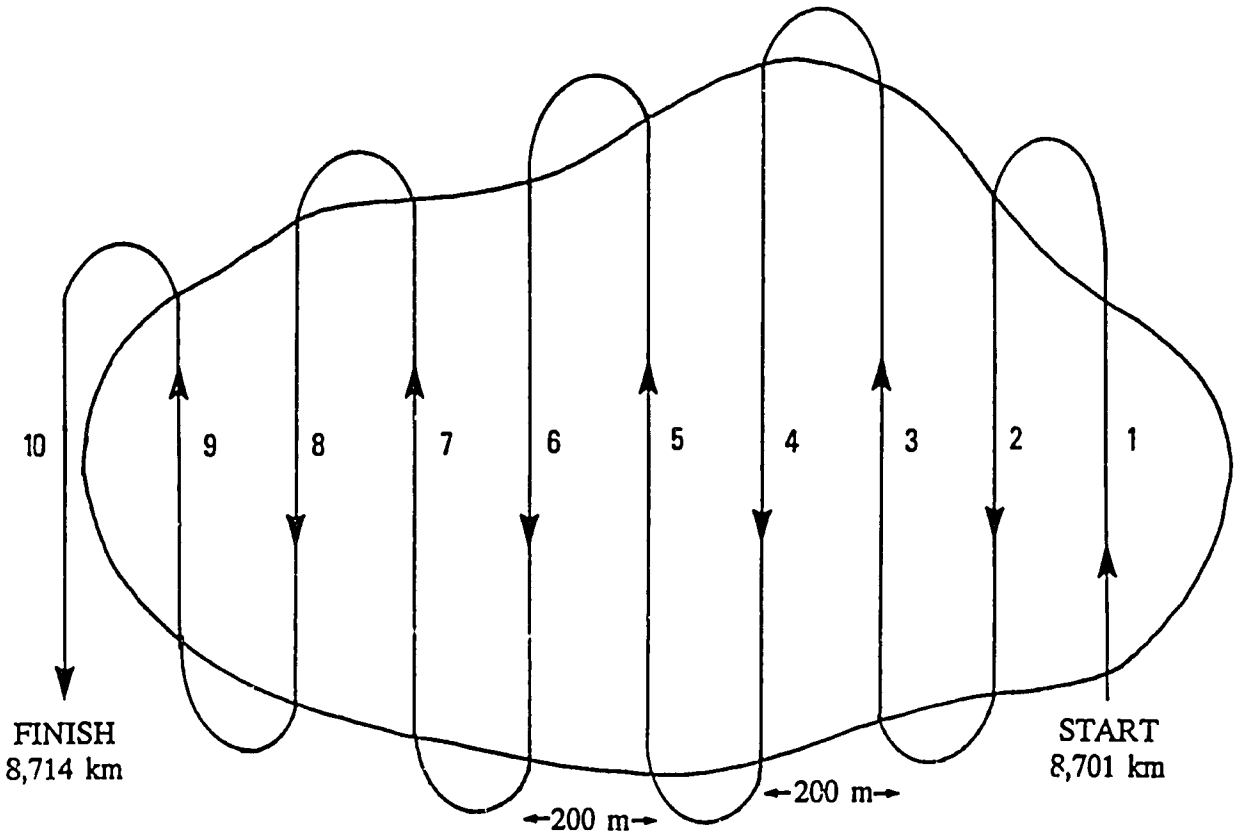
D = distance driven during the treatment in **hectometers.** To find the distance in hectometers, subtract the kilometer reading before the treatment from the kilometer reading after the treatment and multiply by 10.

n = number of passes

L = distance between the passes in **hectometers**

Note: 1 hectometer = 100 meters

- To convert meters to hectometer, divide by 100.
- To convert kilometers to hectometers, multiply by 10.



D = (8,714 - 8,701) x 10 = 130 hectometers

n = 10

L = 200/100 = 2 hectometers

Area treated = $\left(130 - [(10 - 1) \times 2]\right) \times 2 = 224$ hectares

Therefore, the area you have treated is 224 hectares.

Calibrating Application Equipment

What is calibration?

Calibration is measuring how much pesticide a particular piece of application equipment applies to a given area. This is called the "flow rate." Flow rates are usually expressed in liters/hectare or kilograms/hectare.

When is calibration necessary?

Calibration is not always necessary. If a pesticide recommendation indicates that you should mix one liter of a pesticide formulation with 100 liters of water and then spray on plants until the leaves drip, you do not have to calibrate your sprayer.

In other cases, however, it is necessary. Suppose you want to apply one liter of an emulsifiable concentrate per hectare. You have a sprayer that holds 10 liters. How much pesticide do you add to the sprayer tank in order to evenly apply the one liter of formulation over the entire hectare?

It is impossible to answer this question if you do not know the flow rate of your sprayer.

How do you calibrate?

There is more than one way to calibrate most types of application equipment. The method used depends on the particular piece of equipment and your personal preference. Two methods which are commonly used are described below.

Method I. The simplest method of calibration is to measure out an area, treat it, determine the amount of material applied to the area, and then calculate the amount which the machine would apply per hectare. This method can be used for just about any type of application equipment. When calibrating machinery for formulations which are to be diluted with water, it is best to use water during the calibration operation. If the machine is to be used to apply a formulation which will not be diluted, then see the special notes at the end of this section. The steps to follow for this method are given below, and examples for both methods can be found in the Appendix.

1. Measure out an area. This could be 10 m^2, 100 m^2, 1,000 m^2, or one hectare depending on the size of your machine.

2. Fill the machine with an appropriate material and treat the area.

3. Determine how much was applied by refilling the machine to the same level you started with. You now know the amount of material that was applied to the surface you measured out. This can easily be converted to amount applied/hectare. Remember:

$$1 \text{ hectare} = 10{,}000 \text{ m}^2.$$

Method II. The second method of calibration is usually faster than the first, but possibly more complicated. The steps involved in this method are outlined below:

1. Fill the machine with the appropriate calibration material. This would be either the pesticide, or a substitute for the pesticide such as water.

2. Operate the application machine for 5 minutes.

3. Refill the machine to the same level that you started with and measure this amount. This will give you the amount of material applied in 5 minutes. In some cases, it might be easier to collect the material that comes out of the machine and directly measure this quantity, rather than measuring the amount it takes to refill the machine.

4. Divide the amount of material applied in 5 minutes by 5 to determine the amount applied in one minute.

5. Determine the speed of the sprayer in **meters/minute.**

   - If the machine is hand-carried, then simply measure the distance in meters the person treating walks in one minute. This will give you his speed in meters/minute.

   - If the machine is mounted on a truck which has a speedometer, you can multiply the kilometers/hour reading on the speedometer times 17 to get meters/minute. For example, 10 kilometers/hour = 170 meters/minute.

6. Measure the width of the band treated by the machine. For a backpack sprayer this might be 1 meter. For a large ULV sprayer such as an Exhaust Nozzle Sprayer, this could be 300 meters or more.

7. Calculate the surface treated in one minute. This is done by multiplying the speed of the sprayer (step 5) times the width of the band treated (step 6). For example, if the speed of a sprayer is 100 meters/minute and the width of the band treated is 5 meters, then the surface treated in one minute is 500 m^2.

8. Calculate the amount of time needed to treat one hectare. This is found by dividing the surface area of a hectare, 10,000 m^2, by the surface area treated in one minute. For example, if your machine treats 500 m^2/minute, you would divide the area of a hectare, 10,000 m^2, by 500 and arrive at 20 minutes per hectare.

9. Calculate the amount of material applied per hectare. This is found by multiplying the amount of material applied/minute (step 4), times the number of minutes it takes to treat one hectare (step 8). For example, let's suppose your machine applies 5 liters/minute and it takes 20 minutes to treat one hectare. The machine would therefore apply 100 liters/hectare.

   As with the first method, this method can be used for just about any type of application equipment. With formulations that are to be diluted with water before application, you would calibrate the machine with water. With formulations which would not be diluted, you would probably use the pesticide itself for calibrating the machine.

Calibrating application equipment used for applying pesticides that are not to be diluted

To calibrate application equipment which is used for pesticides which will not be diluted before application, such as dusters, granular and bait application equipment, and ULV sprayers, you can use either of the two methods previously described. One difference is that you would never use water to calibrate these types of machines. It is obvious that water can not be used to calibrate equipment designed to apply dry pesticides. For these types of machines you would calibrate with the pesticide that you will be applying. The same is true for ULV sprayers. ULV sprayers should be calibrated with either the pesticide itself or an oil which has approximately the same viscosity. Viscosity is the property of liquids which determines how fast they will flow.

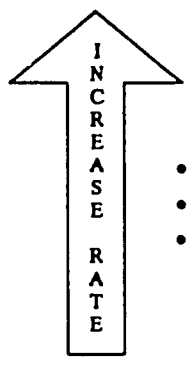
A second difference is that since these formulations are not diluted, then you cannot change the amount applied by changing the percentage of pesticide in a solution. There are three ways to change the application rate of equipment used to apply pesticides that will not be diluted before treatment:

1. Change the speed at which the machine moves through the field. An increase in speed will decrease the amount of pesticide applied per surface area. If you double the speed that a machine is treating, then you will decrease the amount applied by one-half. For example, if you apply one liter/hectare at 5 kilometers/hour and want to decrease the rate to 1/2 liter/hectare, you could do so by increasing the speed to 10 kilometers/hour.

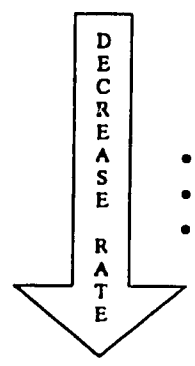
2. Change the pressure of the machine. An increase in pressure will increase the amount of pesticide applied. A decrease in pressure will decrease the amount of pesticide applied. If your sprayer is equipped with a pressure gauge, you can double the amount applied by increasing the pressure by four. For example, if the flow rate of a sprayer is 1 liter/hectare at a pressure of 1.5 bars and you want to increase the flow rate to two liters/hectare, then you would have to increase the pressure to 6 bars.

3. Change the size of the opening that the pesticide comes out of the machine. The larger the opening, the greater the amount of pesticide that will come out. For sprayers, this means changing the diameter of the nozzle. For dust, granule, and bait application equipment, this means adjusting the size of the opening between the pesticide hopper and the blower.

TO CHANGE THE APPLICATION RATE:



- decrease speed
- increase pressure
- larger opening



- increase speed
- decrease pressure
- smaller opening

Pesticide Dosages

After choosing a pesticide and pesticide application equipment, another critical decision is how much pesticide to use. The amount of pesticide recommended is called the "dosage."

It is very important to apply the correct amount of pesticide during control operations. If too small a quantity is used, it is likely that the target pest will not be controlled. If the recommended quantity is surpassed, damage could be caused to the plants, to man, and the environment, and it would be a waste of pesticide.

Field agents who apply pesticides usually have a set of guidelines given to them. This helps them to decide which pesticide to use and what dosage is needed for a given pest problem. Supervisors should be issued specific up-to-date recommendations by the National Crop Protection Service each year, based on the current availability of chemicals, and any changes in uses or dosages recommended by researchers, manufacturers, or regulatory agencies.

The most useful guidelines for field personnel are those which senior technical staff prepare based on specific factors such as the local availability of formulations, water or other diluents, measuring cups, and application equipment. In many localities, applicators may have only four or five chemicals, and each may be in only one or two formulations. Therefore, only a simple chart is needed that lists the available chemicals and formulations.

Common measures

It may be more convenient to measure pesticides in empty tins, matchboxes, or other containers that are widely available rather than weighing a quantity of pesticide on a set of scales every time you make an application. You need to use a set of weighing scales initially to determine how much a given container holds. For example, you can weigh an empty tomato paste tin and find that it weighs 20 grams. Then you fill it with a pesticide dust and find that it weighs 170 grams. Now you know that the weight of the dust it holds is (170-20) = 150 grams. **Note:** The densities of dusts, granules, and wettable powders are very different. The tin that holds 150 g of dust may also hold 200 g of granules or 175 g of wettable powder. Once you determine how much a given container holds, mark that amount on the container. Be sure to mark the container with the warning: "DANGER - POISON - PESTICIDES" and keep in a safe place so that it is not accidentally used for drinking or cooking.

Preparing dosage recommendations

The next page has an example of a worksheet format for senior technical staff to use in preparing dosage recommendations for field personnel. Note that there is space for dosages expressed in locally common measures as well as in metric measures. After such a worksheet has been completed, a simple chart can be prepared for field staff. A generalized format for such a chart is in the Appendix. This format can be adapted to the particular needs of a country. Separate charts may be prepared for each crop. Separate recommendations may be made for different insect species within a family, or more general recommendations may be made. In some cases, recommendations may vary with the time of year.

Pesticide Dosage Recommendations: Sample Worksheet to Be Prepared by Crop Protection Service Technical Staff

•	•	•		•		•		•		•
						Motorized mistblower Dosage/tank[2]		Manual backpack duster Dosage/tank[2]		
Crop	Pest	Pesticide	Dosage/ha (a.i.)	Formulation available	Dosage/ha (formulation)[1]	metric measure	common measure	metric measure	common measure	Notes on application
X	Army worm	A	0.85 kg	85 WP	1.0 kg					
	Grasshoppers	A	1.0-1.5 kg	85 WP	1.2 kg (H)					
					1.8 kg (A)					
		B	1.0-2.5 kg	10 D	10.0 kg (H)					
					25.0 kg (A)					
		C	1.0 litre	50 EC	2.0 litre					
	Flower or grain-feeding beetles	B	2.0 kg	10 D	20.0 kg					
	Sucking	D	1.0-1.5	60 EC	1.7 litre (N)					
					2.5 litre (A)					

• These columns should be included on chart of dosage recommendations given to pesticide applicators.

1 The dosage/ha formulation is calculated by dividing the dosage/ha of active ingredient (a.i.) by the percentage of a.i. in the formulation (e.g., 0.85 kg – 85% = 1.0 kg).

2 The dosage/tank is calculated by dividing the dosage/ha of formulation by the number of tanks needed to spray 1 hectare (obtained by previous sprayer calibration).

NOTE: Information obtained from reference books, research reports, pesticide labels, etc. Calculations based on local availability of formulations and application equipment. H = hoppers, A = adults, N = nymphs.

Once recommendations are developed, the technical staff should test them to assure that adequate coverage and adequate control are obtained. If coverage is not adequate, dosages or dilutions should be changed accordingly.

Dosage depends on growth stage

Sometimes the pesticide dosage is given as a range of values. For example, a dosage may be 1.2-1.8 kg per hectare. Should you use 1.2 kg or 1.8 kg or something in between those values? As a general rule, use the minimum value if the insect and/or the host plant is in an early growth stage. For example, use the minimum dosage when treating early instar caterpillars on young cereal plants. Use the maximum dosage/value if the insect and/or the host plant is in a mature growth stage.

Dilution

For certain formulations (EC, WP, SP, S, and F), once you know how much formulated pesticide is needed to treat an area, you must then decide how much water or other diluent to use. This topic has already been discussed in the section on calibration (p. 48). The decision depends on the **type of sprayer** that you have and the growth **stage of the plant**. Higher dilution rates may be used on tall plants such as millet or maize in late growth stages. For younger cereal plants or for low-growing crops such as groundnuts or vegetables, you may get adequate coverage by diluting the formulated pesticide in a much lower volume of diluent. This is possible because you can walk faster when the sprayer is aimed down at low crops, and because there is less plant surface area to cover. You should use the minimum amount of diluent required for adequate coverage. This speeds up the operation, because less time is spent in refilling. It also makes it physically less fatiguing for the operator, and will keep to a minimum the labor required to bring diluent into the field.

Pesticide Dosage Calculations

In some cases, calculations must be made in order to apply the correct dosage of the pesticide to the target area. Dosages can be expressed in numerous ways. Six different types of pesticide dosage recommendations are explained below. An example of the calculations necessary to apply the correct dosage is also provided.

1. **Volume of a pesticide to be mixed with a given volume of water.**

   Suppose a pesticide label states that one liter of the formulation should be mixed with 100 liters of water and then sprayed on the plants until they drip.

   You have read the above recommendation but your backpack sprayer only has a capacity of 10 liters. How much of the formulation do you add to the tank in order to comply with the recommendation?

Solution: 10 liters is 1/10 of 100 liters. Therefore, you would add 1/10 of a liter of the formulation for every full sprayer. 1/10 of a liter is 100 ml.

2. **Weight of active ingredient to be mixed with a given volume of water.**

Your supervisor tells you to use 500 grams of active ingredient of Malathion in 100 liters of water to spray a field infested with blister beetles. He gives you a drum of Malathion 50EC and a 10-liter backpack sprayer. What do you do?

Malathion 50EC means that it is an emulsifiable concentrate of Malathion with 50% active ingredient. One liter of Malathion 50EC has 500 grams of active ingredient. You would, therefore, use one liter of the formulation for every 100 liters of water. Your backpack sprayer holds 10 liters which is 1/10 of 100 liters. You would, therefore, use 1/10 of a liter of the formulation for each backpack sprayer. 1/10 of a liter is 100 ml. The 100 ml would contain 50 grams of active ingredient.

3. **Volume of a pesticide to treat one hectare.**

A pesticide label indicates that you should apply 1/2 liter of Fenitrothion 50EC per hectare. You have a truck-mounted sprayer that holds 100 liters. How much Fenitrothion 50EC do you put in the sprayer tank?

This problem cannot be solved unless you know the rate of liquid your sprayer applies per hectare. This is called the flow rate of the sprayer. In order to determine the flow rate of a sprayer see the section of this manual titled "Calibrating Application Equipment."

Let us assume we know the flow rate and it is 50 liters per hectare. Your sprayer holds 100 liters and the flow rate is 50 liters/hectare. Therefore, a full sprayer will hold enough to treat two hectares. The recommendation is to apply 1/2 liter of the formulation per hectare. You would, therefore, add one liter of the formulation per full sprayer tank and be able to treat two hectares before refilling.

4. **Weight of active ingredient to be applied per hectare.**

This is one of the most common ways that pesticide dosages are recommended. You are told by an expert to treat a pest problem with 500 grams of Malathion per hectare. You have a drum of Malathion 50EC and a backpack sprayer that holds 20 liters. The flow rate of your sprayer is 400 liters/hectare. How much of the Malathion 50EC do you add per full sprayer?

Your sprayer holds 20 liters and the flow rate is 400 liters per hectare. You would, therefore, use 20 full sprayers to treat one hectare.

The recommended dosage is 500 grams of active ingredient per hectare. Each liter of Malathion 50EC contains 500 grams of active ingredient. You would, therefore, need one liter of the formulation per hectare.

The one liter must be evenly divided between the 20 sprayer loads. One liter divided by 20 = 1/20 of a liter per sprayer. 1/20 of a liter is 50 ml.

Example 2: You are distributing Propoxur 2% dust to farmers for grasshopper control. The recommended dosage of Propoxur is 1 kilogram of active ingredient per hectare. The farmer who you are giving the pesticide to has 5 hectares which must be treated. How many kilograms of Propoxur 2% dust do you give him?

Two percent Propoxur dust has 20 grams of active ingredient per kilogram of formulation (2% x 1 kg = 20 grams). For each hectare, the desired dose is one kilogram of active ingredient. You would, therefore, need to apply 50 kilograms of 2% dust per hectare to arrive at a rate of one kilogram of active ingredient per hectare.

If the farmer has 5 hectares to treat, you would have to give him 250 kilograms of the 2% Propoxur formulation.

A useful formula to use in making this type of calculation is:

$$\frac{\text{number of hectares x dosage a.i./hectare}}{\text{grams of a.i./kilogram of formulation}} = \text{kilograms of formulation needed.}$$

$$\frac{\text{5 hectares x 1,000 grams/ha}}{\text{20 grams/kilogram}} = \text{250 kilograms}$$

5. **Percentage of active ingredient in a solution.**

A recommendation indicates that in order to control a certain fungal disease of potatoes known as Verticillium wilt, it is recommended that seed potatoes be dipped before planting in a 2% solution of the fungicide Captan.

You have a sack of Captan 80SP (SP means soluble powder, a formulation similar to wettable powders) and want to make 10 liters of the 2% dipping solution. How much Captan 80SP do you add to 10 liters of water to arrive at a 2% solution?

The easiest way to solve problems of this type is to use a formula. The formula is:

$$\frac{\text{liters of soluble desired x \% of solution desired}}{\text{\% of active ingredient in the formulation}} = \text{The amount of formulation to be added to the desired amount of water.}$$

$$\frac{\text{10 liters x 2\%}}{\text{80\%}} = \text{.25 kilograms} = \text{250 grams}$$

You would, therefore, add 250 grams of Captan 80 SP to 10 liters of water to arrive at a 2% solution.

6. **Percentage of active ingredient mixed with a bait.**

To control grasshoppers in millet fields an expert has recommended using a bait. The bait is to be made using Propoxur 75WP and millet bran. The percentage of active ingredient in the bait is to be 2% by weight. How much of the Propoxur 75WP would you mix with 100 kilograms of millet bran to arrive at a 2% bait?

Formula:

$$\frac{\text{Kgs of bait desired x \% a.i. desired}}{\text{\% of a.i. in formulation}} = \text{Kilograms of formulation to add to desired total weight}$$

$$\frac{100 \text{ kg x } 2\%}{75\%} = 2.667 \text{ kilograms}$$

You would, therefore, add 2.667 kilograms of the Propoxur 75WP to 100 kilograms of millet bran to arrive at a 2% bait.

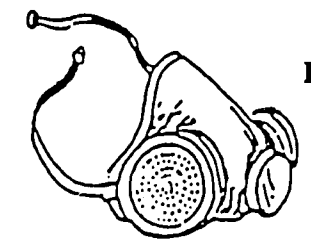
APPLYING PESTICIDES

WHAT TO DO BEFORE APPLICATION

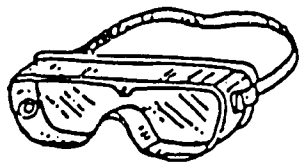
Protective Clothing

The most common cause of pesticide poisoning for applicators is through skin contact. Some pesticides enter the body very quickly through the skin. Oil solutions, ULV, and emulsifiable concentrates can be especially dangerous. Most pesticide spilled on the skin is absorbed within the first few minutes. If any pesticide is spilled on you, wash it off immediately. To minimize contact between the skin and pesticides, protective clothing is often worn while working with pesticides. Protective clothing includes coveralls, gloves, boots, goggles, hat, and respirator. Protective clothing should be washed often and separately from other clothing.

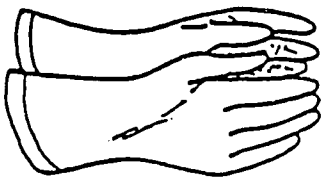
If special care is taken, some of the less toxic pesticide formulations can be used without special clothing. However, pesticides should **never** be used by applicators without shoes, full length trousers, and long-sleeved shirts. Where possible, gloves should also be worn, especially when transferring and mixing concentrates. Small farmers should **never** be issued pesticides which are so toxic that protective clothing other than gloves, long trousers, and shirts are an absolute necessity.



Respirator



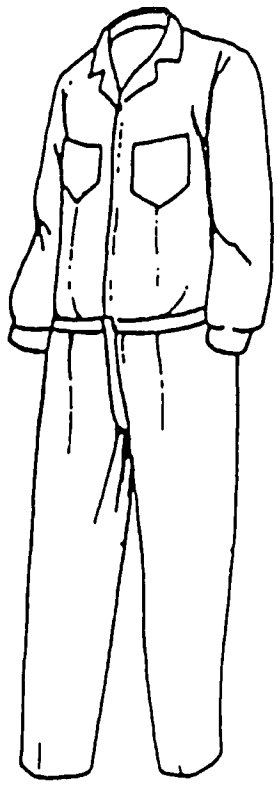
Goggles



Long rubber gloves

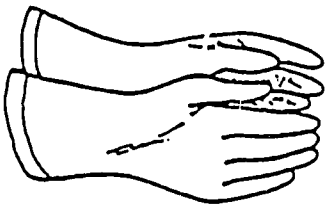
Rubber boots

Waterproof hat



Long trousers over boots

Gloves

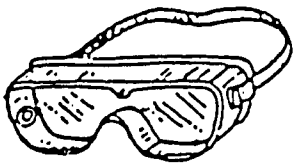


Gloves should be made of unlined neoprene and at least elbow length. Wear the gloves underneath the sleeves of your coveralls. Do not tuck your sleeves into the gloves because any pesticide spilled onto the sleeves will then run inside your gloves. Check gloves often for holes by filling them with water and squeezing. Gloves with holes should be thrown away. Never use cotton or leather gloves as these can soak up pesticide and hold it close to your skin for long periods. When cleaning up after a pesticide treatment **wash your gloves before you remove** them to avoid contaminating your hands.

Boots

Wear neoprene boots that go halfway to the knee. The soles of the boots should be thick enough to keep thorns from puncturing through. Always wear your boots inside your trouser legs to avoid pesticide running down your trouser leg to your feet. Boots should be washed often inside and out.

Goggles



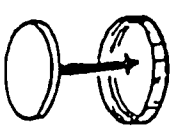
Goggles should always be worn during mixing and filling operations or when working with highly toxic chemicals. Goggles should be tightly fitting. Wash with soap and water after using.

Hats

It is very important to protect your head from exposure to pesticides. Pesticides are absorbed more rapidly through the scalp than many other areas of the body. A plastic hat should be worn. Wide brim models are best. If a plastic hat is not available, any hat is better than no hat.

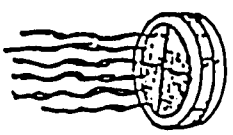
Respirator

A cartridge-type respirator with a filter suitable for pesticides should be worn when working with certain chemicals. This type of respirator covers the nose and mouth and usually has two replaceable filters. Filters should be changed when breathing becomes difficult, or after 8 hours use. After each usage, remove the filters and wash the face piece with soap and water. Respirators should be stored in a clean and dry place away from pesticides. A strong plastic bag is best for storage. Particular care must be given to respirator cleaning and maintenance.



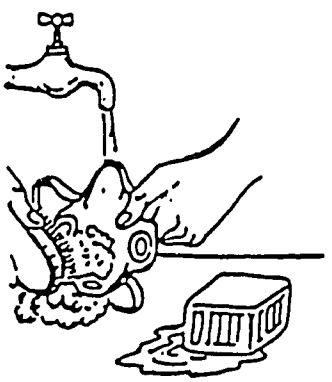
(a)

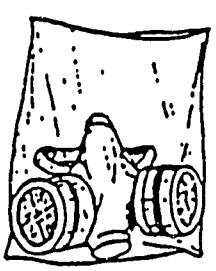
If a cartridge-type respirator is not available, use a handkerchief or a turban to cover your nose and mouth. This should be washed thoroughly after the pesticide application.



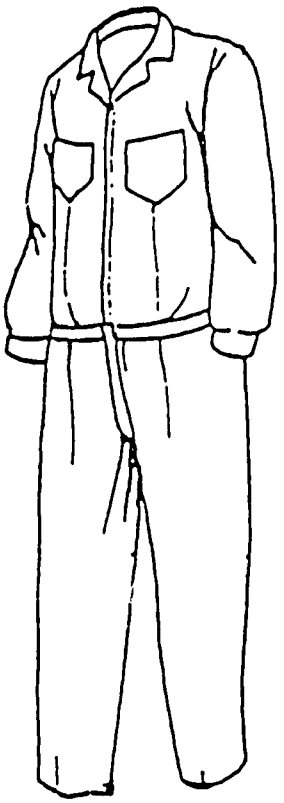
(b)

No matter how well the respiratory device is designed and made, unless it is properly cared for and maintained, it may fail to provide protection. The two most common failings are said to be (1) failure to occasionally wash the face piece with soap and water and (2) neglecting to change the filter cartridges or canisters regularly.





Coveralls



Wear coveralls that will cover your entire body from neck to ankles. A light denim material is best for the hot African climate. After use, wash with soap and water. Each applicator should have at least two sets of coveralls so that one can be washed while the other is being worn.

Safety Precautions

Pesticides are dangerous substances that can cause illness and death to pesticide applicators if handled, stored, or applied without taking the necessary safety precautions. Safety should always be the most important thing on your mind when working with pesticides. Listed below are some of the safety precautions that must be taken before pesticide treatments.

1. When moving pesticides from the warehouse to the treatment site, follow the safety precautions recommended in the section of this manual titled "Transporting of Pesticides."

2. Have plenty of soap and water available at the application site for emergencies or cleanup.

3. Have all the necessary protective clothing available (see section of this manual titled "Protective Clothing").

4. Always choose the safest effective pesticide available (see section of this manual titled "Choosing a Pesticide").

5. Never work alone. Always have at least one other person at the application site in case of an accident.

6. Warn people in the area that you will be treating. Tell them to keep out of the area while you are treating and to keep their animals out. In most cases, they should be warned not to reenter the area for 24 hours after the treatment.

7. Check your application equipment to make sure that it is functioning properly before filling the tank. This includes making sure there are no leaks.

Mixing and Filling Tanks

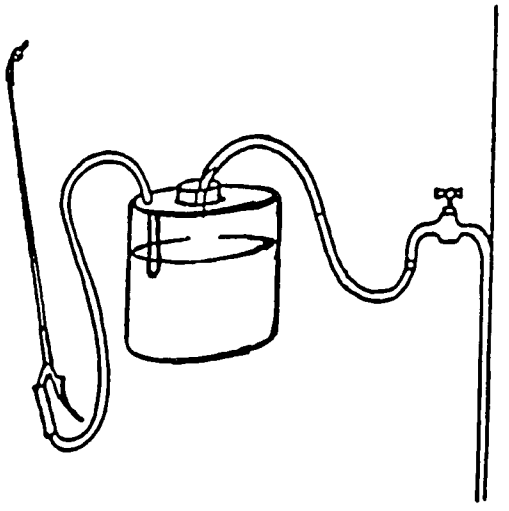
The mixing and filling operation is considered the highest risk time for pesticide accidents.

1. Wear your protective clothing.

2. Always mix and fill outdoors to avoid pesticide fumes that can concentrate in closed areas.

3. Stand upwind during mixing and filling operations.

4. Open pesticide containers with extreme care. Metal drums and glass bottles sometimes have high pressure inside, especially if they have been in the sun. Open lids slowly until you hear the pressure has been equalized before taking the lid completely off. This will avoid pesticide being sprayed out of the container. With pesticides stored in sacks, it is best to open the sacks with a knife to avoid fine dust from billowing up as the sacks are being opened. Keep your face as far away as possible from the container being opened.



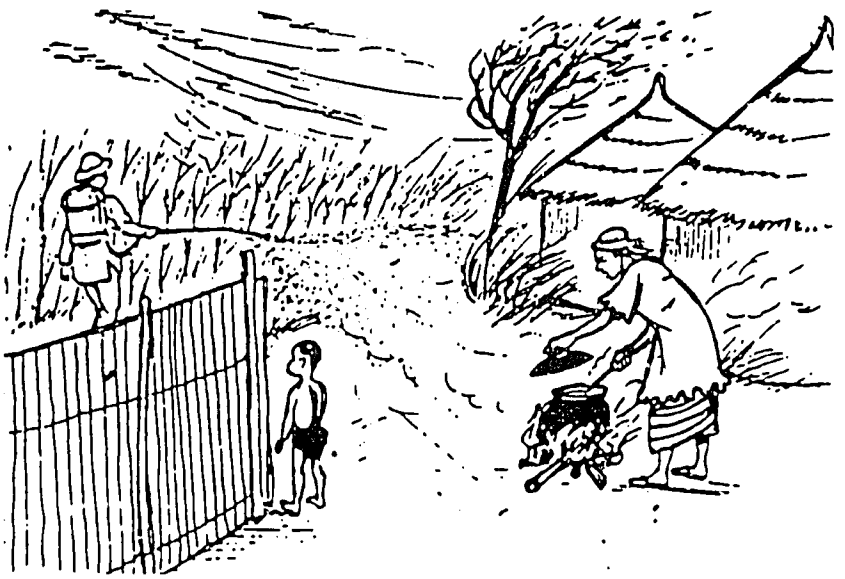
5. If you are adding water to the sprayer tank from a hose, keep the end of the hose above the surface of the liquid in the tank. This will avoid back-siphoning of pesticide into the hose when you shut the water off.

6. Add only enough pesticide to the tank for the job you will be doing. Seal containers when you have finished pouring the pesticide from the container to the spray tank or hopper.

Weather Considerations

The prevailing weather conditions before, during, and soon after a pesticide treatment can greatly affect the results of the treatment. Wind velocity, temperature, and the possibility of rain should be evaluated before beginning a pesticide treatment. These factors are discussed in detail below.

Wind: One problem that is often encountered during pesticide applications is pesticide being carried away from the target site by wind. This is called "**drift.**" If too much pesticide drifts away from the target site, there is a good chance that the target pest(s) will not be controlled. Drift can also cause adverse effects to the environment because the pesticide is being applied to an area where we do not want it. Pesticides drifting into water sources or populated areas could have serious adverse effects to man and other nontarget organisms.



Certain pesticide formulations are more susceptible to drift than others. Fine sprays and dusts drift the most. Granular formulations drift very little. For formulations which are sprayed, the smaller the droplet size, the farther the particles will drift. Low-volume (mistblowers) and Ultra Low Volume applications are the most prone to drift.

As a general rule:

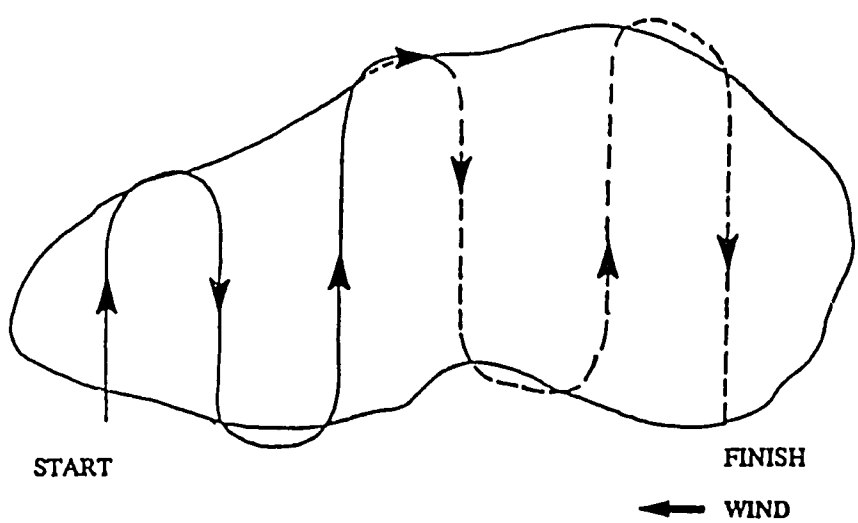
AVOID APPLYING PESTICIDE SPRAYS AND DUSTS WHEN THE WIND VELOCITY IS GREATER THAN 4 METERS/SECOND.

Wind velocity can be measured with an anemometer. Simple hand-held models are available at low cost. If you do not have an anemometer, the chart below can be used to estimate wind speed.

Wind Force Chart

DESIGNATION	SPECIFICATIONS AT GROUND LEVEL	METERS/SECOND	
		Average	Extremes
Calm	Smoke goes straight up	0	0.0-0.2
Light puff of air	Smoke moves in some direction with the wind	0.8	0.3-1.5
Light breeze	Wind is felt on face; tree leaves stirring	2.4	1.6-3.0
Gentle breeze	Leaves and small plants are continually moving; light flag moves with the wind	4.3	3.4-5.4
Moderate breeze	Dust and scraps of paper raised, small branches move	6.7	5.5-7.9

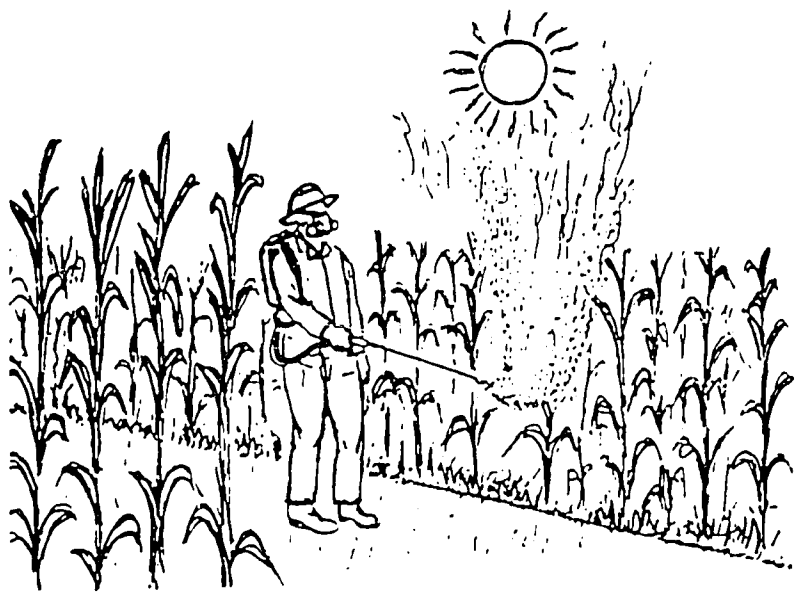
For some types of pesticide applications, a certain velocity of wind is necessary. This is the case with Exhaust Nozzle Sprayers and other ULV sprayers which are used in several African countries. This type of equipment depends on the wind to carry the pesticide to the target site. OCLALAV recommends a wind velocity of 1-6 meters/second when applying pesticides with an Exhaust Nozzle Sprayer. When winds are less than 1 m/sec or greater than 6 m/s, applications should not be made.



Check the direction of the wind before beginning to treat to avoid being exposed to pesticide drift carried by the wind. Treatments should be according to the diagram above.

Heat: In Sahelian Africa, daytime temperatures often reach 35°-40°C during the growing season. Extremely high temperatures can affect the success of a treatment for several reasons:

- Convection currents often accompany high temperatures. Convection currents are currents of hot air rising from the ground up towards the atmosphere. When convection currents are strong they can carry pesticide spray away from the ground and, therefore, away from the target site. This is especially true with pesticide sprays applied in small droplets from ULV sprayers and mistblowers.



- During the hottest part of the day, many pests, especially insects, will hide from the heat in the soil or in various parts of plants. Because of this, pesticide applications carried out in the hottest part of the day might not be as effective as treatments made during the cooler parts of the day when the pests are often more accessible.

- The chance of phytotoxic effects increases with temperature.

- In very hot weather, pesticide sprays can evaporate before they reach the target.

For the above reasons, you should **AVOID APPLYING PESTICIDES DURING THE HOTTEST PART OF THE DAY.** As a general rule, pesticide applications should be made before 1100 hours and after 1600 hours.

Rain: Rain during or soon after a pesticide treatment will wash the pesticide off the target site. This is especially true for foliar treatments.

AVOID PESTICIDE APPLICATIONS IF YOU THINK IT WILL RAIN WITHIN THE NEXT 12 HOURS.

WHAT TO DO DURING APPLICATION

1. Never eat, drink, or smoke during pesticide treatments. Do not carry food, drinks, or cigarettes with you during treatments.

2. Wear appropriate protective clothing, including gloves, even if you are hot and uncomfortable.

3. If a hose or nozzle gets clogged, do not try to blow it out with your mouth. Use a fine wire or stick.

4. Never put your fingers in your ears, eyes, mouth, or nose during application. Always wash immediately after applying pesticides.

5. If pesticide is spilled on your gloves, do not wipe it off on your sleeve or trousers.

6. If you or a coworker show signs of pesticide poisoning, **stop the treatment immediately.** Do not try to finish up a field. Begin first-aid measures at once.

WHAT TO DO AFTER APPLICATION

Safety Rules

1. Make sure you have used all the pesticide in your machine. If there is some left over, it is better to use it up in the field or in fallow areas adjacent to the field rather than trying to save it for future use. This is especially true with formulations that have been mixed with water. Pesticides diluted with water usually lose their capacity to kill pests within one day after dilution, due to deterioration. However, the deteriorated products can still be toxic to humans, livestock, and fish. For nondiluted pesticides, you can recover what is left in the machine but make sure that you properly repackage the pesticide in the original container.

2. Never leave empty containers at the application site. Collect all empty containers and store them until they can be properly disposed of (see section of this manual titled "Disposal of Empty Containers").

3. Do not reenter the treated area or allow others to reenter the area until the spray is at least dry. For some highly toxic pesticides, you should wait 24 hours. Check the recommendation for the pesticide you treated with. If you do not know, it is better to wait a minimum of 24 hours before reentering the area. Be sure to advise the local population of this. Children and domestic animals should be kept out.

Cleaning Up

1. Remove your protective clothing and put aside.

2. The last article of protective clothing to remove is your gloves.

3. Wash your gloves **before removing them**.

4. Wash your body completely with soap and water. Be sure to include your head, hair, and under your fingernails.

5. Do not wash up in a river, stream, or lake as this could contaminate the water source.

6. Your dirty protective clothing should be washed separately from other clothes.

7. Keep a record of the treatment (see the section of this manual titled "Recordkeeping").

Evaluating Pesticide Applications

After completing a pesticide application, there are still two important things that must be done:

- Evaluation of the effectiveness of the application
- Recording information concerning the application

Evaluation

It is highly desirable that the person in charge of an application operation return to the site treated 12-24 hours after the treatment to determine whether the application was successful in controlling the target pest(s). A posttreatment survey should be conducted using the same method which was used for the pretreatment survey. The pest density of the pretreatment survey and posttreatment surveys can then be compared to determine if there was a decrease in the pest population density and, if so, to what degree.

If, after completing the posttreatment survey, you find that the pest population did not decrease to an acceptable level, there are several possible explanations:

1. The dosage which was applied was too low. Check your dosage calculations and the equipment calibration to make sure you applied the correct amount of pesticide to the target area.

2. The pesticide used had deteriorated or was not formulated correctly. Had the pesticide been stored incorrectly or for a long period of time? If you think this was the problem, inform your supervisor and he will either recommend that the pesticide no longer be used or that the dosage be increased.

3. Weather conditions: Did it rain soon after the pesticide was applied? Was it excessively hot the day it was applied, or was there a strong wind? All of these weather factors can affect the efficacy of a pesticide treatment.

4. Resistance: When a pest population has been treated with the same pesticide many times, the pests can develop resistance to the pesticide. This is especially true of insects. Pests that have developed resistance are no longer affected by the pesticide or are affected to a lesser degree. For resistance to occur, you would usually have to treat the same pest population with the same pesticide many times during one growing season and possibly for several consecutive growing seasons. There have been very few verified cases of pesticide resistance reported in Africa, but, as pesticide use increases, it is expected that resistance will become more of a problem.

Recordkeeping

Pesticide treatments should always be documented for future use. This information is used to determine how much pesticide and what types of pesticides were used during a cropping season. This information can also be analyzed to determine which pesticides were most effective against which pests. Information that should be recorded includes:

- The date and time of the treatment
- The type of vegetation treated
- The target pest(s)

- Surface area treated
- Pesticide used
- Dosage employed
- The type of application equipment
- Pest density before treatment
- Pest density after treatment
- Any observations which might be important (weather conditions, etc.)

All of the above information can easily be recorded on one form. An example of the type of form which can be used is provided in the Appendix. These forms, or copies of them, should be sent to the headquarters of the National Crop Protection Service. They can be extremely valuable in determining future needs and strategies for upcoming years.

TRANSPORTING OF PESTICIDES

LOADING

1. Before beginning to load pesticides in a vehicle, give the vehicle a complete safety check. Make sure the tires are in good condition and inflated to the correct pressure. Check the brakes, lights, and horn. Make sure that there is a fire extinguisher in the vehicle and that it is fully charged.

2. Always carry soap and water in a vehicle used to transport pesticides.

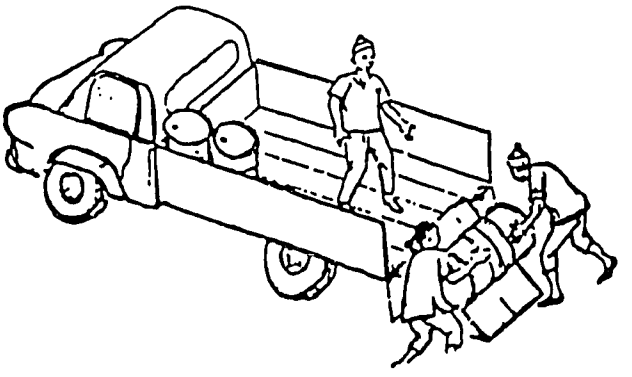
3. Wear protective clothing.

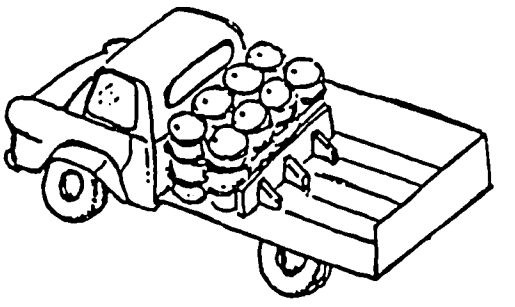
4. Do not eat, drink, or smoke while loading pesticides.

5. Check all containers while loading to make sure there are no leaks. Leaky containers should not be transported. Also make sure that lids are tightly sealed.

6. Use a ramp to roll heavy drums up into the vehicle.

7. All containers must be well secured so that they will not shift during transport. Wooden blocks should be nailed to the bed of the truck to make sure that pesticide containers do not shift. Ropes, chains, and cables can also be used to secure containers.





8. Check the bed of the truck to make certain that there are no nails, bolts, screws, or other sharp protruding objects that could damage pesticide containers.

9. Do not overload the vehicle.

10. Load the vehicle so that the weight is evenly distributed.

11. Cover the load with a tarp. This is especially important if you are transporting dust formulations which can be blown by the wind.

12. Do not carry food, drinks, or animal feed with the pesticides.

13. Never transport pesticides in the cab of a truck.

WHILE MOVING

1. Drive carefully. Of course, you should always drive carefully, but be especially attentive when transporting pesticides. They are dangerous substances and accidents can have serious consequences.

2. Do not park the vehicle and leave it unattended even for a short period of time. Always have someone with the vehicle to keep unauthorized persons away.

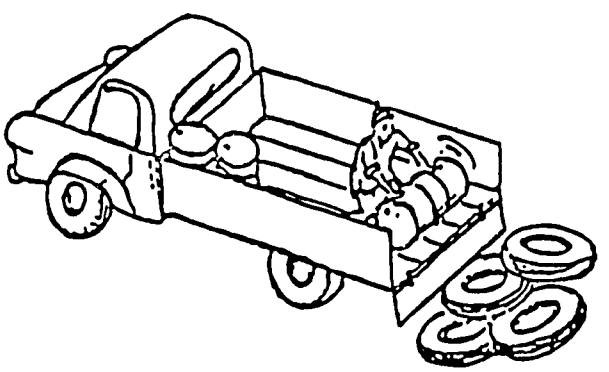
3. Do not carry unauthorized persons in the vehicle. There is no need to expose more people to the dangers involved in pesticide transportation than necessary.

UNLOADING

1. Wear your protective clothing. Do not eat, drink, or smoke while unloading pesticides.

2. While unloading, check all pesticide containers for leaks. Leaky containers should be put aside for repackaging.

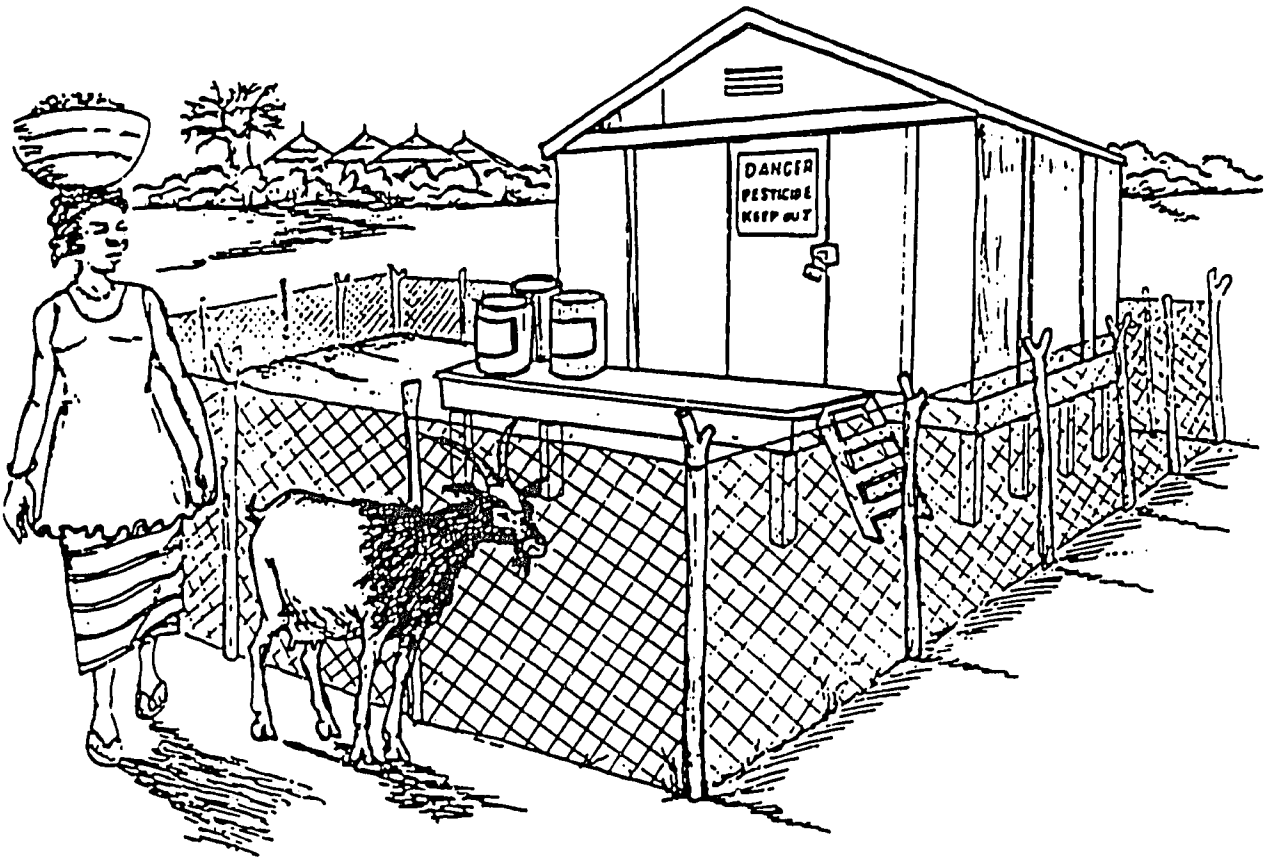
3. Do not abuse containers during unloading operations. If there is an unloading/loading ramp at the unloading site, use it. If not, the best way to get heavy drums out of a truck is to gently roll them off the end of the truck on to used tires.



4. After unloading, stored the pesticides properly.

5. Wash out the vehicle. If pesticides have spilled in the vehicle, clean it and decontaminate. Follow the recommendations in the sections of this manual titled "Cleaning Up Pesticide Spills" and "Decontamination of Spill Sites."

PESTICIDE STORAGE



In order to protect man and the environment, certain requirements must be met in the storage of pesticides. Also, incorrectly stored pesticides can lose their effectiveness against the pests that they are meant to control. You should never attempt to store more pesticide than will be used in one cropping season. The longer pesticides are stored, the greater the chance the pesticides and containers will deteriorate. The length of time a pesticide can be stored before it loses its effectiveness is called the "shelf life" of the pesticide. The shelf life assumes that the pesticide is being stored properly.

GOVERNMENT STORAGE

Crop Protection Services and other government agricultural agencies in Africa use large quantities of pesticides each year. These pesticides are stored in capital cities and regional centers. The following criteria should be considered when storing large quantities of pesticides.

Choosing the Site

If a new pesticide storage facility is to be built, the following criteria should be considered before choosing the site.

- The area should not be prone to flooding during the rainy season.
- The site should be as far away from residential areas as practical. Prevailing winds should be taken into consideration to avoid pesticide dusts from being blown towards inhabited areas.
- There should be no chance that water runoff or drainage from the warehouse site will contaminate water resources in the area, or seep into the underground water table.

The Building

- Should be constructed of fire-resistant materials such as concrete block or metal.
- Should have a cement floor to avoid pesticide seepage into the ground.
- Should be well ventilated to keep the warehouse cool and free from fumes. It is sometimes necessary to install wind-driven ventilators to keep the storage building cool during the hot season.
- Should have trees surrounding it to provide shade which will cool the building.
- Should be fenced if possible; if not, the building itself should be lockable.
- Waterproof signs should be posted on the fence or the building itself which state:

DANGER PESTICIDES !
KEEP OUT

- Should have an outside cement area for cleaning pesticide application equipment and vehicles used to transport pesticides.
- The doors should be large enough to permit trucks to enter for loading and unloading operations. Large doors at both ends of the building will allow trucks to drive through. This can greatly simplify loading and unloading operations.
- A loading dock can be very convenient and decrease the risk of damaging containers during loading and unloading operations.
- A dike or trench should be built around the building to prevent runoff water from cleanup operations from entering a water source.

Inside the Building

- The various pesticides should be kept separated; this will make loading and unloading easier, make inventory easier, and prevent possible cross-contamination. Herbicides should never be stored next to insecticides as cross-contamination is likely.

- No food, drink, or animal feed should be stored in the warehouse.

- Explosives should not be stored in same areas as pesticides.

- Protective clothing should not be stored in the same room as pesticides. Protective clothing should be stored in a separate room or building.

- All pesticides should be clearly labeled. If pesticides arriving at the facility are not correctly labeled, the person responsible for the warehouse should have these properly labeled before they are stored.

- Fire extinguishers should be kept in the storage area.

- Sawdust, sand, or charcoal should be available in the storage area to use in cleanup operations.

- Brooms and shovels should be available for cleanup operations.

- Pesticides should be stored on pallets or shelves to avoid dampness. This is especially true for dry formulations such as dusts, granules, and wettable powders which will clump and lose their efficacy if they get wet.

- Highly toxic pesticides which are in categories Ia and Ib of the WHO Toxicity Classification System should be stored in a separate area.

Safety Measures in and Around the Warehouse

- Never allow children, animals, or unauthorized persons in the storage area.

- Wear protective clothing, especially gloves, while working in the storage area.

- Never put your fingers in your eyes, nose, ears, or mouth while working in the storage area.

- Never smoke, eat, or drink in the storage area.

- Do not handle containers roughly. They are not meant to be dropped, thrown, or otherwise abused.

- Always wash up after working in a pesticide storage area.

VILLAGE-LEVEL STORAGE

If pesticides are to be left in villages for use by farmers, the government agent leaving the pesticide should be certain that the village has a proper pesticide storage area. In general, only pesticides of low toxicity should be given to farmers. Usually, these are dusts or baits with 1-5% active ingredient. **The quantity of pesticide left in a village should never exceed the needs of the area for one growing season.** The criteria for village-level storage are similar to large government storage, although it is recognized that villages will not have the financial resources available to construct an elaborate storage area in every case. The minimum requirements which should be met by villagers before pesticides are left at their disposal are:

- One person must be named to be responsible for the storage area. This could be a village chief, the president of an agricultural cooperative, or some other responsible person. It is usually best to have the villagers themselves choose the person. This person's duties will include recordkeeping, distribution, and making sure the storage facility is kept locked when not in use.

- The storage area should be outside the village.

- The storage area should be fenced to keep out children, animals, and unauthorized persons. A thorn branch fence is sufficient if other construction materials are not available or are too expensive.

- The warehouse should not be built in an area which floods during the rainy season.

- The roof should be waterproof. Zinc sheeting is a good roofing material.

- Pallets should be built to keep pesticides off the ground. It should be explained to villagers that when the pesticides get wet, they lose their power to control pests.

- Plants should not be allowed to grow around the storage area. Plants will attract domestic animals to feed. Animals can be poisoned by eating plants that have been contaminated with pesticides.

- The warehouse must have a lock. It should be kept locked at all times except during loading and unloading operations. The person designated as responsible for the warehouse should keep the only key.

PESTICIDE INVENTORY

It is very important to have a good inventory of what pesticides, and in what quantities, are stored in the warehouse. This will help you decide on what quantities to order for the upcoming year. One person should be designated to be responsible for the warehouse operation. This person's duties should include:

- Keeping the inventory records.

- Making sure that all pesticides are properly labeled.
- Making sure fire extinguishers are fully charged.
- Surveying the warehouse on a periodic basis to check containers for leaks. This should be done at least once a **month**.
- Supervising all loading and unloading operations.
- Making sure all cleanup operations are done properly. This includes checking the warehouse to make sure that brooms, shovels, sand, sawdust, bleach, and other necessary materials are always present for cleanup and decontamination operations.
- Being familiar with pesticide poisoning symptoms and first-aid measures.
- Making sure that pesticides are rotated. This means using up old stocks of a particular pesticide before beginning to use newer stocks of the same pesticide. In order to do this, **all containers should be dated** upon their arrival at the warehouse, **and stored in batches**. This is sometimes called the "**First in-first out**" rule of pesticide storage.

Inventory records should include the following information:

- The names of the pesticides stored at the facility.
- The quantities of the various pesticides stored at the facility.
- The destination and quantities leaving the facility.
- The origin and quantities of pesticides entering the facility.
- The dates when pesticides enter and leave the warehouse.

All of this information can easily be kept on forms similar to the example provided in Appendix II, C. It is advisable to have a separate sheet for each pesticide stored at the warehouse. This will make recordkeeping much simpler.

PESTICIDE LABELS

The best source of information concerning the safe and effective use of a pesticide product should be the label of the pesticide container. Pesticide labeling laws should be an integral part of pesticide legislation. Any person, company, or organization selling or donating pesticides in a country should be required to meet certain provisions in the labeling of pesticides. These provisions should include the language the label is written in, the stability of the label (how long it should last under normal conditions), and the information that must be included on the label.

Below you will find a list of recommended information that should be included on the pesticide label.

1. **Trade name or brand name.** Each company which produces pesticides has brand names for their products. The brand name is the name used in their advertisements and this name is particular for any one company. The brand name is usually written in the largest print found on the label.

2. **Common or chemical name.** Many pesticides have complex chemical names. Many have been given another name to make them easier to identify. This name is called the "**common name**" of the pesticide. For example, Malathion is a common name for the chemical O,O-Dimethyl phosphorodithioate of diethyl mercaptosuccinate. One of many brand names for Malathion is Zithiol. No matter what the brand name is, the common name should appear on the pesticide label. For the pesticides that do not have common names, the chemical name should appear.

3. **Ingredient statement.** Every pesticide label must list the concentration of active ingredient(s) in the product. This information should appear on the front panel of the label directly below the brand name. The amount of active ingredient(s) can be given in one of two forms: as a percentage by weight, for example, Propoxur 2% dust contains 2% active ingredient by weight; or by weight of active ingredient per volume of product, for example, Fenitrothion 1,000g ULV would have 1,000 grams of active ingredient per liter of product. The active ingredient can be listed by either the common name or the chemical name, but common names are preferable because they are usually more widely recognized. Inert ingredients need not be named but the label should indicate what percentage of the product consists of inert ingredients.

4. **Type of formulation.** Different types of pesticide formulations (such as emulsifiable concentrates, dusts, ULV, granules, etc.) require different methods of handling. The label must indicate what type of formulation the package contains. The same pesticide may be available in more than one type of formulation. Formulations are abbreviated using a standardized form. The abbreviations are given in the section of this manual titled "Formulations."

5. **Net contents of the package.** The net contents tells you now much of the product is in the container. This can be expressed in liters, kilograms, or other units approved by the authorities concerned.

6. **Name and address of manufacturer, distributor, or formulator.** This information must be included on the pesticide label so that the company which produced or distributed the product can be contacted if additional information is needed concerning the pesticide. This information can also be used if the pesticide is found to be faulty.

7. **Registration number.** Every pesticide sold in a country should be registered for use in that country by the proper authorities. As each product is approved, it should be given a registration number. This number should be included on the pesticide label.

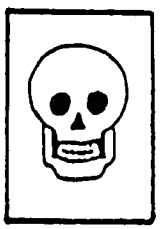
8. **Restricted or general use.** Pesticides used in a country should be divided into two groups: one for general use, and one for restricted use. It should be clearly stated on a pesticide label whether the pesticide is approved for General Use or Restricted Use.

9. **Warning or signal words.** Every pesticide label should include the words "KEEP OUT OF REACH OF CHILDREN." Also, pesticide labels should contain a signal word that refers to the relative toxicity of the pesticide. The commonly used WHO System is as follows (see p. 27 for explanation of this system):

Signal Word	WHO Toxicity Category
Danger-Poison	Extremely Hazardous
Danger-Poison	Highly Hazardous
Warning	Moderately Hazardous
Caution	Slightly Hazardous

The toxicity categories are defined by the type of formulation, the oral LD50, and dermal LD50. The parameters of each category are given in the chart on p. 27.

10. **Symbols.** Graphic symbols are an excellent way to call attention to the danger of pesticides. This is why a "skull and crossbones" symbol is frequently found on pesticide containers. The symbol is a graphic reminder that the contents can kill if not handled properly.



11. **Hazards to humans and domestic animals.** This section should indicate the ways in which the pesticide may be poisonous to man and animals. The LD50 (oral, dermal, and inhalation) should be given in this section. It should also indicate what type of protective clothing is required when working with the pesticide.

12. **Environmental hazards.** To help avoid undesirable adverse effects to the environment, the pesticide label should contain, if applicable, precautions such as:

> "This product is highly toxic to fish; do not contaminate bodies of water when applying, cleaning equipment, or disposing of excess pesticide."

or

> "This product is extremely toxic to bees exposed to direct treatment or residues; do not apply in areas where bees are kept."

13. **Physical and chemical hazards.** This section should indicate any special fire, explosion, or chemical hazard posed by the product.

14. **Statement of practical first aid.** If the product poses a hazard from ingestion, inhalation, or skin or eye contact, the label must indicate emergency first-aid procedures. It should also indicate what types of exposure require medical attention. The label should list the information required by a physician in treating someone who has been poisoned. The names and dosages of antidotes should be provided.

15. **Reentry statement.** If required, this section should indicate how much time must pass before a pesticide-treated area is safe for reentry by a person not wearing protective clothing.

16. **Storage and disposal directions.** This section should indicate the correct procedures for storing the pesticide product and disposing of the pesticide containers once emptied.

17. **Warranty statement.** Each pesticide label should specify to what degree the manufacturer or distributor limits the warranty of the pesticide product.

18. **Misuse statement.** This section is a reminder that it is in violation of national laws to use the pesticide product in a manner inconsistent with its labeling. This includes the use of a pesticide on a crop or pest for which it is not registered.

19. **Directions for use.** The instructions on how to use the pesticide product are a very important part of the label. This section should state:

    - The pests for which the product is registered control.
    - The crop or other areas where the pesticide can be used.
    - The form in which the pesticide should be applied (sprayed, dusted, used as a dip, etc.)
    - How much to use (the dosage).
    - Where the pesticide should be applied (fruit, foliage, incorporation into soil).
    - When it should be applied and how frequently.

20. **Harvesting statement.** This section should state the minimum interval between the last application of the pesticide on a crop and the time to harvest.

    In the Appendices you will find a sample prototype label.

RELABELING

For various reasons, you will at times be faced with the problem of unlabeled or improperly labeled pesticide containers. This could be due to deterioration of pesticide labels during transport or storage, or pesticide containers which are not labeled correctly when purchased.

The person in charge of a pesticide warehouse is responsible for making certain that all pesticides stored at the facility are properly labeled. He should keep copies of labels of all the pesticides stored at the facility on file. If pesticides are delivered in improperly labeled containers, he should immediately **contact the supplier and request sufficient copies of the correct labels.** If labels deteriorate during transport or storage, the file copies can be used to make additional copies. The copies can then be attached to any containers missing labels. The use of a strong glue is probably the best method for attaching new labels to containers.

The warehouse manager should double-check all pesticides leaving the facility to make certain they are correctly labeled.

In Appendix III, you will find an example of labels of pesticides commonly used in Africa.

SIGNS OF PESTICIDE DETERIORATION

Pesticides do deteriorate with age. Some pesticides will remain effective longer than others. The amount of time that a pesticide will remain effective if stored properly is called the **"shelf life"** of the pesticide. Improperly stored pesticides lose their efficacy much faster than properly stored pesticides. How do you tell if a pesticide has lost its efficacy? One way, of course, is to treat with it. If the pest is controlled at the recommended dosage, the pesticide is still good; if the pest is not controlled, then there is a chance that the pesticide has lost at least some of its effectiveness. For some formulations, there are ways to tell whether a pesticide is still good without actually testing it on pests. These are presented in the table below.

Formulations	**Signs of Deterioration**
Emulsifiable concentrates	When water is added to the formulation, the solution does not turn a white milky color; or when there is sludge present in the formulation
Wettable powders	Lumping occurs and the powder will not stay mixed with water
Dusts	Excessive lumping
Granulars	Excessive lumping

For other formulations, it is more difficult to tell. ULV and oil solution formulations have relatively long shelf lives and, if properly stored, will remain effective for many years.

What should you do with pesticides that have reduced effectiveness? The best solution is to treat with the pesticide, using a higher than normal dosage rate. Experiment with dosage rates until the effectiveness of your treatments matches the effectiveness of a treatment made using pesticide that has not deteriorated. If the pesticide has virtually no effectiveness, that is, it will not control pests even at very high dosage rates, it must be disposed of (see section of this manual titled "Disposing of Unwanted Pesticides").

CLEANING UP PESTICIDE SPILLS

Pesticides are safe and effective only when used in accordance with professional recommendations by properly trained persons. When a pesticide is spilled, it can create an extreme danger to man and the environment. The best way to avoid pesticide spills is by not letting them happen. Always be extremely careful when working with pesticides.

Nevertheless, sometimes pesticides are spilled where we do not want them and you should be familiar with the procedures to follow in containing and cleaning up pesticide spills.

What to Do if a Pesticide Is Spilled

1. **Evaluate the situation.** Have people been hurt or exposed to the pesticide? Has the pesticide entered into a water source? Is there a chance of fire? Do you have the knowledge and means necessary to deal with the situation, or should you call for help? All these questions must be answered as soon as possible. Once you have evaluated the situation, you can begin to take steps to contain and clean up the spill.

2. If people have been directly exposed to the pesticide, begin decontamination and first-aid measures at once. (Several excellent source materials on first-aid procedures are found in Appendix V.) Get the people to a hospital if necessary.

3. Certain pesticide formulations, especially emulsifiable concentrates, oil solutions, and ULV are highly flammable. In case of a fire at a pesticide warehouse:

   - If there are people in the area downwind from the fire, begin evacuating this area immediately. **Fumes from pesticide fires can be extremely toxic.**

   - Contact the nearest Fire Department and Police Station.

   - Alert firemen that they should wear protective clothing and respirators while fighting the fire.

   - Firemen should attempt to stay upwind from the fire, if at all possible.

   - Firemen should be made aware that some pesticide containers will explode if overheated. They should stay as far away from the fire as possible.

   - Firemen should avoid using a heavy stream of water from hoses as this will spread the pesticide and could cause pesticide dusts to become airborne which presents a possible explosion hazard.

   - As soon as firefighting operations are completed, firemen should remove their clothing and thoroughly wash. The clothing worn during firefighting operations should be decontaminated before being worn again.

   - Runoff water from firefighting operations is usually contaminated with pesticide. Make sure this water does not enter a stream, lake, or ground water source.

4. If a water source has been contaminated, notify the police and public health officials. Immediate steps must be taken to keep people and animals from drinking contaminated water.

5. Keep bystanders and any other unauthorized persons away from the spill site.

Cleanup Techniques

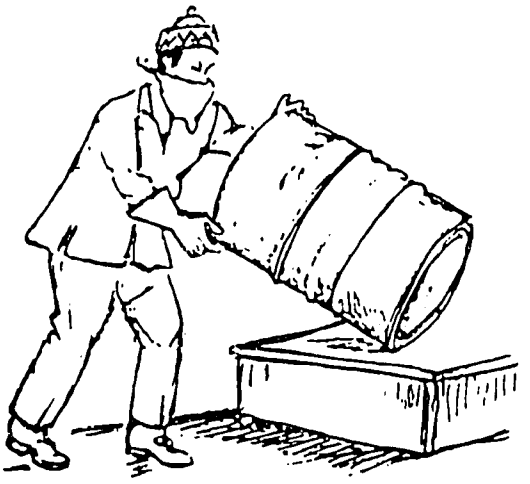
Dry formulations (dusts, granules, baits, wettable powders)

1. Keep the pesticide from spreading. Finely ground formulations such as dusts and wettable powders are easily blown by the wind. Cover the spill with a tarp or plastic sheet.

2. Sweep the pesticide into a pile and shovel it into appropriate containers such as plastic sacks or steel drums. Keep a tarp over the spill while sweeping and shoveling to keep the pesticide from blowing away.

3. Once the pesticide is in sacks or other appropriate containers, the containers must be properly labeled. The pesticide can probably still be used. If not, dispose of it following the recommendations in the section of this manual titled "Disposal of Pesticides and Containers."

Liquid formulations (Emulsifiable concentrates, ULV, Oil Solutions)



1. If possible, stop more liquid from leaking out of the faulty container by turning it over. Place the container so that the hole is on top.

2. Stop the spill from spreading by shoveling sand, sawdust, charcoal, or other absorbent material around the spill to create a barrier. Dirt will work if no other material is available.

3. Shovel sand, sawdust, charcoal, or other absorbent material over the spill to soak it up. Do not use more absorbent material than you have to since this contaminated material will eventually have to be disposed of.

4. Shovel the mixture of pesticide and absorbent material into appropriate containers. Metal drums are the best. Label the containers.

5. Store the contaminated material in a safe locked place until you dispose of it. This material should be disposed of according to the recommendations given in the section of this manual titled "Disposal of Pesticides and Containers."

Decontamination of Spill Sites

After cleanup procedures have been completed, there will still be pesticide remaining on the spill site. The area should be decontaminated. Most agricultural pesticides can be chemically altered to less toxic substances by adding bleach and/or lime to the pesticide. If lime is not available, wood or charcoal ash can be used. This process is called "decontamination." The steps below outline spill site decontamination procedures:

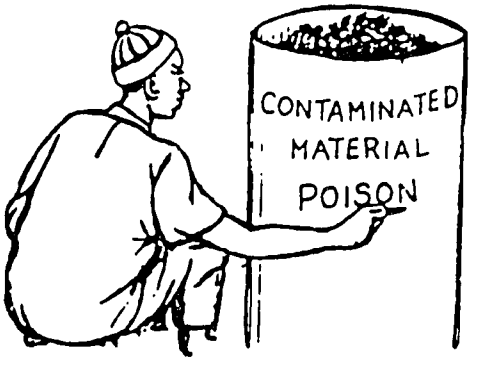
1. Spread the spill as thinly as possible over the spill site.

2. Sprinkle or spray the area with a mixture of equal parts of bleach and water.

3. Spread lime or ash over the area and let it sit for a minimum of one hour.

4. Wash down the area with water. Make sure the runoff water will not enter into a water source. If there is a chance this will happen, the runoff water must be collected, or diverted to keep it from contaminating the water source.

5. If the pesticide was spilled in a populated area such as in a village, remove the top 3-5 cm of dirt from the spill site. Shovel the soil into containers and dispose of as recommended in the section of this manual titled "Disposal of Pesticides and Containers."



DISPOSAL OF PESTICIDES AND CONTAINERS

There are two disposal problems related to pesticide usage: first, what to do with excess pesticides; and second, what to do with empty containers.

DISPOSING OF UNWANTED PESTICIDES

Disposing of Excess Pesticides

The best way to deal with this problem is to avoid it. Excess pesticides can be divided into two categories:

- Pesticides left in the sprayer after completing a treatment.
- Old pesticide stocks that you do not want to use or which have lost their effectiveness.

The first problem can be avoided by always carefully estimating how much pesticide to mix or add to the application equipment to treat the target area. The second problem can be avoided by procuring only the pesticides you will be using, and in the quantities you will be using, for a one-year period.

Nevertheless, both types of excess pesticide problems do arise, and you should be familiar with the correct procedures for disposing of excess pesticides.

Excess pesticide remaining in an application machine after treatment

The best method to dispose of excess pesticide left in your sprayer (or other type of application equipment) is to apply it to an area where it will have as little adverse effect as possible. An adjacent area which has a similar pest problem is ideal. This is preferable to dumping all the pesticide in one place. If you want to increase the speed of breakdown of the pesticide, you can add bleach to the pesticide before spraying. This will help neutralize it.

If the pesticide remaining in the machine has not been diluted, then you can probably recover the pesticide and return it to its **original container**. The container should then be properly resealed and stored. Never use any container except the original one or one exactly like it.

Old pesticide stocks

The best method to get rid of old pesticide stocks is to use them as they were intended to be used. If, however, the pesticide in question is no longer effective or can no longer be legally used (e.g., certain chlorinated hydrocarbons), alternative methods of disposal must be found.

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Because of the dangers associated with unwanted pesticides, experts should always be consulted on their disposal. No one method can be recommended for all situations. The best method will depend on the type of pesticide, the formulation, the quantity concerned, and the resources available. Some of the disposal alternatives are described below:

- High-temperature dedicated rotary-kiln incineration. Nearly all pesticides can be destroyed by burning at very high temperatures (1,000-2,000 °C). Special incinerators can be constructed to burn pesticides and other hazardous wastes. However, these incinerators are very expensive and many countries do not have any.

- Cement-kiln incineration. High-temperature kilns are used to make cement and most countries have at least one cement factory. Hazardous wastes, such as pesticides, can be used to meet part of the fuel requirements for producing cement. The cement factory must be slightly modified to allow burning of liquid pesticides for fuel. Solid pesticides (dust, wettable powders, granules, and baits) can also be burned in cement kilns with more extensive modification to the kiln. Cement-kiln incineration is certainly one technique whose use should be further investigated for Africa.

- Land farming. This method involves the application of unwanted pesticides to remote tracts of land and letting nature take care of the degradation over time. For some pesticides this will occur very rapidly (few days or weeks) while others can persist for long periods of time. The pesticides are primarily degraded by sunlight and microbial organisms.

- Chemical methods. There is great hope that methods will be found for the destruction of pesticides using other chemicals. However, no suitable methods have reached a field application stage.

The disposal of obsolete pesticides is a difficult and potentially dangerous undertaking. As mentioned previously, expert advice should always be sought before disposing of unwanted pesticide stocks.

Centralization/Containment

As an interim solution to the problem of unwanted pesticide stocks, it is advisable to centralize the obsolete stocks in one or a few safe and secure locations. If done properly, this will minimize the danger to people and the environment.

Choosing the site(s):

- The area should not be prone to flooding during the rainy season.

- The site should have a deep water table so that the likelihood of leaking pesticides entering ground water are minimized.

- The site should be located near areas where the largest stocks of obsolete pesticides are found.

- The site should be as distant from residential areas as possible. Prevailing winds should be taken into consideration to avoid pesticide dusts.

- There should be no chance that runoff water from rains will flow into a watershed or towards inhabited areas.

- Once chosen, the site should be secured with a strong fence which should be always locked except when pesticides are transported to or from the containment site. Signs should be attached to the fence in several locations to warn the public of the danger. It is also a good idea to post a guard at the site to keep persons and animals from attempting to enter.

Overpack barrels

Overpack barrels are simply containers large enough to hold original pesticide containers. Pesticides which are in leaking or deteriorating containers are placed inside the overpack barrels and sealed to keep pesticides from entering the environment. Overpack barrels are a useful interim solution to the unwanted pesticide stock problem.

DISPOSAL OF EMPTY CONTAINERS

After pesticide containers have been emptied, they must be properly disposed of. **Pesticide containers can never be washed out well enough to make them safe for alternate usage.** The disposal of used containers is a problem that has not yet been satisfactorily resolved in many countries. Many governments do not have set policies concerning the disposal of empty pesticide containers.

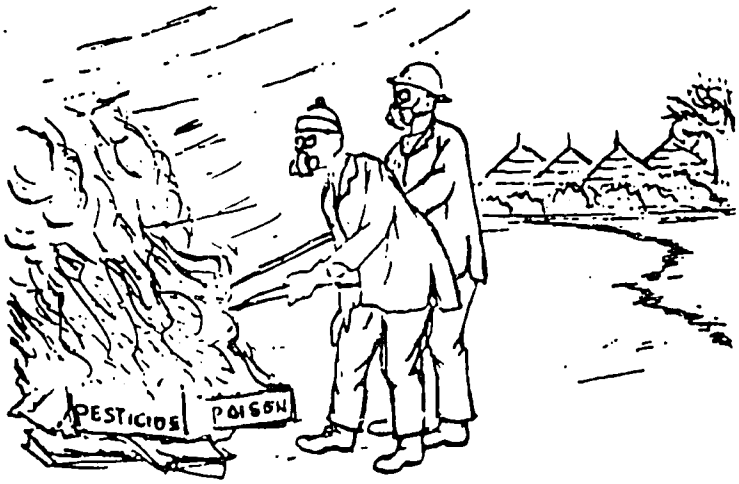
Below are guidelines on how to dispose of empty containers. Reference is also made to the disposal of pesticides and pesticide-contaminated materials.

Containers That Will Burn

This category includes containers that are made out of paper, cardboard, fabric, plastic, and wood. These types of containers can be burned. If at all possible, they should be burned in **high-temperature incinerators.** If a high-temperature incinerator is not available, they can be burned in the open, but this is a very dangerous procedure. It is usually preferable to bury the containers as outlined in the following section on the disposal of containers that will not burn. If it is decided to burn empty containers, the recommended procedure is outlined below:

- Make sure that all containers to be burned are as empty as possible.

- Choose a site far away from populated areas. The fumes from burning pesticides are extremely hazardous.



- Never attempt to burn containers by yourself. Always have at least two people at the site.
- Wear proper protective clothing. A respirator is essential.
- Before lighting the fire, be sure that you are upwind to avoid inhalation of the fumes.
- Burn only small quantities of containers at one time.
- Herbicide containers should never be burned during the growing season. The fumes can seriously damage plants growing in the area.
- Bury the ashes of the fire.

It must be stressed that burning empty pesticide containers is a dangerous operation. High-temperature incineration is preferable. Governments should take steps to build pesticide incineration facilities if they do not already exist.

Containers That Will Not Burn

This category includes glass and metal containers. The first thing to do when containers are emptied is to follow what is called the "Triple Rinse" procedure.

- When a container is emptied, turn it upside down and drain for thirty seconds into the sprayer tank.

- Add a diluent. For emulsifiable concentrates, use water; for ULV and oil solutions, use an appropriate solvent such as diesel fuel. The table below gives the recommended quantity of diluent to add to various sized containers.

Container Size	Amount of Diluent to Add per Rinse
5 liters	1 liter
20 liters	4 liters
100 liters	15 liters
200 liters	20 liters

- Agitate the container and then let drain for thirty seconds into the sprayer tank. Repeat this procedure two more times.

AFTER COMPLETING THE TRIPLE RINSE, THERE WILL STILL BE PESTICIDE REMAINING IN THE CONTAINER AND IT SHOULD NEVER BE USED FOR ANY PURPOSE OTHER THAN STORING PESTICIDES.

The rinsate should be added to the sprayer and applied as if it was a full-strength pesticide.

The triple-rinse procedure, although recommended in some developed countries, may not be desirable in Africa due to the problem posed by the large volume of rinsate produced. Spraying out the rinsate is expensive, may damage crops (if the diluent is not water), and will probably not effectively control the target pest.

An alternative to triple-rinsing is to neutralize any liquid pesticide remaining in barrels with an alkaline substance. For most organophosphates and carbamates the following procedure should be used to neutralize the pesticide remaining in 200-liter barrels:

- Drain the barrel as complete as possible into the spray tank or collection container.

- Add 20 liters of water, 250 ml of detergent, and one kilogram of flake lye or sodium hydroxide to each empty barrel.

- Close barrel and rotate to wet all surfaces.

- Let stand for 15 minutes.

- Drain completely and rinse twice with water. Rinsate should be drained into a shallow pit in the ground far from ground or surface water and inhabited areas.

Although the procedure described above will work for most organophosphate and carbamate pesticides, pesticide manufacturers or their representatives should be contacted for specific recommendations on neutralizing their products.

After the container has been rinsed, the best thing to do is to return it to the supplier. The supplier can reuse the container if it is in good condition, or properly dispose of it if the container is damaged.

If it is not possible to return the container to the supplier, then you must properly dispose of it. The following steps are recommended:

- Break glass containers and crush metal ones. This will assure that they are not used for alternative purposes such as carrying water or food.

- Bury the containers. Certain guidelines should be followed when burying pesticide containers. These are:

  1. The site chosen for burial should not be near ground or surface water sources. Avoid areas which have ground water close to the surface.

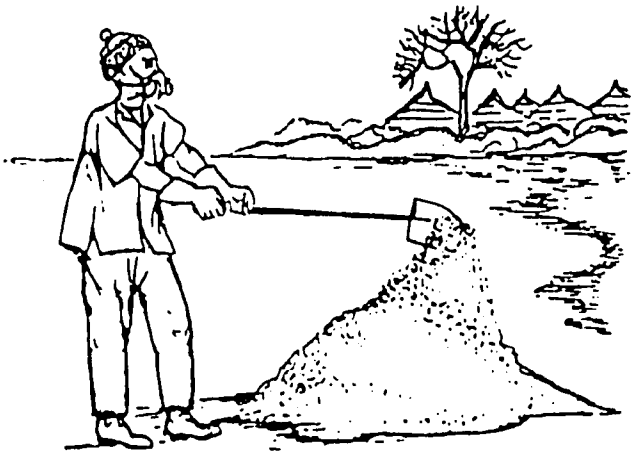
  2. Avoid areas that become flooded with water during the rainy season.

  3. The site should be far away from inhabited areas.

  4. The soil at the site should be clay or have a heavy organic matter content.

  5. Large numbers of containers or amounts of pesticides should not be buried at one site.

  6. Liquid pesticide containers will still contain small amounts of liquid pesticide. It is advisable to add an absorbent material like groundnut husks, sawdust, charcoal, or sand when burying liquid pesticide containers. This will slow seepage of pesticide into the ground.



7. Ash, lime, or bleach can be added to speed up breakdown of the pesticide.

8. Pesticides or containers should be buried at least 50 cm below the surface of the ground.

9. When filling in the pit where pesticides were buried, mound the soil over the site so that it is higher than adjacent areas. This will allow rainwater to run off rather than soak in at the site.

10. The location where pesticides are buried should be recorded and filed at an appropriate location.

APPENDIX I

SAMPLE PROBLEMS AND CALCULATIONS

A. Economic Thresholds

Example: Suppose you have a one-hectare tomato field infested with caterpillars that are eating the tomato fruits. Each worm eats 2 tomatoes during its life. You can sell the tomatoes for 100 FCFA each. To purchase enough pesticide to treat your field and control the caterpillars would cost 2,000 FCFA. What is the economic threshold for these caterpillars?

Answer: Remember that the economic threshold is the insect population density at which the value of the harvest lost is equal to the cost of a control treatment.

The cost of a control treatment is given as 2,000 FCFA.

The value of the harvest lost **per caterpillar** is:

$$\frac{\text{2 tomatoes destroyed}}{\text{caterpillar}} \times \frac{\text{100 FCFA}}{\text{tomato}} = \frac{\text{200 FCFA destroyed}}{\text{caterpillar}}$$

The economic threshold is therefore:

$$\text{2,000 FCFA} \div \frac{\text{200 FCFA}}{\text{caterpillar}} = \text{10 caterpillars per hectare}$$

If there are more than 10 caterpillars in your field, you should treat. If there are less than 10, you will lose money by treating.

Economic thresholds get lower as the amount of damage done per insect increases. What would the economic threshold be, if each caterpillar ate 4 tomatoes?

Answer: 5 caterpillars per hectare.

Economic thresholds get lower as the value of the crop increases. What would the economic threshold be if each tomato could only be sold for 50 FCFA?

Answer: 20 caterpillars per hectare.

Economic thresholds get lower as the cost of treatment decreases. What would the economic threshold be if the pesticide needed to treat the field only costs 1,000 FCFA?

Answer: 5 caterpillars per hectare.

Note: This is a very simplified example. For instance, the cost of the treatment did not include the cost of the sprayer, the monetary value of labor required to treat, etc. For grasshoppers

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feeding on millet leaves, where the pest does not damage the harvest portion of the plant directly, calculation of an economic threshold is more complicated.

B. LD50 of Various Formulations of Pesticides

In order to better understand toxicity ratings of pesticides, a few examples using LD50 values are provided.

1. The acute oral LD50 for Malathion is 1,300 mg/kg. Suppose you have a Malathion 50EC formulation (50% active ingredient). What is the LD50 for this formulation?

   Answer: Since the LD50 of 1,300 is for pure Malathion and you have a formulation which is only 50% Malathion with the other 50% being inert, then it would take twice as much of the formulation to have the same effect as the pure active ingredient. Therefore, we can conclude that the LD50 of the formulation is 2,600 mg/kg.

   Using the formula: $\frac{\text{LD50 of a.i. x 100}}{\text{\% a.i. in formulation}}$ = LD50 of formulation

   $\frac{1{,}300 \times 100}{50} = 2{,}600$ mg/kg

2. Suppose a baby weighing 15 kg accidentally swallows 25 grams of Malathion 50EC. Is there more than a 50% chance that the baby will die?

   Answer: The acute oral LD50 of Malathion is 1,300 mg/kg. Therefore, a baby weighing 15 kg would have a 50% chance of dying, if he/she swallowed 15 x 1,300 milligrams of Malathion. This would be 19,500 mg or 19.5 g.

   But remember: the formulation only contains 50% active ingredient and, therefore, the baby swallowing 25 grams would only be ingesting 12.5 grams of the active ingredient. Since 12.5 g is less than 19.5 g we can conclude that the baby would have a greater than 50% chance of living.

   Note: This does not mean that the baby would not become very sick and possibly die. The LD50 is an average figure for a population of test animals and, therefore, individual human responses cannot be predicted with certainty.

3. Carbofuran (Furadan) is a very toxic pesticide with an acute oral LD50 of 10 mg/kg. Endosulfan is less toxic with an acute oral LD50 of 70 mg/kg.

   Suppose we have a formulation of Endosulfan 35 EC and a formulation of Carbofuran 3G (3% granules). Which formulation is more toxic orally?

Answer:

Using the formula: For Carbofuran $\frac{10 \times 100}{3} = 333$ mg/kg

For Endosulfan $\frac{70 \times 100}{35} = 200$ mg/kg

We can, therefore, conclude that the Endosulfan formulation is the more orally toxic of the two. Also, remember that liquid formulations, such as the Endosulfan 35 EC, are generally more hazardous for the applicator than dry formulations. The reason is because the liquid formulations are more readily absorbed through the skin, lungs, and stomach than dry formulations.

C. Calculating Field Area

Example: You pace off an area and find the length to be 250 steps and the width to be 100 steps. You know that your step is 70 cm long. What is the size of this area?

Length = 250 steps x 70 cm = 17,500 cm = 175 m

Width = 100 steps x 70 cm = 7,000 cm = 70 m

175 m x 70 m = 12,250 m^2 = 1.225 hectares

Therefore, the area is 1.225 ha.

Example: You are treating with an Exhaust Nozzle Sprayer mounted in a Unimog. Before the treatment, the kilometer reading on the odometer is 8,701 km. After completing the treatment, the kilometer reading is 8,714 km. You have made 10 passes through the area and the distance between passes is 200 meters. What is the area treated?

D = (8,714 - 8,701) x 10 = 130 hectometers

n = 10

L = 200/100 = 2 hectometers

Area treated = $\left(130 - [(10 - 1) \times 2]\right) \times 2 = 224$ hectares

Therefore, the area you have treated is 224 hectares.

D. Sprayer Calibration

1. Suppose you want to calibrate a manual backpack sprayer which you will use to apply an emulsifiable concentrate diluted in water.

   - Measure out 100 m^2.
   - Fill the sprayer completely full with water.
   - Treat the 100 m^2 area.
   - Determine how much water has been applied by measuring how much water it takes to refill the sprayer to the level you started with.

   Let us assume that it takes 2 liters to refill the sprayer.

   You know that the sprayer applied 2 liters/100 m^2. Now convert this to liters/hectare. Remember.

   1 hectare = 10,000 m^2.

   100 m^2 is 1/100 of a hectare. Therefore, you would multiply the amount applied on 100 m^2 by 100 to find the flow rate per hectare.

   2 liter x 100 = 200 liters/hectare.

2. Suppose you have a crank duster and want to determine how much Propoxur dust the duster will apply per hectare. You would follow the same steps as above, except that you would use the Propoxur dust to calibrate rather than water. Suppose the duster puts out 500 grams/100 m^2. What is the application rate per hectare?

   $$500 \text{ grams} \times \frac{10{,}000}{100} = 50{,}000 \text{ grams or } 50 \text{ kg/hectare}$$

APPENDIX II

SAMPLE FORMS

A. Pest Survey Form

MINISTRY OF AGRICULTURE & NATURAL RESOURCES
CROP PROTECTION SERVICE, THE GAMBIA

FIELD CROP INSECT SURVEY

1. Crop: _____
2. Stage of crop growth: _____
3. Village: _____
4. Farmer: _____
5. Date: _____
6. Time: _____
7. Field area (hectares): _____
8. Scout: _____
9. Pretreatment inspection: _____
   Or
   Posttreatment inspection: _____
10. Notes on weather conditions: _____
    _____
    _____
11. Notes on presence of other pests or pest damage:
    a. Vertebrates (birds, rodents, monkeys, bush pigs, hippos): _____
    _____
    _____
    b. Plant diseases: _____
    _____
    _____
    c. *Striga* (silo) or other weeds: _____
    _____
    _____
12. If this field is one of those being evaluated in the Crop Loss Assessment Program, then indicate the plot number: _____
    _____
    _____

FIELD CROP INSECT SURVEY

		*	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
I. Insects chewing on leaf, flower, fruit	Grasshoppers																						
	Blister beetles																						
	Leaf beetles																						
	Net-winged beetles																						
	Scarab beetles																						
	Army worms																						
	Other caterpillars																						
	Earwigs																						
II. Insects sucking on leaf, flower, fruit	Aphids																						
	Scale insects																						
	Mealybugs																						
	White flies																						
	Frog, Leafhoppers																						
	Seed bugs																						
	Stainers																						
	Stink bugs																						
	Leaf-footed bugs																						
	Thrips																						
	Sorghum midge																						
	Other _____																						
III. Insects in stem or fruit	Stemborers																						
	Corn earworm																						
	Millet earworm																						
	Rice gall midge																						
	Other _____																						
IV. Soil insects	Termites																						
	Ants																						
	Crickets																						
	Grubs																						
	Millipedes																						
	Sowbugs																						
	Other _____																						
V. Beneficial insects	Praying mantids																						
	Assassin bugs																						
	Lacewings																						
	Lady beetles																						
	Ground beetles																						
	Syrphid flies																						
	Robber flies																						
	Tachinid flies																						
	Parasitic wasps																						
	Other _____																						

*Level of observed damage (H = high, M = medium, L = low, N = none) due to this potential pest.

B. Record of Pesticide Treatment

RECORD OF PESTICIDE APPLICATION

Name _____ Position _____

Region _____ Duty Station _____

Locality treated _____

Pest(s) _____

Type of vegetation _____

Date of treatment _____

Time of treatment _____

Pesticide used _____

Dosage _____

Type of application equipment _____

Area treated (ha) _____

Amount of pesticide used _____

Pest density before the treatment _____

Pest density after the treatment _____

Observations _____

_____

_____

_____

_____

C. Pesticide Inventory Form

PESTICIDE INVENTORY FORM

Location _____ Pesticide _____

Responsible Agent _____

DATE	ORIGIN/DESTINATION	QUANTITY ARRIVING	QUANTITY LEAVING	TOTAL STOCK	REMARKS

APPENDIX III

SAMPLE PESTICIDE LABEL

Sevin® 4-Oil

Brand Carbaryl Insecticide Rhône-Poulenc

For Agricultural or Commercial Use Only

ACTIVE INGREDIENTS:
Carbaryl (1-naphthyl N-methylcarbamate).....46.1% by wt.
INERT INGREDIENTS:.....53.9% by wt.
This product contains petroleum distillates.
Contains 4 pounds carbaryl per gallon

KEEP OUT OF REACH OF CHILDREN

CAUTION

For PRODUCT USE Information Call 1-800-334-9745
For EMERGENCY Information ONLY Call 24 Hours A Day 1-800-334-7577

E.P.A. Reg. No. 264-323 E.P.A. Est. No. 264-MO-02

PRECAUTIONARY STATEMENTS

CAUTION
HAZARDS TO HUMANS AND DOMESTIC ANIMALS
MAY BE HARMFUL IF SWALLOWED. OVEREXPOSURE MAY CAUSE: Salivation, watery eyes, pinpoint eye pupils, blurred vision, muscle tremors, difficult breathing, excessive sweating, abdominal cramps, nausea, vomiting, diarrhea, weakness, headache. IN SEVERE CASES CONVULSION, UNCONSCIOUSNESS AND REPIRATORY FAILURE MAY OCCUR. SIGNS AND SYMPTOMS OCCUR RAPIDLY FOLLOWING OVEREXPOSURE TO THIS PRODUCT.

Avoid breathing of spray mist. Do not take internally. Avoid contact with eyes, skin or clothing. Wear regular long-sleeved work clothing and head covering when making overhead applications. Change to clean clothing daily. Bathe and wash hair after each work day. Do not eat, drink or use tobacco while working with this product or spray solutions. Wash hands and face before eating, drinking or using tobacco. Keep out of reach of children and domestic animals.

ANTIDOTE STATEMENT

ATROPINE SULFATE IS HIGHLY EFFECTIVE AS AN ANTIDOTE. Narcotics and other sedatives should not be used. Further, drugs like 2-PAM (pyridine-2-aldoxime methiodide) are NOT recommended. See NOTE TO PHYSICIAN below.

STATEMENT OF PRACTICAL TREATMENT

GENERAL

Contact a physician immediately in all cases of suspected poisoning. Transport patient to a physician or hospital immediately and SHOW A COPY OF THIS LABEL TO THE PHYSICIAN. If poisoning is suspected in animals, contact a veterinarian.

IF SWALLOWED: Call a physician or Poison Control Center immediately. Give 1 or 2 glasses of water or milk to drink. Do not induce vomiting, may cause aspiration hazard. GET MEDICAL ATTENTION.

IF IN EYES: Hold eyelids open and flush with a steady, gentle stream of water for at least 15 minutes. Get medical attention if irritation persists.

IF ON SKIN: Wash thoroughly with soap and water.

IF INHALED: Remove to fresh air. If not breathing, give artificial respiration. Administer oxygen if necessary. GET MEDICAL ATTENTION.

NOTE TO PHYSICIAN

Carbaryl is a carbamate insecticide, which is a cholinesterase inhibitor. Overexposure to this substance may cause toxic signs and symptoms due to stimulation of the cholinergic nervous system. These effects of overexposure are spontaneously and rapidly reversible. Gastric lavage may be used if this product has been swallowed. Carbaryl poisoning may occur rapidly after ingestion and prompt removal of stomach contents is indicated. PRECAUTION: To prevent aspiration of petroleum distillates, lay patient on side with head lower than waist.

Specific treatment consists of parenteral atropine sulfate. Caution should be maintained to prevent overatropinization. Mild cases may be given 1 to 2 mg intramuscularly every 10 minutes until full atropinization has been achieved and repeated thereafter whenever symptoms reappear. Severe cases should be given 2 to 4 mg intravenously every 10 minutes until fully atropinized, then intramuscularly every 30 to 60 minutes as needed to maintain the effect for at least 12 hours. Dosages for children should be appropriately reduced. Complete recovery from overexposure is to be expected within 24 hours.

Narcotics and other sedatives should not be used. Further, drugs like 2-PAM (pyridine-2-aldoxime methiodide) are NOT recommended.

To aid in confirmation of a diagnosis, urine samples should be obtained within 24 hours of exposure and immediately frozen. Analyses will be arranged by Rhône-Poulenc Ag Company.

Consultation on therapy can be obtained at all hours by calling the Rhône-Poulenc emergency number 1-800-334-7577.

ENVIRONMENTAL HAZARDS

This product is extremely toxic to aquatic and estuarine invertebrates. Do not apply directly to water and wetlands, except under the forest canopy. Do not apply when weather conditions favor drift from the area treated. Do not contaminate water by cleaning equipment or disposal of wastes. Do not contaminate water when disposing of equipment wash waters.

BEE CAUTION: MAY KILL HONEYBEES IN SUBSTANTIAL NUMBERS. This product is highly toxic to bees exposed to direct treatment on blooming crops or weeds. Do not apply this product or allow it to drift to blooming crops or weeds if bees are visiting the treatment area. Contact your Cooperative Agricultural Extention Service or your local Rhône-Poulenc Ag Company representative for further information.

SPECIMEN ONLY

DIRECTIONS FOR USE

IT IS A VIOLATION OF FEDERAL LAW TO USE THIS PRODUCT IN A MANNER INCONSISTENT WITH ITS LABELING.

GENERAL INFORMATION

SEVIN® brand 4-Oil Carbaryl Insecticide is a dispersion of finely ground technical carbaryl in a non-aromatic, low volatile oil. It is designed for air application as a low volume or ultra low volume spray. It may also be applied by ground mist blower or cold fogging, if diluted with diesel fuel, kerosene or #2 fuel oil. READ THIS LABEL BEFORE USE. USE IN STRICT ACCORDANCE WITH DIRECTIONS AND CAUTIONS.

GENERAL WORKER PROTECTION STATEMENT

Do not apply this product in such a manner as to directly or through drift expose workers or other persons. The area treated must be vacated by unprotected persons.

Do not enter treated areas without protective clothing until sprays have dried.

Because certain states may require more restrictive reentry intervals for various crops treated with this product, consult your State Department of Agriculture for further information.

Written or oral warnings must be given to workers who are expected to be in treated area or in an area about to be treated with this product. Advise workers to stay out of fields during application and until sprays have dried. Regular long-sleeved work clothing should be worn when working in treated fields. See PRECAUTIONARY STATEMENTS, STATEMENT OF PRACTICAL TREATMENT AND NOTE TO PHYSICIAN for information on accidental exposures. When oral warnings are given, warnings shall be given in a language customarily understood by workers. Oral warnings must be given if there is reason to believe that written warnings cannot be understood by workers. Written warnings must include the following information: Appropriate signal work (CAUTION), area treated with SEVIN® brand 4-Oil Carbaryl Insecticide, date of application, appropriate clothing, and re-entry interval (i.e., until sprays have dried).

PRE-HARVEST AND GRAZING USE INFORMATION AND LIMITATIONS

Tolerances established under the Federal Food, Drug and Cosmetic Act permit the sale of crops bearing probable carbaryl residues when this product is used in accordance with label directions. If used as directed, treated forage may be grazed or used as feed for dairy and meat animals without causing illegal residues in meat or milk. See specific crop directions for grazing and preharvest interval restrictions and limitations.

Do not plant rotational food and feed crops not listed on this or other carbaryl labels in carbaryl treated soil.

Do not use reclaimed irrigation water from crops treated with carbaryl on upland crops for which carbaryl tolerances are not established.

PLANT RESPONSE PRECAUTION

To avoid possible injury to tender foliage, do not apply to wet foliage or when rain or high humidity is expected during the next two days.

SPRAY PREPARATION

SEVIN® brand 4-Oil Carbaryl Insecticide thickens during storage. Roll or agitate drums or recirculate product in bulk tanks before use to reduce viscosity and restore homogeneity. SEVIN® brand 4-Oil Carbaryl Insecticide may be held prior to use and transferred in any materials of construction suitable for use with fuel oil, kerosene or diesel oil. Protect from water.

Before and after use, flush nurse tanks, pumps, lines, hoses and entire spray systems with diesel fuel, kerosene or #2 fuel oil until clean. Water, scale, rust and other residue must be removed from pumps, mixing and spray systems before use.

COMPATIBILITY

SEVIN® BRAND 4-OIL CARBARYL INSECTICIDE COMPATIBILITY.INSECTICIDE IS NOT COMPATIBLE WITH AND SHOULD NOT BE MIXED WITH WATER, ALCOHOL OR AROMATIC SOLVENTS, but can be diluted with aliphatic oils (diesel fuel, kerosene or #2 fuel oil). Compatibility with other pesticides has not been thoroughly tested. DO NOT USE IN TANK MIX COMBINATIONS UNLESS YOUR EXPERIENCE INDICATES THAT THE MIXTURE IS EFFECTIVE AND WILL NOT RESULT IN PLANT INJURY OR MECHANICAL DIFFICULTY. For best mixing when preparing diluted SEVIN® brand 4-Oil Carbaryl Insecticide, add diluent oil to mix tank before adding proper volume of SEVIN® brand 4-Oil Carbaryl Insecticide. Provide complete recirculation of diluted suspensions once every 24 hours to maintain uniformity.

APPLICATION

On all crops use sufficient gallonage to obtain thorough and uniform coverage. Calibrate equipment to deliver the desired spray volume. Flat fan nozzles may be used to apply both undiluted and diluted SEVIN® brand 4-Oil Carbaryl Insecticide. Rotary atomizing and hollow cone nozzles are not recommended for applying undiluted SEVIN® brand 4-Oil Carbaryl Insecticide but can be used if 1 to 1 dilution is made. Use of a high-volume 50-mesh in-line strainer is suggested. Use of screens behind nozzles is not recommended. Apply by air undiluted, or diluted with kerosene, diesel fuel or #2 fuel oil. At temperatures below 50°F (10°C) dilution of 4 volumes of SEVIN® brand 4-Oil Carbaryl Insecticide with 1 volume of diluent oil is recommended to assure uniform flow and spray distribution. Dilutions greater than 1 to 1 by volume are not recommended; higher dilutions will reduce residual properties. Dilute 1 to 1 by volume when applying with ground equipment. Apply only when weather conditions are favorable. Wind and rising air currents may cause undesirable spray drift and reduce insect control.

DIRECTIONS FOR USE THROUGH SPRINKLER IRRIGATION SYSTEMS

Apply this product only through sprinkler irrigation systems including center pivot and solid set. Do not apply this product through any other type of irrigation system.

SPRAY PREPARATION: Remove scale, pesticide residues, and other foreign matter from the chemical tank and entire injector system. Flush with clean water.

APPLICATION INSTRUCTIONS: First prepare a suspension of SEVIN® brand 4 Oil Carbaryl Insecticide in a mix tank. Fill tank with 1/2 to 3/4 the desired amount of diesel. Start mechanical or hydraulic agitation. Add the required amout of SEVIN® brand 4 Oil, and then the remaining volume of diesel. (Suspension concentrations using the appropriate dosage per acre recommended on this label of SEVIN® brand 4 Oil per 1 to 4 gallons of diesel are recommended). Then set sprinkler to deliver 0.1 to 0.3 inch of water per acre. Start sprinkler and uniformly inject the suspension of SEVIN® brand 4 Oil into the irrigation water line so as to deliver the desired rate per acre. The suspension of SEVIN® brand 4 Oil should be injected with a positive displacement pump into the main line ahead of a right angle turn to insure adequate mixing. If you should have any other questions about calibration, you should contact State Extension Service specialists, equipment manufacturers or other experts.

NOTE: When treatment with SEVIN® brand 4 Oil has been completed, further field irrigation over the treated area should be avoided until foliage has dried to prevent washing the chemical off the crop.

GENERAL PRECAUTIONS FOR APPLICATIONS THROUGH SPRINKLER IRRIGATION SYSTEMS

Maintain continuous agitation in mix tank during mixing and application to assure a uniform suspension.

Greater accuracy in calibration and distribution will be achieved by injecting a larger volume of a more dilute solution per unit time.

The system must contain a functional check value, vacuum relief valve, and low pressure drain appropriately located on the irrigation pipeline to prevent water source contamination from backflow. The pesticide injection pipeline must contain a functional, automatic, quick-closing check value to prevent the flow of fluid back toward the injection pump. The pesticide injection pipeline must also contain a functional, normally closed solenoid-operated valve located on the intake side of the injection pump and connected to the system interlock to prevent fluid from being withdrawn from the supply tank when the irrigation system is either automatically or manually shutdown. The system must contain functional interlocking controls to automatically shut off the pesticide injection pump when the water pump motor stops. The irrigation line or water pump must include a functional pressure switch which will stop the water pump motor when the water pressure decreases to the point where pesticide distribution is adversely affected. Systems must use a metering pump, such as a positive displacement injection pump (e.g., diaphram pump) effectively designed and constructed of materials that are compatible with pesticides and capable of being fitted with a system interlock. Do not apply when wind speed favors drift beyond the area intended for treatment.

Do not apply when wind speed favors drift, when system connection or fittings leak, when nozzles do not provide uniform distribution or when lines containing the product must be dismantled and drained.

Crop injury, lack of effectiveness, or illegal pesticide residues in the crop may result from non-uniform distribution of treated water.

Allow sufficient time for pesticide to be flushed through all lines and all nozzles before turning off irrigation water. A person knowledgeable of the chemigation system and responsible for its operation shall shut the system down and make necessary adjustments should the need arise.

Do not connect an irrigation system (including greenhouse systems) used for pesticide application to a public water system unless the label-prescribed safety devices for public water supplies are in place.

INSECT CONTROL

Apply when insects or their damage appear. To maintain control repeat at 7 to 14 day intervals or as necessary unless a shorter interval is specified below. Where a dosage range is indicated, use lower rate on young plants and early instars and higher rate on mature plants, advanced instars and adults. Thorough and uniform spray coverage is essential for effective control.

SEVIN® brand 4-Oil Carbaryl Insecticide does not control spider mites. If spider mites are a problem, use a registered miticide.

Regional differences have been noted in the susceptibility of certain strains of fall armyworm to SEVIN® brand 4-Oil Carbaryl Insecticide. If local experience indicates inadequate control, use an alternative pesticide.

Follow directions for most effective use. DOSAGES LISTED REFER TO QUARTS OF SEVIN® BRAND 4-OIL CARBARYL INSECTICIDE PER ACRE, NOT TO VOLUME OF FINISHED SPRAY PER ACRE.

CAREFULLY CALIBRATE ALL APPLICATION EQUIPMENT

ALFALFA INSECT CONTROL

For grasshoppers:
Apply 1/2 to 1 1/2 quarts of this product per acre. To avoid possible injury to tender alfalfa foliage, do not apply to wet foliage or when rain or high humidity is expected during the next two days.

Apply only once per cutting.

Do not apply to alfalfa within 7 days of harvest.

CORN (field, pop) INSECT CONTROL

For corn rootworm beetles:
Apply 1 quart of this product per acre as needed at first silking if populations are at economic levels and/or apply later when needed to control adult population buildup to reduce larval damage to next year's crop. Do not make more than two applications.

For western bean cutworm:
Apply a single application of 2 quarts of this product plus 2 quarts diesel fuel, kerosene or #2 fuel oil per acre when an average of 1 in 7 plants have western bean cutworm egg masses or newly hatched larvae and 90 to 100% of the tassels have emerged. Application after 100% of the silks have emerged will reduce effectiveness.

For Japanese beetle:
Apply 1 quart of this product per acre when adult beetles are present.

For grasshoppers:
Apply 1/2 to 1 1/2 quarts of this product per acre. Lower rate is suggested for nymphs on small plants. Use 1 1/2 quarts when grasshoppers of foliage are mature and greater coverage is required.

FOREST INSECT CONTROL

For control of gypsy moth, fall and spring cankerworms, saddled prominent, forest tent caterpillar, elm spanworm, oak leafroller complex and Japanese beetle: Apply 1 quart of this product per acre when larvae are in early instars and leaves are at least 1/3 grown, or when adult Japanese beetles are present.

For spruce budworm and western spruce budworm:
East of the Rocky Mountains apply 1/2 to 1 quart of this product per acre when a majority of the larvae are in the third through sixth instars. Lower rate is suggested for heavy spruce budworm infestations where 2 applications are necessary for adequate foliage protection. In the Rocky Mountains and west of the Rocky Mountains apply 1/2 to 1 quart of this product per acre when a majority of the larvae are in the third through fifth instars.

For Douglas-fir tussock moth:
For maximum foliage protection apply 2 quarts of this product per acre when larvae are in first and second instars. Application to later instars will provide control but with reduced foliage protection.

For population control and foliage protection of high value trees using ground mist blower application: Apply 0.8 pint of spray mixture containing equal volumes of this product and diesel fuel, kerosene or #2 fuel oil per 20 to 30 foot tree (0.2 lb. ai/tree) when larvae are in early instars. Cover foliage thoroughly, but avoid runoff.

PASTURE INSECT CONTROL

For grasshoppers:
Apply 3/8 quarts (12 fl. oz.) to 1 1/2 (48 fl. oz.) of this product per acre in a total spray volume of at least 20 fluid ounces per acre. For true armyworm, fall armyworm, black grass bug, chinch bugs, essex skipper, striped grass looper, thrips: Apply 1/2 to 1 quart of this product per acre. Use the lower rate for nymphs and immature insects on small plants or sparse vegetation. Apply the higher rate for adults or when vegetation is thick.

Apply a maximum of 2 applications per year. Allow at least 14 days between applications. Do not allow foraging or cut for hay within 14 days of last application by ground. Aerially treated pastures may be grazed or cut for hay on day of treatment.

Carefully mark swaths to avoid over-application.

RANGELAND INSECT CONTROL (FOR AERIAL APPLICATION ONLY)

For grasshoppers:
Apply 3/8 quart (12 fl. oz.) to 1 quart (32 fl. oz.) of this product per acre in a total spray volume of at least 15 fluid ounces per acre. **For black grass bugs, mormon cricket, range caterpillars, range crane fly:** Apply 1/2 to 1 quart of this product per acre. Use the lower rate for nymphs and immature insects on small plants or sparse vegetation. Apply the higher rate for adults or when vegetation is thick.

Apply a maximum of 2 applications per year. Allow at least 14 days between applications.

Carefully mark swaths to avoid over-application.

WASTELANDS, RIGHTS-OF-WAY, HEDGEROWS, DITCHBANKS, ROADSIDES INSECT CONTROL

For grasshoppers:
Apply 3/8 quart (12 fl. oz.) to 1 quart (32 fl. oz.) of this product per acre in a total spray volume of at least 20 fluid ounces per acre.

For black grass bugs, mormon cricket range caterpillar, range crane fly:
Apply 1/2 to 1 quart of this product per acre. Use the lower rate for nymphs and immature insects on small plants or sparse vegetation. Apply the higher rate for adults or when vegetation is thick.

Apply a maximum of 2 applications per year. Allow at least 14 days between applications. Do not allow foraging or cut for hay within 14 days of last applications by ground. Aerially treated areas may be grazed or cut for hay on day of treatment.

Carefully mark swaths to avoid over-application.

WHEAT INSECT CONTROL - (DO NOT USE IN CALIFORNIA.)

Do not apply within 21 days of harvest of grain. No time limitation on green wheat used as pasture or forage.

For grasshoppers:
Apply 1/2 to 1 1/2 quarts of this product per acre. Lower rate is suggested for nymphs on small plants. Use higher rate when grasshoppers are mature or vegetation is thick.

For cereal leaf beetle:
Apply 1 quart of this product per acre. Application is effective against eggs, larvae and adults.

For armyworm and fall armyworm:
Apply 1 to 1 1/2 quarts of this product per acre.

DIRECTIONS FOR USE AS A WHEAT BRAN BAIT
FOR END USE ONLY. NOT FOR REPACKAGING.

FOR USE ONLY BY GOVERNMENT PERSONNEL OR PERSONS UNDER THEIR DIRECT SUPERVISION.

Mixing Instructions
Mix the appropriate amount of SEVIN® brand 4-Oil Carbaryl Insecticide with wheat bran to make carbaryl wheat bran bait containing 2% to 10% active carbaryl. For example, for a bait containing 5% carbaryl, mix 1 quart SEVIN® brand 4-Oil Carbaryl Insecticide (contains 1 lb. active carbaryl) with each 19 pounds of wheat bran. Mix only the amount of bait necessary for each insect control program.

Storage Instructions
Store carbaryl bran baits in cool, dry area out of reach children and animals.
Do not contaminate water, food, or feed by storage or disposal.

NOTE: Carbaryl bran baits should only be stored temporarily while awaiting application.

Application Instructions
Applications may be made with ground equipment (hand cyclone spreader) or with aerial application equipment with a metered bait spreader attachment.

PASTURES, RANGELAND, WASTELAND, ROADSIDES
Use 0.50-1.50 lbs. active ingredient/acre for the control of grasshoppers and Mormon crickets. The lower rate is suggested for early instars on small plants or sparse vegetation. Use the higher rate for adults or dense vegetation. Use of low bait assay and higher rate is suggested for control of high grasshopper populations. Treatment may be repeated as necessary. Preharvest interval is 0 days.

STORAGE AND DISPOSAL

STORAGE

Store unused SEVIN® brand 4-Oil Carbaryl Insecticide in original container only, in cool, dry area out of reach of children and animals. Do not store in areas where temperatures frequently exceed 100° F.

PESTICIDE DISPOSAL

Do not contaminate water, food or feed by storage or disposal. Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.

CONTAINER DISPOSAL

Decontaminate empty bulk tanks. For drums: Triple rinse (or equivalent). Then offer for recycling or reconditioning, or puncture and dispose of in a sanitary landfill, or by other procedures approved by state and local authorities.
Consult Federal, State or local disposal authorities for approved alternative procedures.

LIMITED WARRANTY AND DISCLAIMER

The manufacturer warrants (a)that this product conforms to the chemical description on the label; (b)that this product is reasonably fit for the purposes set forth in the directions for use when it is used in accordance with such directions; and (c) that the directions, warnings and other statements on this label are based upon responsible experts' evaluation of reasonable tests of effectiveness, of toxicity to laboratory animals and to plants, and of residues on food crops, and upon reports of field experience. Tests have not been made on all varieties or in all states or under all conditions. THE MANUFACTURER NEITHER MAKES, NOR INTENDS, NOR DOES IT AUTHORIZE ANY AGENT OR REPRESENTATIVE TO MAKE, ANY OTHER WARRANTIES, EXPRESS OR IMPLIED, AND IT EXPRESSLY EXCLUDES AND DISCLAIMS ALL IMPLIED WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE.

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THIS SPECIMEN LABEL IS INTENDED FOR USE ONLY AS A GUIDE IN PROVIDING GENERAL INFORMATION REGARDING THE DIRECTIONS, WARNINGS AND CAUTIONS ASSOCIATED WITH THE USE OF THIS PRODUCT. AS WITH ANY AGRICULTRURAL CHEMICAL, ALWAYS FOLLOW THE LABEL INSTRUCTIONS ON THE PACKAGE BEFORE USING.

Rhône-Poulenc Ag Company
P.O. Box 12014, 2 T.W. Alexander Drive
Research Triangle Park, North Carolina 27709

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APPENDIX IV

TROUBLESHOOTING: PROBLEMS WITH SPRAYERS AND POSSIBLE SOLUTIONS

The following section outlines some of the more common problems that are encountered with manual backpack sprayers, compression sprayers, battery-operated spinning disc sprayers, and mistblowers. The section also provides the steps to follow to remedy the problems.

FAULTS	REMEDIES
Trombone Backpack Sprayers (single- or double-acting)	
No spray at nozzle	Check nozzle and clean, if necessary. Check that container is full. Check pump, especially nonreturn valves. Check for leaks in hose and connections.
No suction	Check pump, especially pump seal. Check valves and seatings. Check strainer in container.
Leaks from pump	Check gland and packing; replace if worn or damaged.
Lever-Operated Backpack Sprayers	
No spray	If resistance is felt on downward movement of lever with cut-off valve open, check nozzle for blockage, and clean if necessary. Check and clean filter or strainer in handle of cut-off valve. If no resistance is felt, check tank contents and fill if necessary. Ensure that operating lever is tight, together with all the connections to the pump. Check that when the lever is operated, the shaft or connecting mechanism and the piston or diaphragm all move together. Pump valves and valve seat should be checked. If worn or damaged, these should be replaced. Dirt and debris should be removed.
No suction	Ensure that liquid is present in the container. Check that the suction and discharge valves are not sticking. Make certain that the liquid ports that permit flow from tank to pump are not blocked. If a piston-type pump is employed, check that the piston seal is not excessively worn or damaged, as this will permit the liquid to pass between the piston and cylinder wall.

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FAULTS	REMEDIES
No pressure	Check liquid contents of container. Fill if necessary. After several strokes of the operating lever, look in the tank to see if air bubbles are rising to the surface. If so, this could indicate a leak in the pressure chamber. Where pressure chamber is screwed into the pump body, check that the seal is not damaged. Replace if necessary. Check both suction and discharge valves. Remove any accumulated dirt or debris from discs or balls and valve seats. If discs are worn or damaged, or the rubber is perished, replace. If ball valves and seats are pitted or balls are no longer spherical, replace with new ones. If resistance is felt when pumping and no reading is seen on pressure gauge, replace gauge. If pump is of diaphragm type, check that it is seating correctly, that is not damaged or split and that the rubber is not porous. Where a pressure-relief valve is embodied in the pressure chamber, check that it is adjusted correctly and that the openings between the pump inlet and outlet ports and the liquid container are not blocked. Check that the air vent in the filler cap is not blocked, as this could be the means of a vacuum forming in the container.
Pressure drops quickly	Check pressure chamber for leaks. Air bubbles seen rising to the liquid surface are a good indication. Check valves for discharge. The discharge rate may be higher than pump capacity.
Liquid leaks on to operator	Where pump is mounted in base of sprayer, a ruptured diaphragm, or one incorrectly assembled, will permit liquid under pressure to leak. For a piston-type pump, a worn piston seal or deep scratches in the cylinder wall will also permit the liquid to escape and wet the operator. Check the container for cracks or leaking joints. Metal tanks can be soldered or brazed. Check that the lid of the container is fitting tightly.
Compression Sprayers	
No spray	Ensure container has liquid. If pressure gauge shows a reading and there is no spray when cut-off valve is opened, close valve and check nozzle. If nozzle is blocked, follow procedure for clearing blocked nozzles. Check strainer in cut-off valve. Clean and replace. Check hose connections and tighten.

FAULTS	REMEDIES
No spray (continued)	If no reading is shown on the pressure gauge, ensure that the gasket between the pump body and the liquid container is not leaking. Replace if leaks are present. Remove pump from container and check by giving a few smart stroke on the pump handle to test the valve. On each pressure stroke, the valve should grunt or make a noise of escaping air. If the valve disc or ball is malfunctioning, it should be replaced. Where a dip-tube is part of the assembly, check that this is not blocked with debris.
Leaks from pump	After the container has been filled with spray liquid to the required level, if on the first or second downward stroke of the pump handle, liquid is forced up past the shaft and out through the guide, this is a good indication that the valve requires attention. Furthermore, if strong resistance is felt on the downward stroke, again the valve is faulty and has permitted liquid to enter the pump barrel and, as liquid cannot be compressed, resistance is encountered.
Pressure drops quickly	Check that the filler cap or lid gaskets are serviceable and that the cap is properly secured. Check also where a safety valve is fitted that it is not leaking and is in a working condition. Some compression sprayers have a constant-pressure valve fitted. Check that this is adjusted correctly and that there are no leaks from the point of entry to the tank. Ensure that all connections to the tank are tight and that all gaskets and washers are serviceable. Check tank for leaking seams by pressurising and immersing completely in water. Air bubbles rising to the surface will indicate the presence of a leak. Leaking tanks cannot be repaired in the field. All repaired compression sprayers must be pressure-tested to at least twice the working pressure before being used on spraying operations.
Other faults	If nozzle dribbles with cut-off valve closed, the "O" ring seal or the valve seat is damaged. Dismantle and check. Replace with new parts if unserviceable. With some of the plastic-type pressure gauges, the indicator pointer sometimes becomes loose on its pivot. This can give a false pressure reading. By tapping the gauge against the hand, it can be seen whether or not it is loose. If it is,

FAULTS	REMEDIES
Other faults (continued)	remove the protective glass front, replace the needle on the pivot loosely, and, with it pointing to zero, press it firmly on to its mounting. Replace the glass and check with a master gauge.
Spinning-Disc Sprayers	
No spray	Restrictor may be blocked. Clean with solvent or piece of very fine wire or grass stem. Check whether air vent is blocked.
Leaks	Check that spray container is fitted correctly.
Spinning disc not rotating, or rotating intermittently or slowly	Check that enough batteries are fitted in containers. Check that batteries are inserted the correct way. Check battery connections. Check switch (if any). Check connections to motor; clean connections with a dry cloth or sandpaper and fit new wires, if necessary. Check that the "+" terminal of the batteries is connected to the "+" terminal marked on the motor. Replace batteries if necessary. Where large numbers of the sprayers are in use, it is advisable to provide a voltmeter and tachometer to check the revolutions per minute of the disc. Check whether disc is fitted correctly to motor shaft; it may be pushed on too far and touch the backing plate. If necessary, replace motor.
Two-Stroke Engines Used for Motorized Mistblowers and ULV Sprayers (From Clayphon and Matthews, 1973)	
Engine does not start	
Fault in fuel system: Fuel cock not opened or locked	Ensure fuel is present in tank. Open cock. If no flow, remove cock, clean, and replace.
Air vent in fuel tank filter is blocked	Clean vent.
Thimble filter in carburetor blocked	Remove filter, clean, and replace.
Main jet in carburetor is blocked	Remove, clean, and replace.
Water in carburetor float bowl	Remove and clean. Check also that fuel in tank is not contaminated with water.

FAULTS	REMEDIES
Float needle sticking and stopping petrol supply	Remove needle, check for burrs or rough surface. Clean off rough surface; if not possible, replace with a new one.
Too much fuel in engine	Close fuel cock, remove spark plug, open throttle, pull recoil starter rope to turn engine over a few times, clean, and replace.
Fault in ignition system:	
High-tension lead to spark plug loose or disconnected, or insulation broken or burned.	Fasten lead securely to plug; if badly damaged, replace.
Dirty spark plug, carbon or oil deposits on electrodes	Remove plug and clean; set gap as recommended by manufacturer. If porcelain insulation is damaged, replace with new plug.
Contact breaker points dirty or pitted	Clean and adjust to correct clearance when points are open. If honing fails to remove pitting, replace with a new set.
Exhaust blocked	Remove exhaust and clean or replace with a new part.
Engine runs erratically or stops	
Dirt or floating debris in fuel system	Clean all fuel lines, filters, and carburetor bowl and check there is no air in fuel line.
Main jet blocked	Remove, clean, and replace. Do not use nail, pin or wire to clear obstruction.
High-tension ignition lead loose or "shorting" on metal parts of the engine	Check that lead is firmly affixed to spark plug. Where lead has been chafing on bare metal, either cover bare wire with insulation tape or replace with a new lead.
Fuel running low in tank. Engine vibration or irregular movement of operator leaves outlet pipe uncovered, resulting in fuel starvation.	Refill tank with correctly mixed fuel.

FAULTS	REMEDIES
Engine lacks power	
Choke is closed	Open choke.
Fuel starvation	Partially blocked pipes or filter should be removed and cleared.
Air cleaner blocked with debris	Remove, clean by washing in petrol, and squirt a little oil on the cleaner element. Conform with manufacturer's recommendations.
Dirty carburetor	Remove from engine, dismantle carefully, clean, and examine all parts. Any worn parts such as float needle valve, etc., must be replaced with new parts.
Loose or leaking joint at carburetor flange to cylinder.	Check gasket. Replace if worn or damaged and tighten nuts or studs.
If whistling noise is heard from cylinder when engine is running, there is a possibility of the cylinder head gasket being worn or damaged.	Check carefully by feel when engine is running. If gases are escaping, remove head, fit new gasket, and tighten nuts evenly. On a new machine, it may be necessary to tighten the nuts evenly without fitting a new gasket. If heavy carbon deposits are seen on piston crown or cylinder head when head is removed, these should be scraped away carefully. The ring of hard carbon should not be disturbed in the cylinder.
Dirty exhaust	Remove exhaust, clean carbon deposits from exhaust, if possible, or replace with new part.
Engine backfires	
Ignition may be badly retarded	Should only be attempted by trained or qualified workshop personnel. Magneto should be checked and reset to manufacturer's specification.
Carbon whisker bridging gap in spark plug	Remove plug, clean, adjust gap to correct clearance, and replace.

FAULTS	REMEDIES
Overheating of engine	
Incorrect mixture of petrol and oil in fuel tank.	Drain off tank. Refill with fuel mixed in the correct ratio (see handbook or markings on tank).
Incorrect size of main jet	Remove and refit one that complies with manufacturer's specification.
Ignition retarded too far	To be checked and reset by a competent person.
Exhaust and silencer choked with carbon	Remove, dismantle, clean, and reassemble.

APPENDIX V

FIRST-AID PROCEDURES

Several excellent sources discuss this subject well. Readers who need information on this subject can write for the following publications:

- Guidelines for emergency measures in cases of pesticide poisoning. 49 p. GIFAP. Nov. 1984.

- *Directives pour les mesures d'urgence dans le cas d'un empoisonnement par un produit phytosanitaire.* 49 p. GIFAP. 1984.

  "Copies of these Guidelines brochures and of the associated poster may be obtained from GIFAP and its member associations: GIFAP, Avenue Hamoir 12, 1180 Brussels, Belgium. Tel.: (2) 374-59-82 or 374-59-81, Telex: 62 120."

  "Des exemplaires de cette brochure et de l'affiche sont disponible au GIFAP ainsi que dans les bureaux des Associations membres: . . ."

- Recognition and Management of Pesticides Poisonings. Fourth Edition, by Donald P. Morgan. 207 p. 1989.

  Available through: Health Effects Branch, Hazard Evaluation Division, Office of Pesticide Programs, U.S. Environmental Protection Agency, Washington, D.C. 20460. Copies may also be available at the USAID mission offices.

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