PN-ABC-730
ISN 61519

PESTICIDE USER'S GUIDE

A Guide for Extension Workers in West Africa

Developed under the Regional Food Crop Protection Project
No. 625-0928, Agency for International Development
under a Participatory Agency Support Agreement with
the Animal and Plant Health Inspection Service of the
U.S. Department of Agriculture

Prepared by William Overholt

Issued in Draft, 1984
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This working document will be further revised after field testing and validation.

Suggested changes and other comments can be sent to:

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The mention of brand names of commercial products or the resemblance of illustrated products to actual commercial products does not imply the endorsement of the Agency for International Development.

ACKNOWLEDGEMENTS

After Bill Overholt prepared the initial version of this manuscript, Celeste Welty substantially revised and expanded it, with Mike Zeiss and Jude Andreasen contributing additional information. John Franklin supervised the entire project. Additional reviewing and editing by Kimberly Stoner, Carl Castleton, Dagnija Kreslins and Carroll Collier.

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PREFACE

This manual has been developed as a practical aid to government agricultural workers in West Africa as they try to reduce food crop losses caused by agricultural pests. More specifically, it is designed as a guide and reference for Crop Protection Service employees and agricultural extension agents who work with pesticides. The relevancy of this manual will vary depending on the user's function, but should be of value to all persons working in agricultural pest control. We have attempted to write in a simple and practical manner to be of use to the widest audience possible, ranging from village-level extension agents to crop protection service staff members.

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 others 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 West 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 West 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 West 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.

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 had caused. Another survey method could be to determine the number, location, and size of bird dormitories 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 ssp*, the millet spike borer. With *Raghuva*, it is difficult to detect their presence before they have already caused damage and by then it's 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 a survey method like this, 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 method used in survey can vary greatly depending upon the crop, the pest, and the resources available to conduct a survey.

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 cultural system (recession, rainfed, irrigation).

- The develpmental stage of the vegetation (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 stage nymphs, later stage 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?

- Localization of the damage (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 the appendix, you will find a survey form which is recommended for use in grasshopper and locust surveys in West 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 tend to be consistently higher or lower than others.

Below you will find a step by step description of a survey method commonly used for grasshoppers.

Survey Method for Grasshoppers in Pasture

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

2. Determine a straight line which traverses the field 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're 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 grasshopper 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've traversed the area. If you've 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.

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 arrrived. 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 West Africa are equiped 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/M2 STOP SEND HELP STOP", the crop protection service will not have sufficient information to accurately assess the situation. Are the grasshopper in cultivated fields or pasture? Has there been any damage to crops? What is the surface area infested, one hectare or 1000 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 on " 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 can 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 valuble in deciding when and where to mobilize intervention efforts in coming years. The three areas could also be analyzed to determine what charateristics 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.

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 didn't treat, we would incur a net loss. In this case, we're losing more than we're 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/m2. When the crop reaches the flowering stage, the plants can tolerate more grasshoppers and, therefore, the threshold might increase to 10 grasshoppers/m2. 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 West Africa is somewhat complicated because in many cases the farmer doesn't pay for pesticide treatments or for pesticides. It is sometimes 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 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?"

II. 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 of 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	NEMATICIDES
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 nematicide.

2. Chemical Group Classification: This is probably the least 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 organo-phosphates, the carbamates, and the synthetic pyrethroids. 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 organo-chlorines): Most pesticides in this group are very persistent in the environment and are not metabolized by most living organisms. 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 West 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 used in West Africa include BHC, DDT, and Dieldrin.

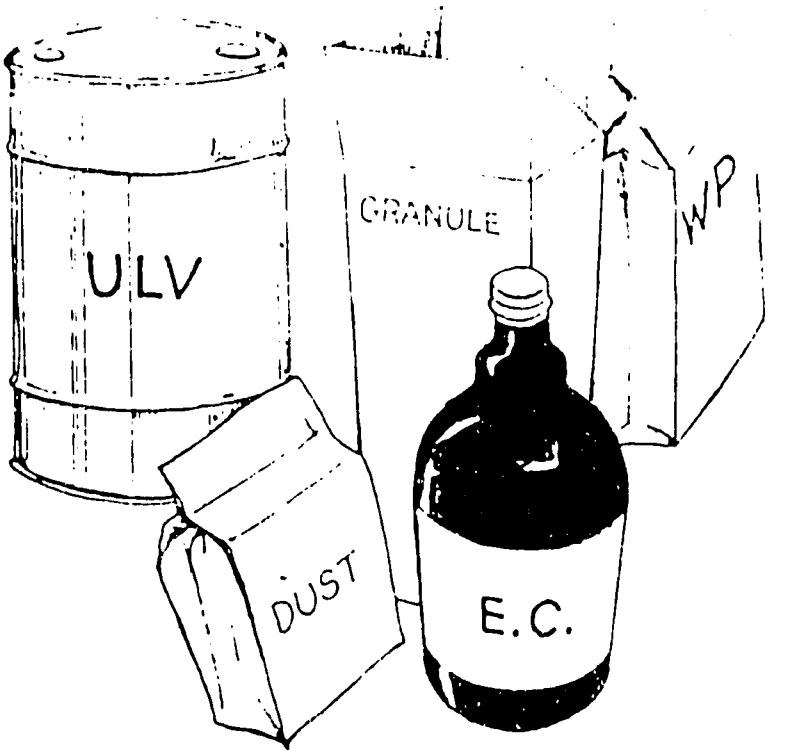
Organo-Phosphates: These pesticides vary from highly toxic to relatively non-toxic.. They are not persistent, lasting less than one month before breaking down into non-toxic substances. Examples of organo-phosphate pesticides used in West Africa include Malathion, Fenitrothion, and Diazinon.

Carbamates: These pesticides have similiar properties to the organo-phosphates. They tend to break down rapidly in the environment. The toxicity of carbamate pesticides varies from highly toxic to relatively non-toxic. Examples of some of the less toxic carbamates used in West Africa are Carbofuran, 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 have low toxicity to mammals. Some synthetic pyrethroids are somewhat persistent 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 West Africa are Deltamethrin (Decis), and Cypermethrin.

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 purpose in the formulation. Inert ingredients are added to dilute the active ingredient, emulsify the active ingredient, increase the sticking ability of the active ingredient to the target site, or increase the dispersion of the active ingredient over the target area.

ACTIVE INGREDIENT

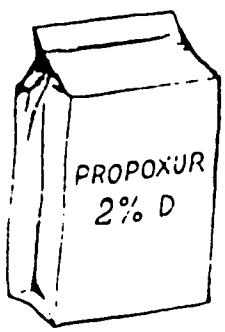
PESTICIDE FORMULATION

INERT INGREDIENTS

Diluents
Solvents
Emulsifiers
Sticking agents
Dispersing agents.

DESCRIPTIONS OF FORMULATIONS

The most common types of formulation used in West 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.

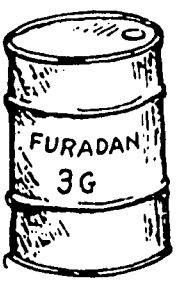
Disadvantages

- 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 West 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.

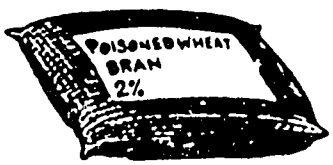
Advantages

- 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 above).

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 West 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 non-target 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.

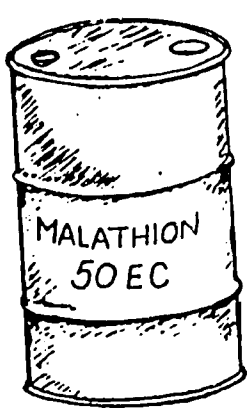
Advantages

- 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 or the powder will settle out.

An example of a wettable powder used in West 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. When mixed with water they form a white colored liquid. 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.

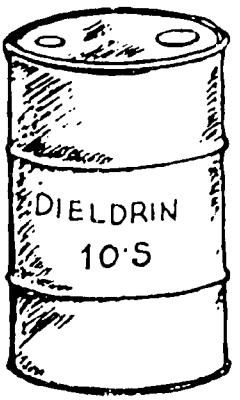
Disadvantages

- 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 West Africa is Malathion EC.

OIL SOLUTIONS

Abbreviations: S



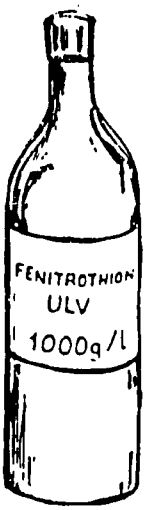
Oil solutions consist of an active ingredient dissolved in an organic solvent such as kerosene. Oil solutions usually have lower concentrations of active ingredient than emulsifiable concentrates. The use of oil solutions is less common than the other formulations, because the solvents can cause damage 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 EC's 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 very much like oil solutions except that the concentration of active ingredient is much higher. ULV formulations are usually between 50-100% active ingredient. 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. 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 West 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 West Africa for agricultural purposes.

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 agent. 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. Very high percentage of active ingredient. Use as formulated.	Most dangerous formulation for applicator. Risk of phytotoxicity.

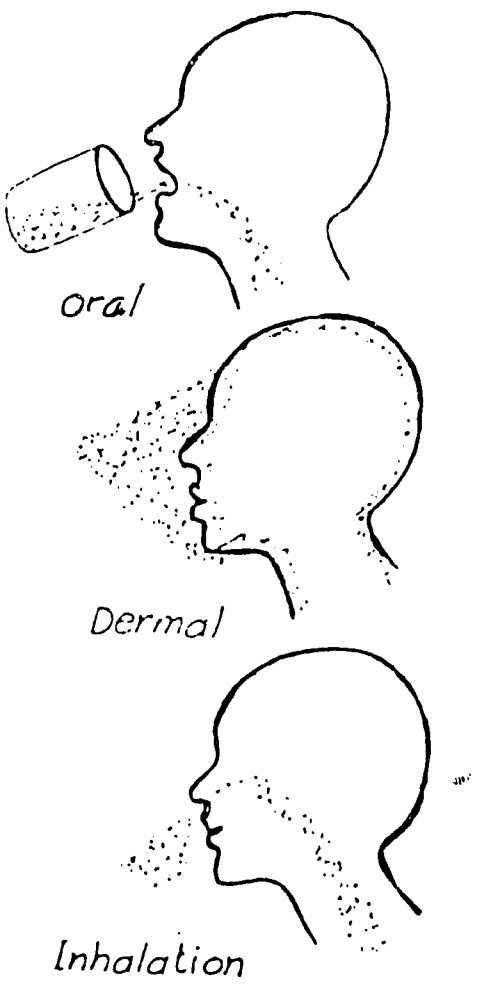
SOLUBLE POWDERS (SP)	Dry active ingredient. Mixed with water to form a solution.	Similar to WPs but no agitation is agitation is needed.
FLOWABLES (F) or (L)	Finely ground solid active ingredient which is suspended in liquid. Must be mixed with water.	Similar in use to ECs. Slight agitation needed.
AEROSOLS (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 <u>should not</u> 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

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

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

Pesticides can also enter your body when you breathe. 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 the 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 West 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 "ADI's" 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?

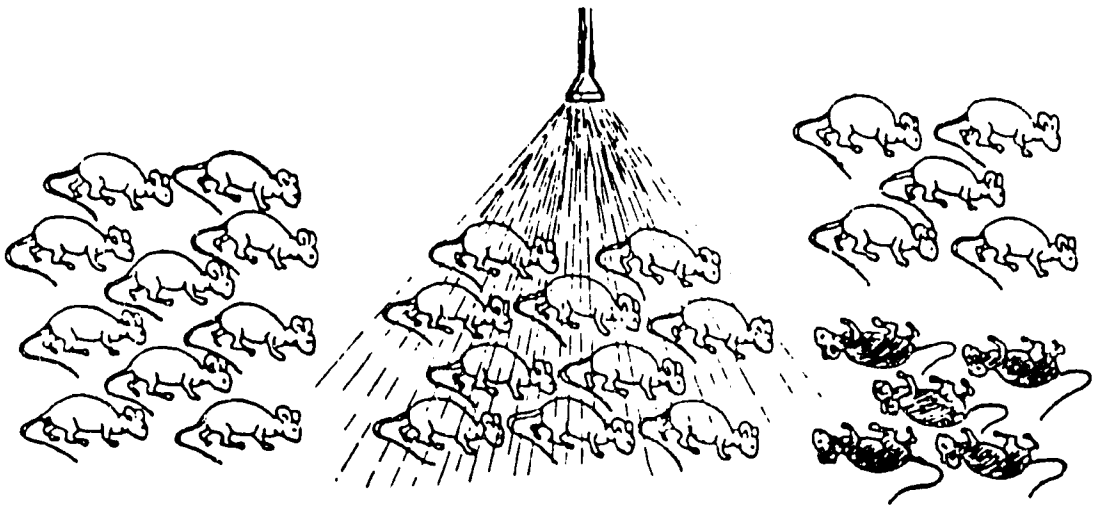
Since man cannot be used as a test animal, tests are made on mice, rats, rabbits, and other small mammals to determine what quantity of active ingredient of a pesticide will kill 50% of the animals tested. For example, after testing pesticide A, it is found that 500 milligrams of the active ingredient 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 non-toxic 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" (1a) or "Highly hazardous" (1b) for small farmers in less developed countries.

W.H.O. CLASSIFICATION SYSTEM ACCORDING TO ACUTE TOXICITY

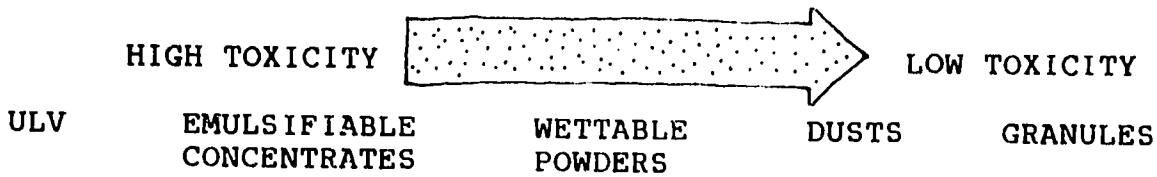
Class	Hazard level	Oral Toxicity*		Dermal Toxicity*	
		Solids**	Liquids**	Solids**	Liquids**
1a	Extremely hazardous	5 or less	20 or less	10 or less	40 or less
1b	Highly hazardous	5-50	20-200	10-100	40-400
II	Moderately hazardous	50-500	200-2000	100-1000	400-4000
III	Slightly hazardous	over 500	over 2000	over 1000	over 4000

* 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 (non-poisonous). 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:

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

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 cotrolled 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 wouldn't 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 wouldn't 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 wouldn't choose a ULV formulation. For certain formulations you don't need any application equipment. Granules and baits can be applied by hand if you're 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 doesn't 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. Don't 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 non-target organisms. In control operations you want to have as little adverse effect on non-target organisms as possible. For example, if you're 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 are usually very phytotoxic to 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 shouldn't be the only consideration. The others 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.

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 equipment most commonly found in West 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 thoroughly read 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

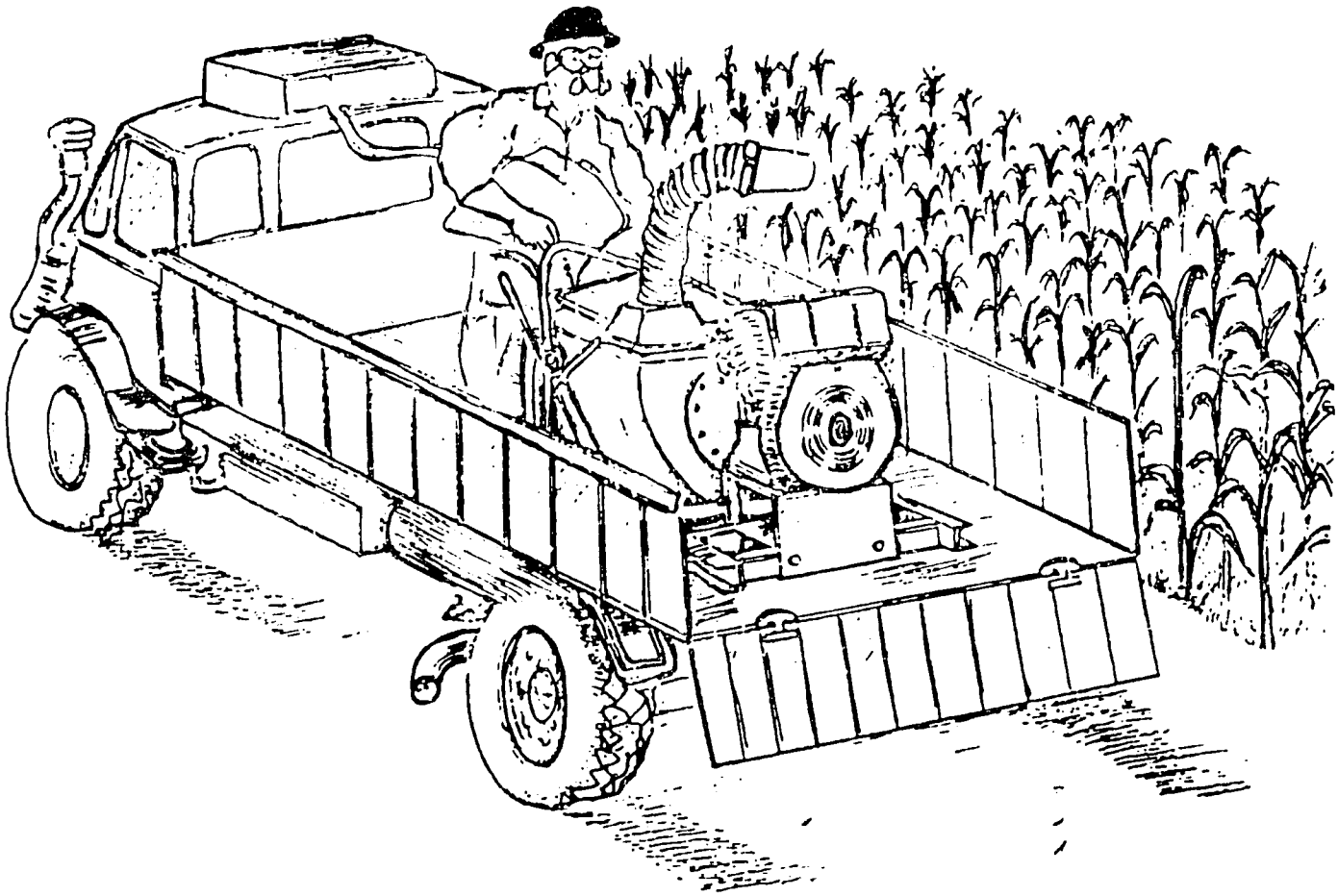
The use of small burlap sacks is a simple and inexpensive method of applying pesticide dusts. In West Africa they are often distributed to farmers along with pesticide dust for village-level insect control operations. The sacks should be about 20 cm wide and 50 cm long. A sack this size will hold

2-3 kgs 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 this manual on Weather Conditions). 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 sacks 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 cranks dusters can also be used for the application of granular and bait formulations. Check the manufacturer's recommendations.

TRUCK-MOUNTED DUSTERS



Large truck-mounted dusters work on the same principle as small hand crank dusters. The only difference is their size and the power source. Truck mounted dusters are driven by a power take off from the truck 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. Truck-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.

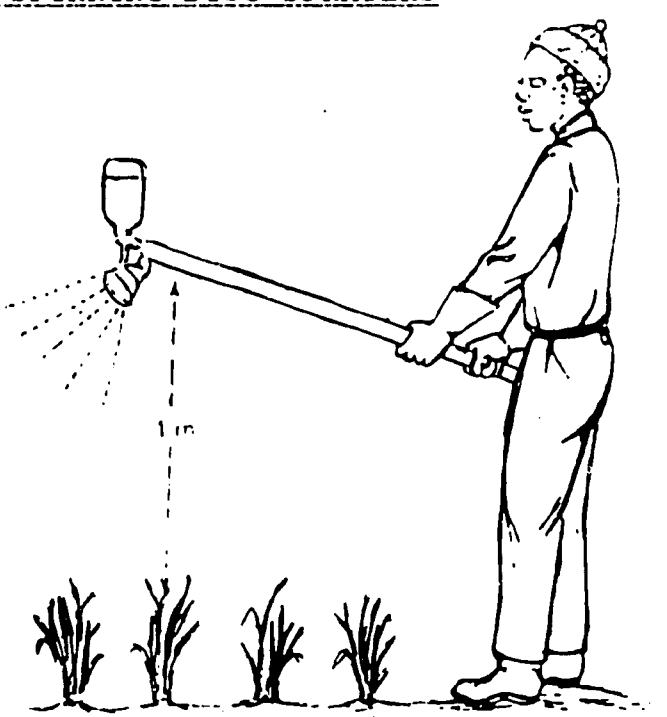
Lever operated:

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. Compres- sion 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.

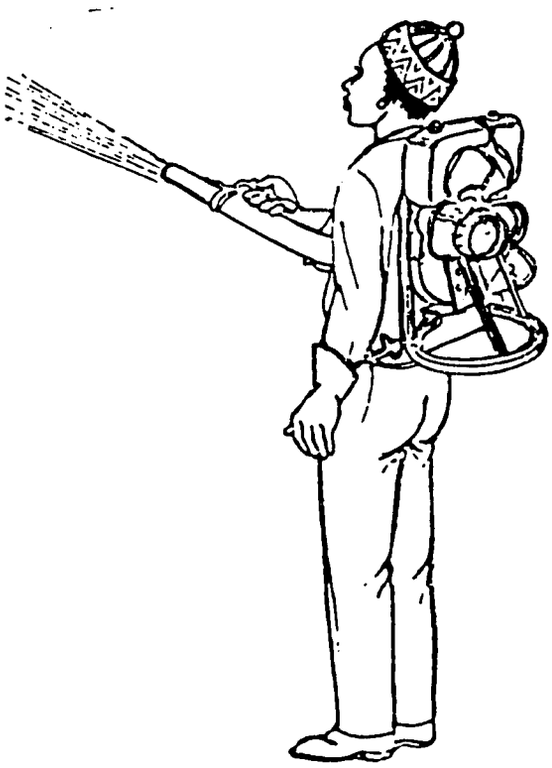
HAND CARRIED SPINNING DISC SPRAYERS



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 (9000-15000) 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 ml-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:

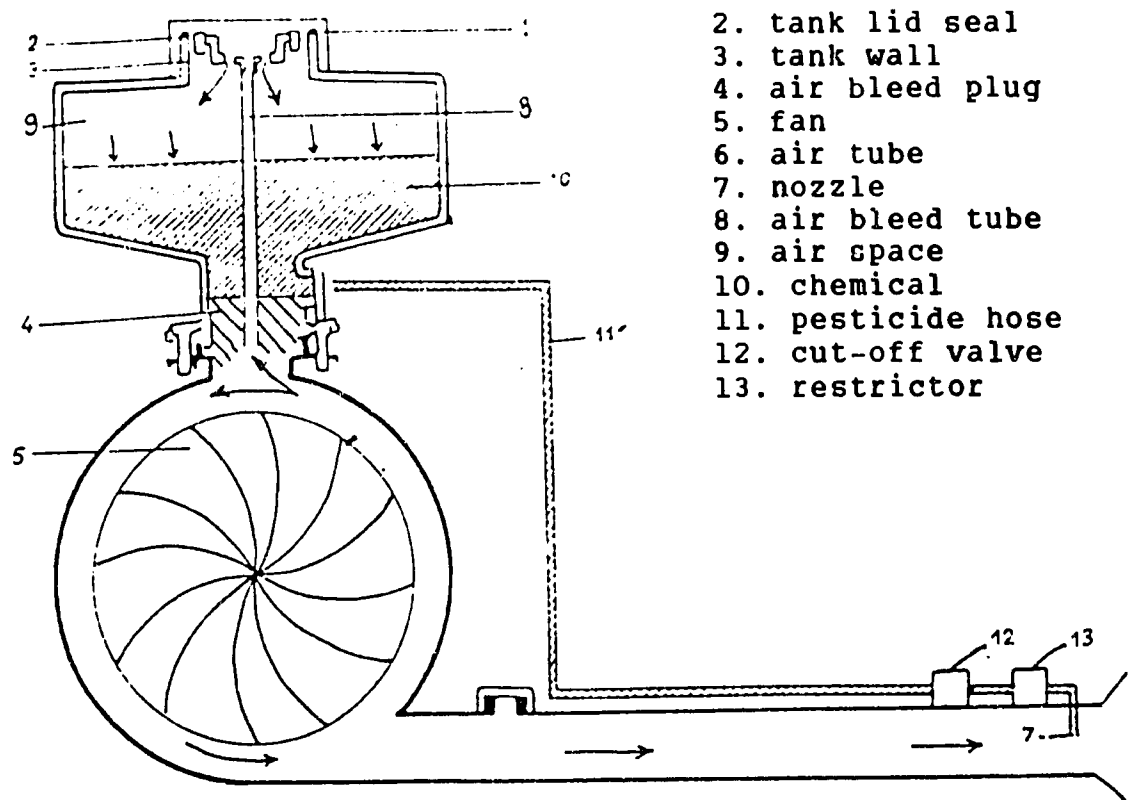


Backpack mistblowers consist of a small gasoline engine, a fan (blower), and spray tank. The engine drives the fan which creates an air stream. Pesticide is introduced into the air stream which breaks the pesticide into very small particles (50-100 microns in diameter). The pesticide is then blown out 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).

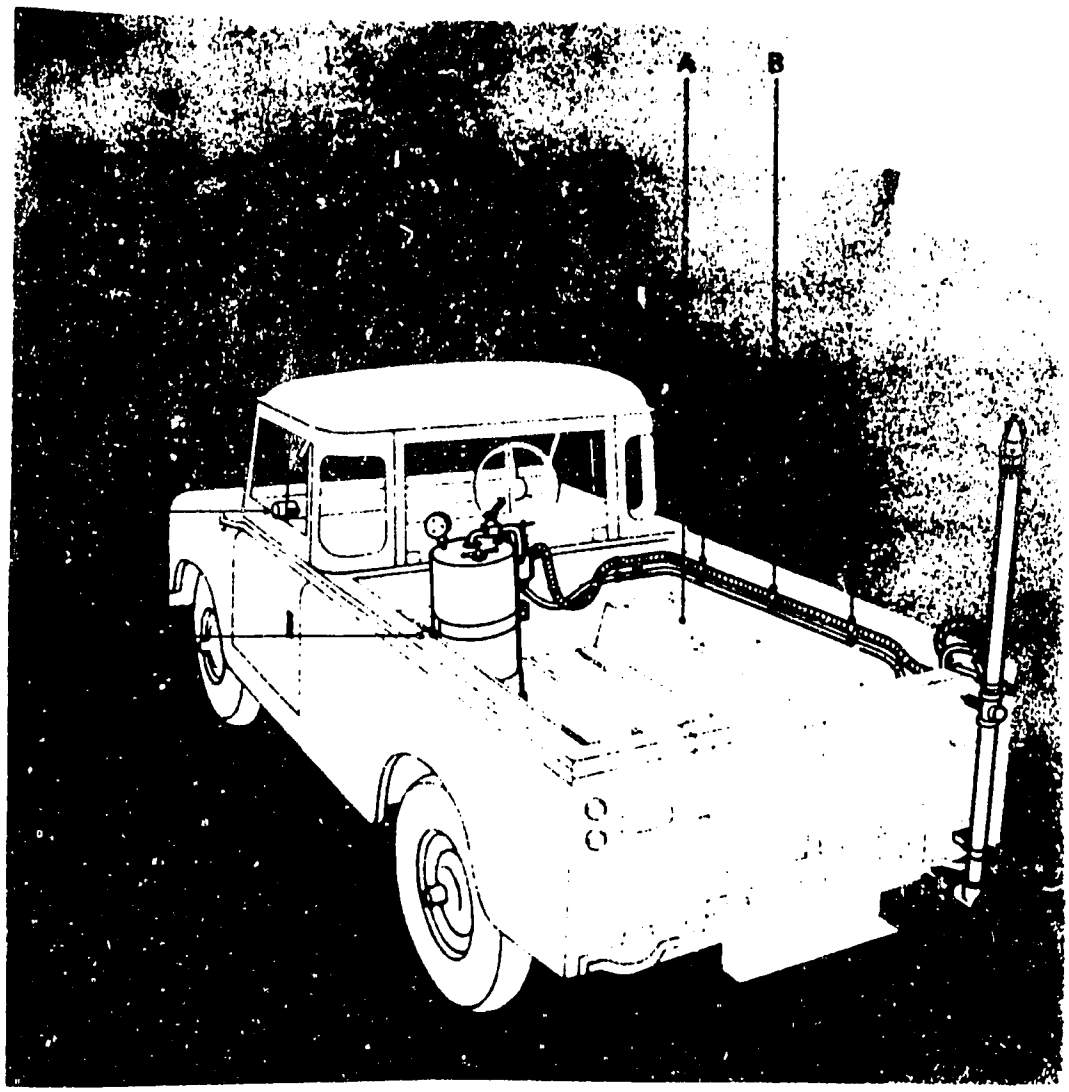
ULV Backpack Sprayers:

ULV backpack 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 4km/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.

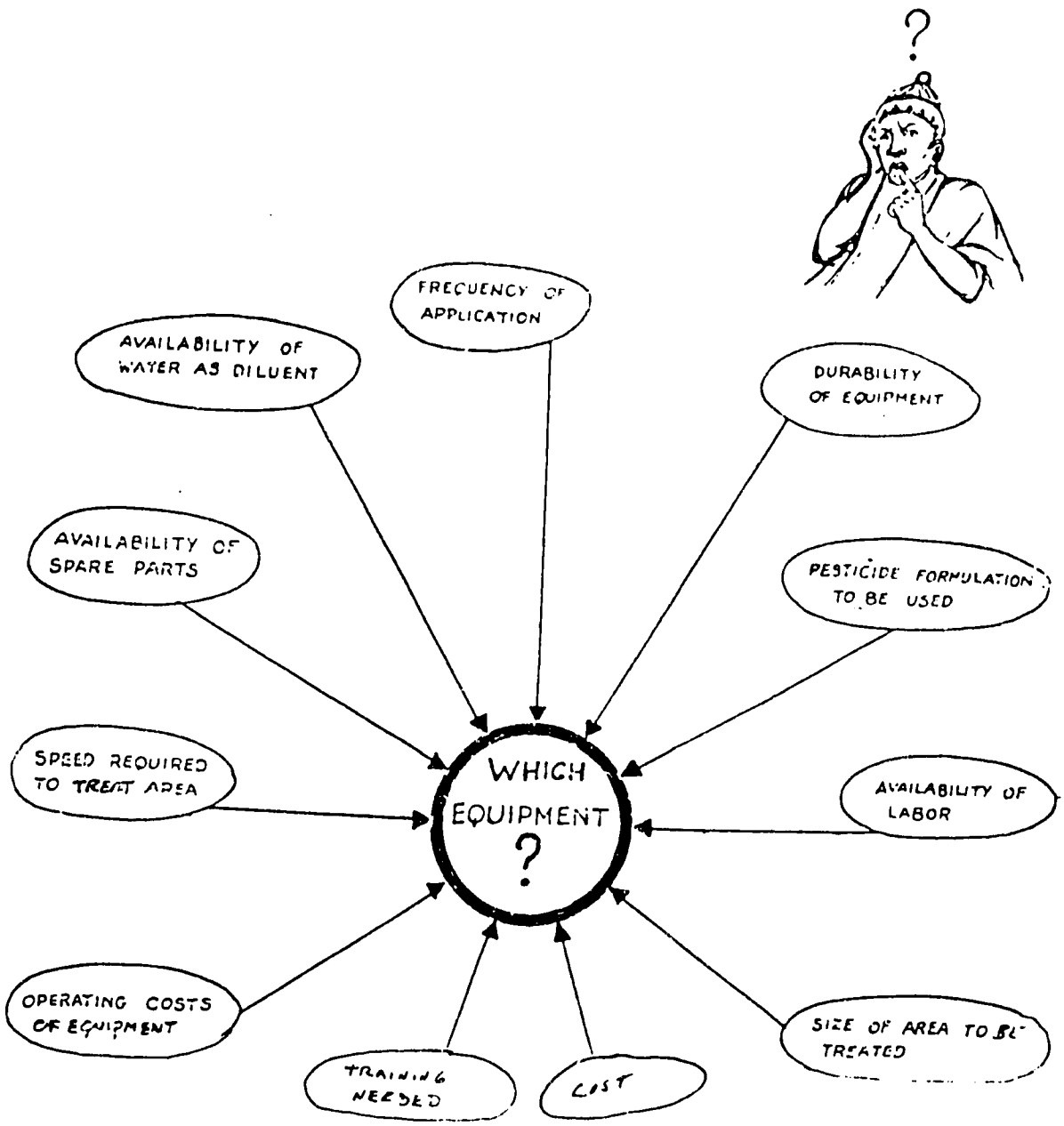
The ENS depends on the wind to carry the pesticide to the target area. The width of the swath treated by the ENS depends on the speed of the wind. OCLALAV recommends treating when wind speed is 1-6 meters/second. A wind of 1 meter/second will carry the pesticide 50-100 meters. A stronger wind of 6 meter/second will carry the pesticide up to 1000 meters.

For specific recommendations on the use of the ENS see "Utilisation du Pulverisateur 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 maintainance it receives. Thoroughly read and follow the manufacturer's recommendations on utilisation, care, and maintainance 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.

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 on Choosing of 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 2000? 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 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't be entered by vehicles so you wouldn't 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, don't choose application equipment designed to apply pesticides which must be diluted with water, such as emulsifiable concentrates and wettable powders. Where water isn't 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

aren't 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.

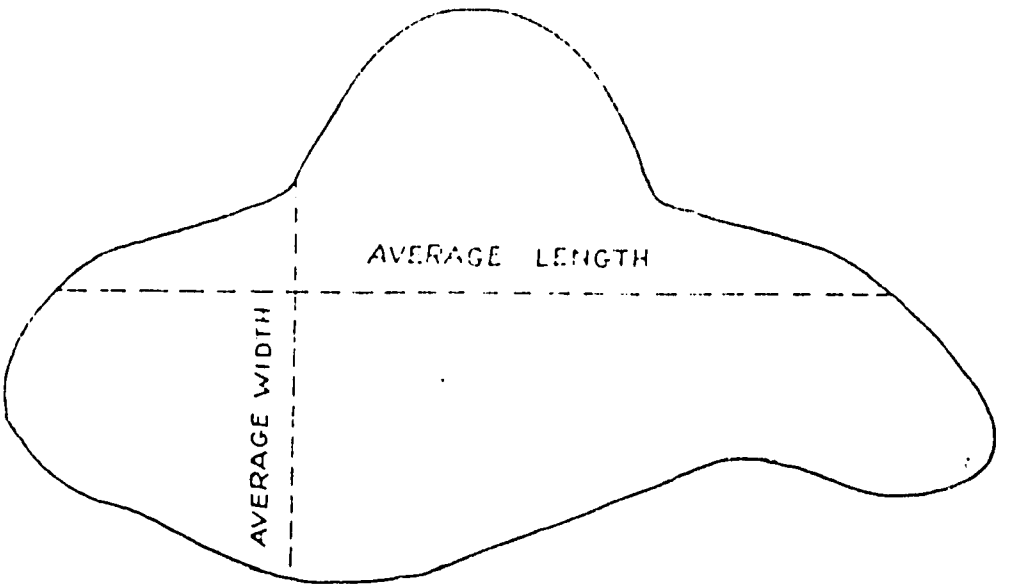
Before beginning, you must know the length of your step. Most adult males have steps 60-80 cm long. To find the length of your step, walk as you normally do for 10 paces, measure the distance that you have gone with a tape measure, and then divide this distance by 10. This will give you the average length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

AREA = LENGTH X 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 don't 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.

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

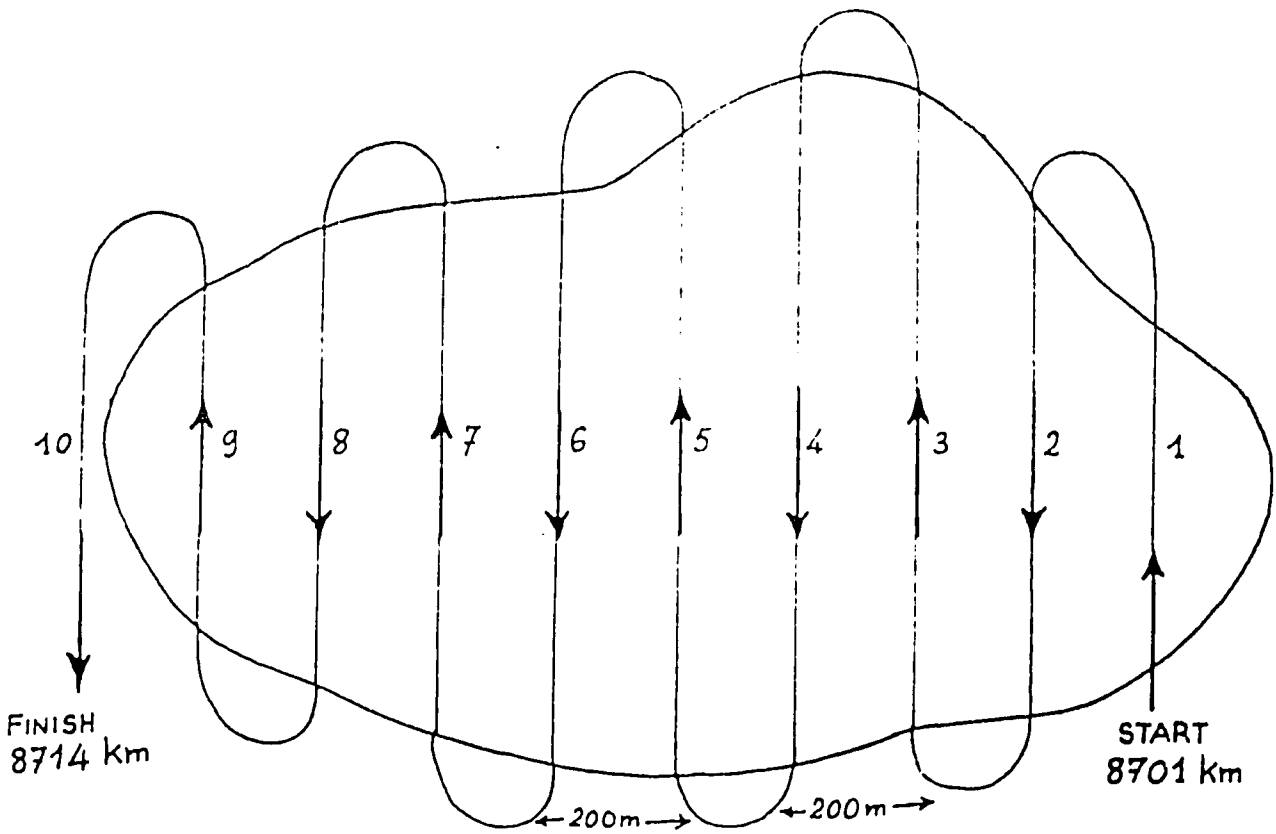
D = distance driven during the treatment in HECTOMETERS. To find the distance in hectometers, substract the kilometer reading before the treatment from the kilometer reading after the treatment and multiply by 10.

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 = (8714 - 8701) x 10 = 130 hectometers

n = 10

L = 200/100 = 2 hectometers

Area treated = [180 - (10 - 1) x 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 don't 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 m2, 100 m2, 1000 m2, 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 hectare = 10,000 m2.

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 handcarried 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 m/minute and the width of the band treated is 5 meters, then the surface treated in one minute is 500 m2.

8. Calculate the amount of time needed to treat one hectare. This is found by dividing the surface area of a hectare, 10,000 m2, by the surface area treated in one minute. For example if your machine treats 500 m2/minute, you would divide the area of a hectare, 10,000 m2, 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't 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.

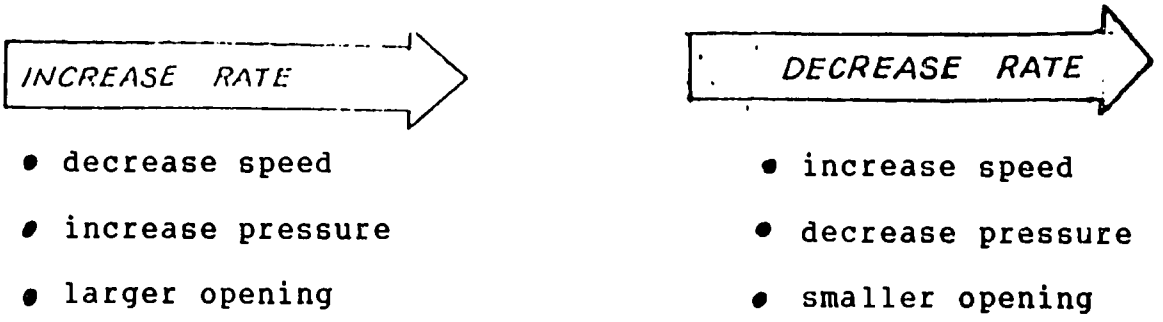
A second difference is that since these formulations are not diluted, then you cannot change the amount applied by changing the percentage of pesticide in a solution. There are three ways to change the application rate of equipment used to apply pesticides that will not be diluted before treatment:

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 equiped 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:



INCREASE RATE	DECREASE RATE
• decrease speed	• increase speed
• increase pressure	• decrease pressure
• larger opening	• 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 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.

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.93). 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

Pesticide Dosage Recommendations:
Sample Worksheet to be prepared by Crop Protection Service Technical Staff

Information obtained from reference books, research reports, pesticide labels, etc.					Calculations based on local availability of formulations and application equipment					
*	*	*		*		*		*		*
Crop	Pest	Pesticide	Dosage/ha (a.i.)	Formulation available	Dosage/ha (formulation) 1/	Motorized mistblower Dosage/tanks 2/		Manual backpack duster Dosage/tanks 2		Notes on application
						metric measure	common measure	metric measure	common measure	
X	Armyworm	A	0.85 kg.	85 wp	1.0 kg.					
	Grass-hoppers	A	1.0 -1.5kg	85 wp	1.2 kg (hoppers)					
					1.8 kg. (adults)					
		B	1.0-2.5kg	10 D	10 kg. (hoppers)					
					25 kg. (adults)					
	Flower or grain-feeding beetles	C	1.0 litre	50 EC	2.0 litre					
		B	2.0 kg.	10 D	20 kg.					
	Sucking	D	1.0-1.5	60 EC	1.7 litre (nymphs)					
					2.5 litre (adults)					

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 ccalculated by dividing the dosage/ha of formulation by the number of tanks needed to spray 1 hectare (obtained by previous sprayer calibration).

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

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 re-filling. 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 ofwater. 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 on Calibration.

Let's 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 700 grams of Thimul per hectare. You have a drum of Thimul 35EC and a backpack sprayer that holds 20 liters. The flow rate of your sprayer is 400 liters/hectare. How much of the Thimul 35EC 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 700 grams of active ingredient per hectare. Each liter of Thimul 35EC contains 350 grams of active ingredient. You would therefore need two liters of the formulation per hectare.

The two liters must be evenly divided between the 20 sprayer loads. Two liters divided by 20 = 1/100 of a liter per sprayer. 1/100 of a liter is 10 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?

2% 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 igredient 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:

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

$$\frac{5 \text{ hectares} \times 1000 \text{ grams/ha}}{20 \text{ grams/kilogram}} = 250 \text{ kilograms}$$

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 a a 2% solution?

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

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

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

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:

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

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

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

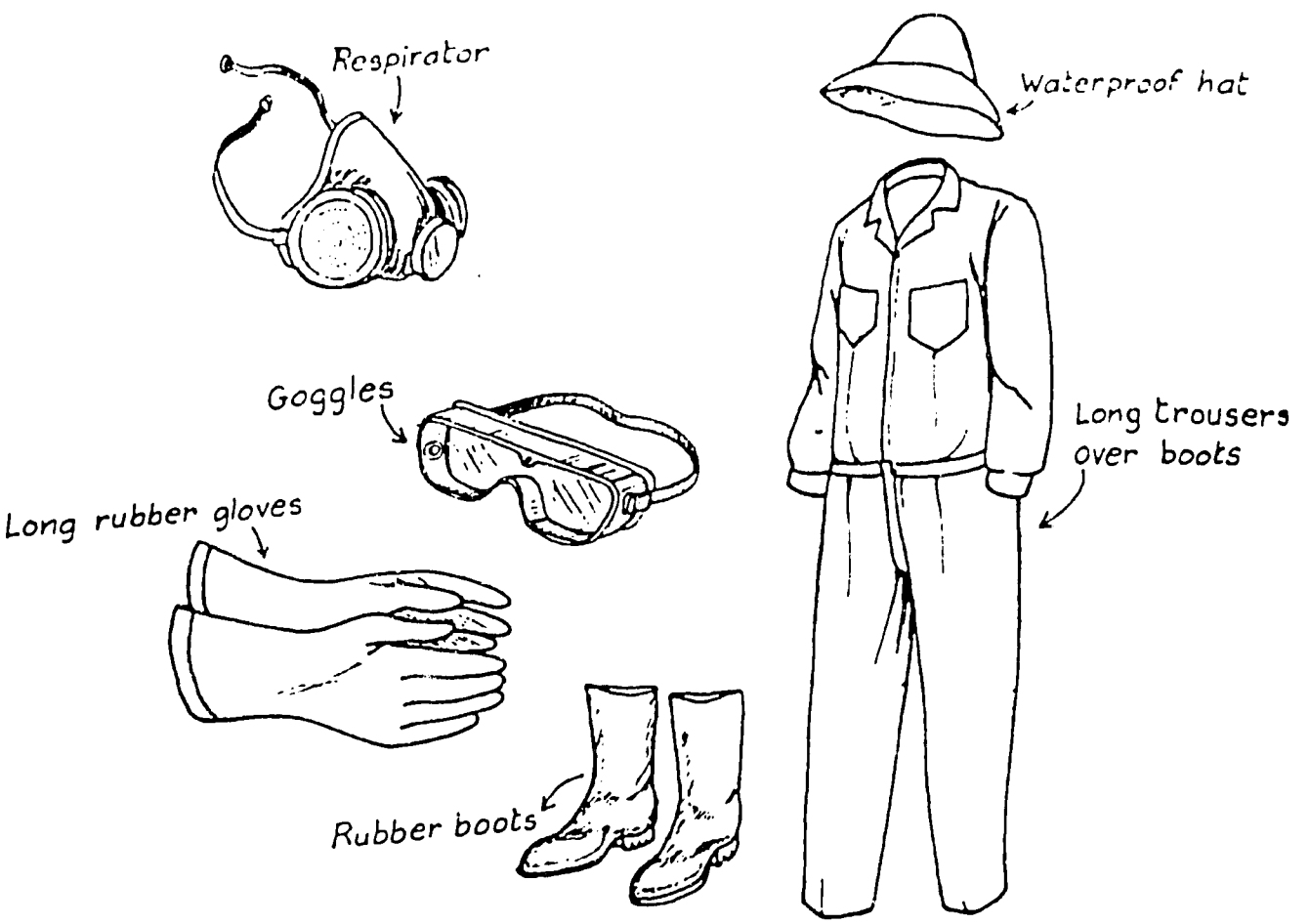
III. APPLYING PESTICIDES

WHAT TO DO BEFORE APPLICATION

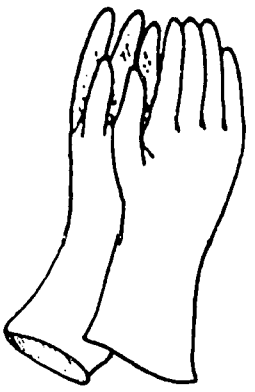
PROTECTIVE CLOTHING

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 <u>never</u> 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 <u>never</u> be issued pesticides which are so toxic that protective clothing other than gloves, long trousers and shirts are an absolute necessity.



Gloves

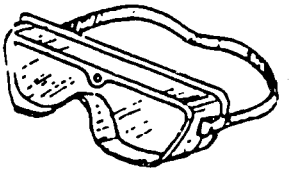


Gloves should be made of unlined neoprene and at least elbow length. Wear the gloves underneath the sleeves of your coveralls. Do not tuck your sleeves into the gloves because any pesticide spilled onto the sleeves will then run inside your gloves. Check gloves often for holes by filling them with water 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

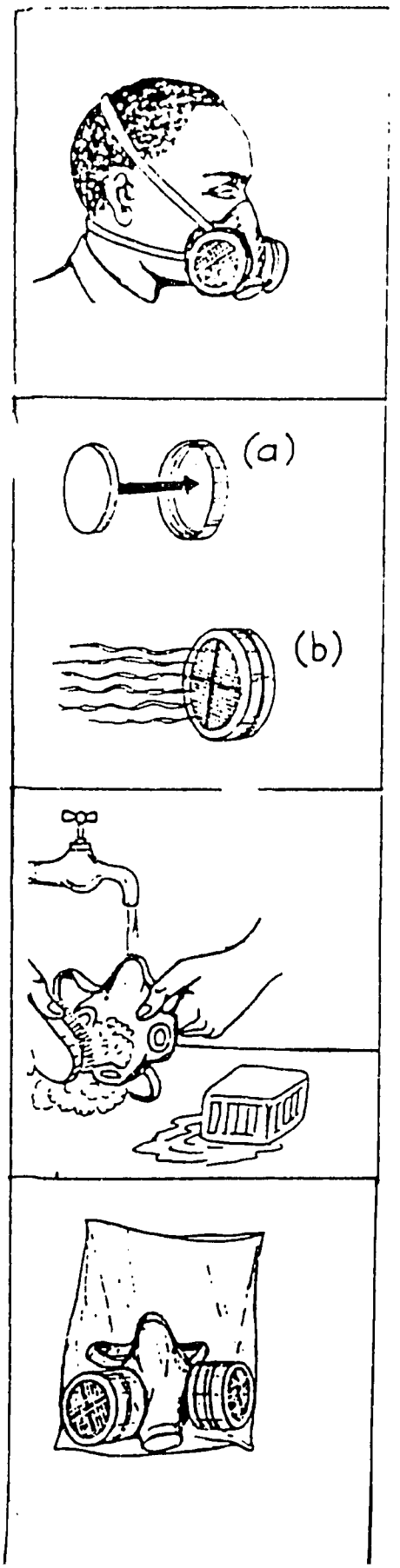


Goggles should always be worn during mixing and filling operations or when working with highly toxic chemicals. Goggles should be tightly fitting. Wash after using with soap and water.

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

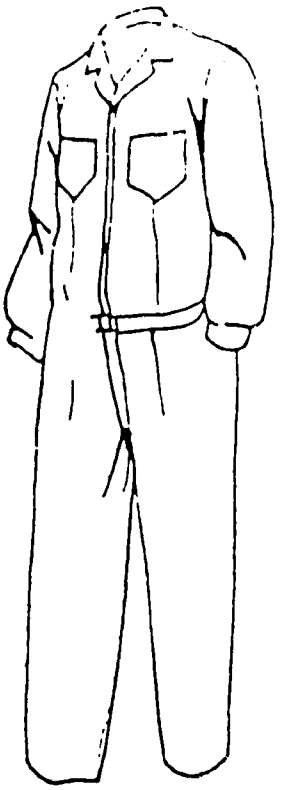


A cartridge type respirator with a filter suitable for pesticides should be worn when working with certain chemicals. This type of respirator covers the nose and mouth and usually has two replaceable filters. Filters should be changed when breathing becomes difficult or after 8 hours use. After each 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.

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.

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 heavy denim material is best for the hot West 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 on Transporting Pesticides.

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

3. Have all the necessary protective clothing available (See Section on Protective Clothing).

4. Always choose the safest effective pesticide available. (See section on 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

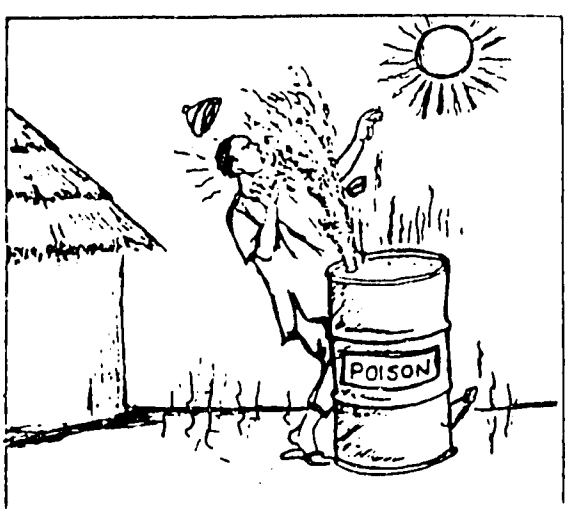
The mixing and filling operation is considered the highest risk time for pesticide accidents.

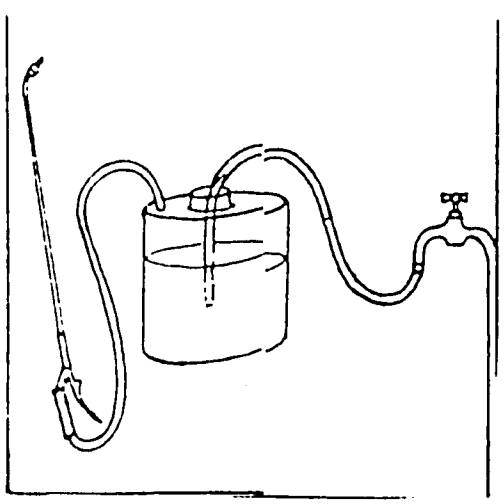
1. Wear your protective clothing.

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

3. Stand up-wind 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.





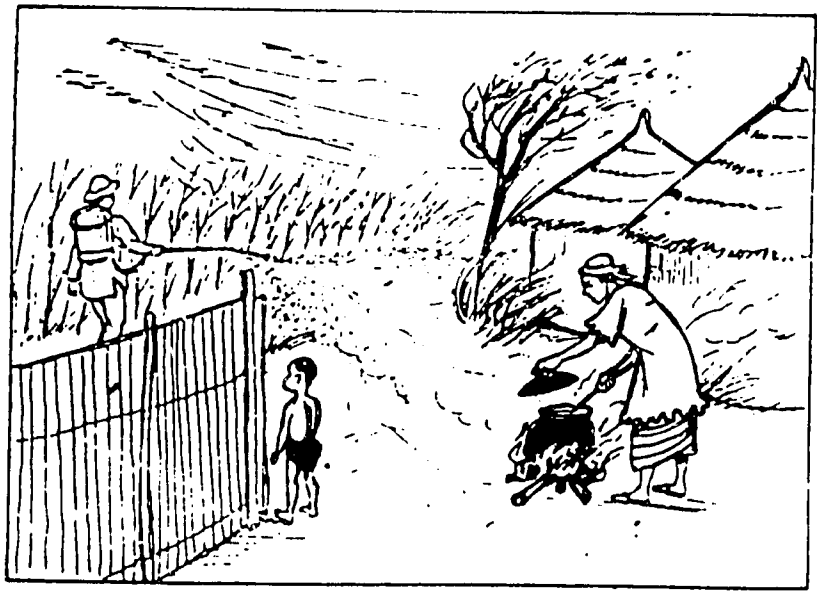
5. If you are adding water to the sprayer tank from a hose, keep the end of the hose above the surface of the liquid in the tank. This will avoid back-siphoning of pesticide into the hose when you shut the water off.

6. Add only enough pesticide to the tank for the job you will be doing. Seal containers when you've 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 don't want it. Pesticides drifting into water sources or populated areas could have serious adverse effects to man and other non-target 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:

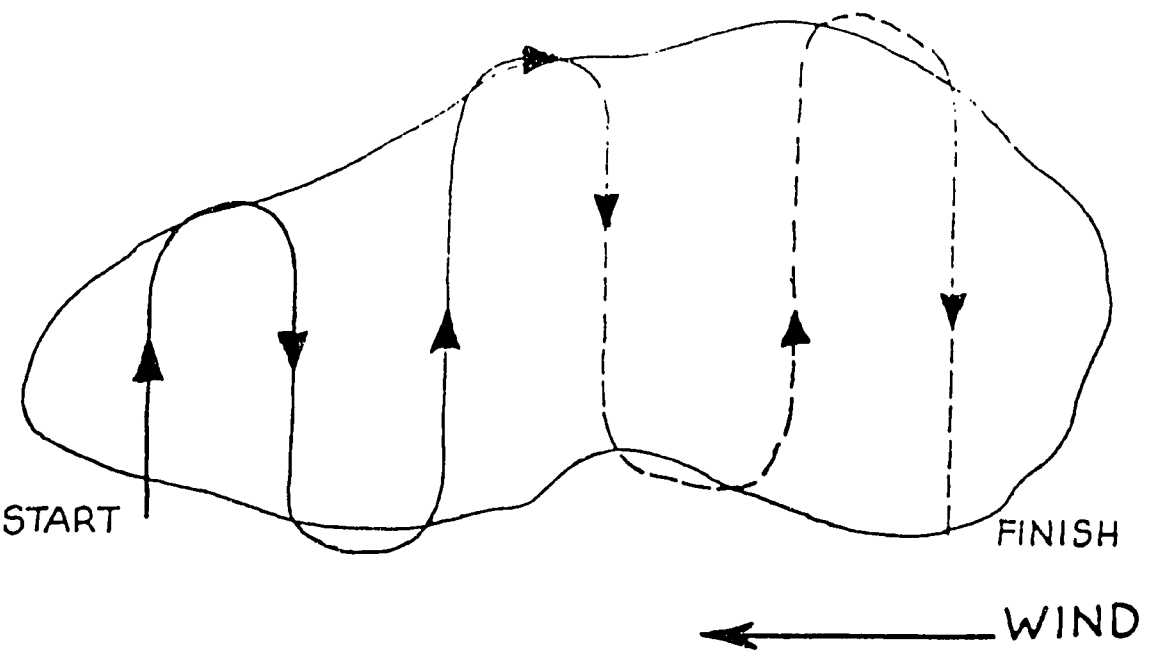
AVOID APPLYING PESTICIDE SPRAYS AND DUSTS WHEN THE WIND VELOCITY IS GREATER THAN 4 METERS/SECOND.

WIND FORCE CHART

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

DESIGNATION	SPECIFICATIONS AT GROUN 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

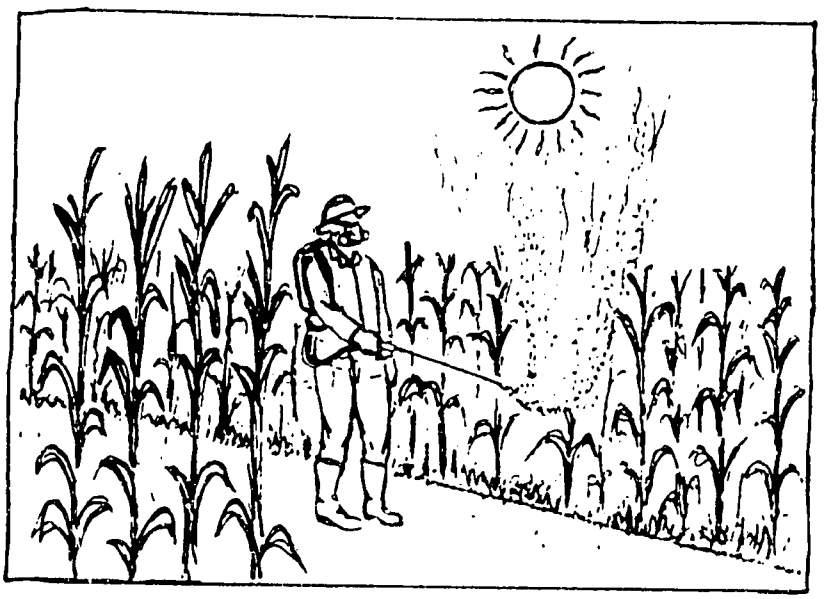
For some types of pesticide applications a certain velocity of wind is necessary. This is the case with Exhaust Nozzle Sprayers which are used in several West African countries. This type of equipment depends on the wind to carry the pesticide to the target site. OCLALAV recommends a wind velocity of 1-6 meter/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 West Africa, daytime temperatures often reach 45°-50°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 11:00 hours and after 16:00 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 don't 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, don't wipe it off on your sleeve or trousers.

6. If you or a co-worker show signs of pesticide poisoning, stop the treatment immediately. Don't try to finish up a field. Begin first aid measures at once .

WHAT TO DO AFTER APPLICATION

SAFETY RULES

1. Make sure you've 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 non-diluted pesticides you can recover what's 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 until they can be property disposed of (see section on 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 don't 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. Don't 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 on Record Keeping)

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 post-treatment survey should be conducted using the same method which was used for the pre-treatment survey. The pest density of the

pre-treatment survey and post-treatment 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 post-treatment 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 West Africa. But, as pesticide use increases, it is expected that resistance will become more of a problem.

RECORD-KEEPING

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.

IV. PESTICIDE CONTRACTING

Government agencies which contract for the purchase of pesticides must make certain that the contracts between the government and the pesticide suppliers are both clear and comprehensive. The contracts must include essential requirements concerning the pesticide, the pesticide containers, the labels, the quantities, the delivery date, and transportation to the delivery site(s). When contracts are written which do not include all the essential requirements there is little or no recourse if the pesticide supplier does not live up to what was expected of him. The same situation exists with pesticides donated by an international organization. Agreements between international organizations donating pesticides and governments should be very specific concerning the pesticide shipment requirements. Bilateral agreements between international donors and governments are legally binding documents and should be written in much the same fashion as contracts with private suppliers.

Below you will find a brief listing of the areas which should be included in a correctly prepared pesticide contract.

1. Pesticide specifications: Contracts must include very precise specifications concerning the pesticide to be purchased. The specifications should include the type of formulation, the color, the physical state, the active ingredient content, and the storage stability. The FAO and WHO have established generalized specifications for certain pesticide products. In the Appendices, you will find the generalized FAO specifications for Malathion emulsifiable concentrates. It would be useful for government agencies that purchase pesticides to request a set of the FAO specifications for the pesticides that they use. Parts of the FAO specifications can be included directly into the pesticide contract. If no international specifications are available, the purchaser should insist on a certified statement from the supplier that the formulation is equivalent in regard to its chemical and physical composition to an equivalent formulation registered in a major developed country.

Note: The generalized FAO specifications are for a specific pesticide and a specific formulation, but do not specify the content of active ingredient. The pesticide contract must state the amount of active ingredient desired in the pesticide product. The content of active ingredient can either be given as a percentage of active ingredient in the formulation by weight (%w/w), or as a weight of active ingredient per volume of product (grams/liter).

Ranges for the content of active ingredient in the pesticide product must also be set in the pesticide contract. The FAO specifications provide the ranges of tolerance for formulations with various percentages of active ingredient. In these sample specifications, you will see that the tolerances of Malathion EC formulations with less that 40% active ingredient are -5% of the declared value and + 10% of the declared value. This means that for a 30% Malathion EC formulation the content of active ingredient would have to be between 28.5% (5% of 30% = 1.5%) and 33% (10% of 30% = 3%).

It is common practice to randomly sample formulated products and test for percentage of active ingredient. Frequently, bilateral donor agencies can assist in getting such analyses done.

2. Analysis Clause: It is always a good idea to include a clause in the pesticide contract stating that the purchaser retains the right to submit a sample of the pesticide to a reputable analytic laboratory for analysis (the laboratory should be named in the contract) to determine if the pesticide conforms to the specifications stipulated in the contract. The clause should indicate that final payment for the pesticide can be withheld by the buyer until the analysis shows that the pesticide product conforms to the specifications in the contract.

3. Container specifications: The contract must stipulate the size, type, and quality of the pesticide containers.

Size: State the volume or weight content of pesticide that each containers should hold.

Type: State whether the containers should be made of steel, paper, plastic, burlap, glass or other. For steel containers state that they must be treated both inside and out (painted) to prevent deterioration by rust or corrosion.

Quality: The quality of containers is often overlooked in pesticide contracts. Pesticides are sometimes delivered in containers that begin leaking soon after delivery. State that the containers must be of "top quality" or "first quality". State the thickness of the material used to construct the containers. State that the containers must not deteriorate to the point of leaking for at least two years after delivery.

4. Quantity: The section of the contract should state how many liters or kilograms of the pesticide product are being contracted for. A small allowance should be made for loss during shipping.

5. Labeling specification: The contract should specify that each container must be labeled according to the laws of the country they are sold in. If the country does not have pesticide labeling legislation then labeling specifications must be included in the contract. For specific recommendations on pesticide labeling requirements see the sections of this manual on Pesticide Labeling and Pesticide Legislation.

6. Delivery Date: This section of the contract should set a precise date when the pesticide must be delivered. It is always a good idea to include a penalty clause in the contract stating that a certain amount of money will be deducted from the payment for each day the delivery is late. Penalty clauses motivate the supplier to deliver the pesticides on time.

7. Transportation: This section of the contract should specify where the pesticides are to be delivered. If you want to have the shipment divided up and delivered at more than one location this must be included in the contract.

V. 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.

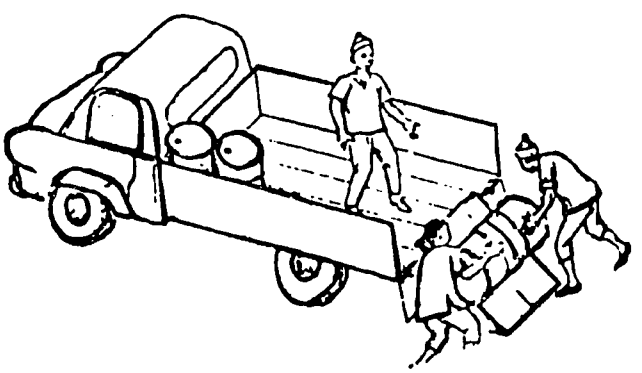
3. Wear protective clothing.

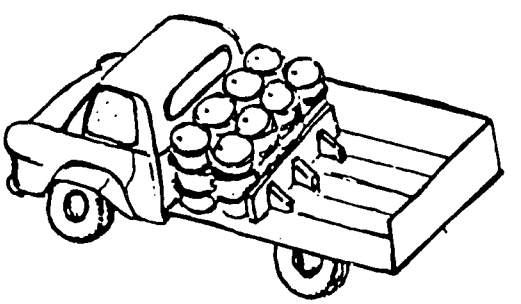
4. Don't eat, drink, or smoke while loading pesticides.

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 won't shift during transport. Wooden blocks should be nailed to the bed of the truck to make sure that pesticide containers don't 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. Don't 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're transporting dust formulations which can be blown by the wind.

12. Don't 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. Don't 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.

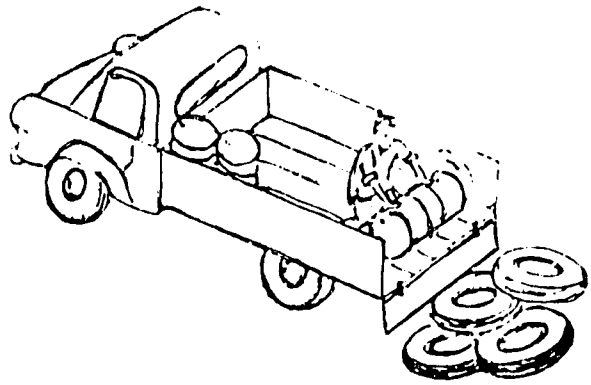
3. Don't carry unauthorized persons in the vehicle. There is no need to expose more people to the dangers involved in pesticide transportation than necessary.

Unloading

1. Wear your protective clothing. Don't eat, drink, or smoke while unloading pesticides.

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

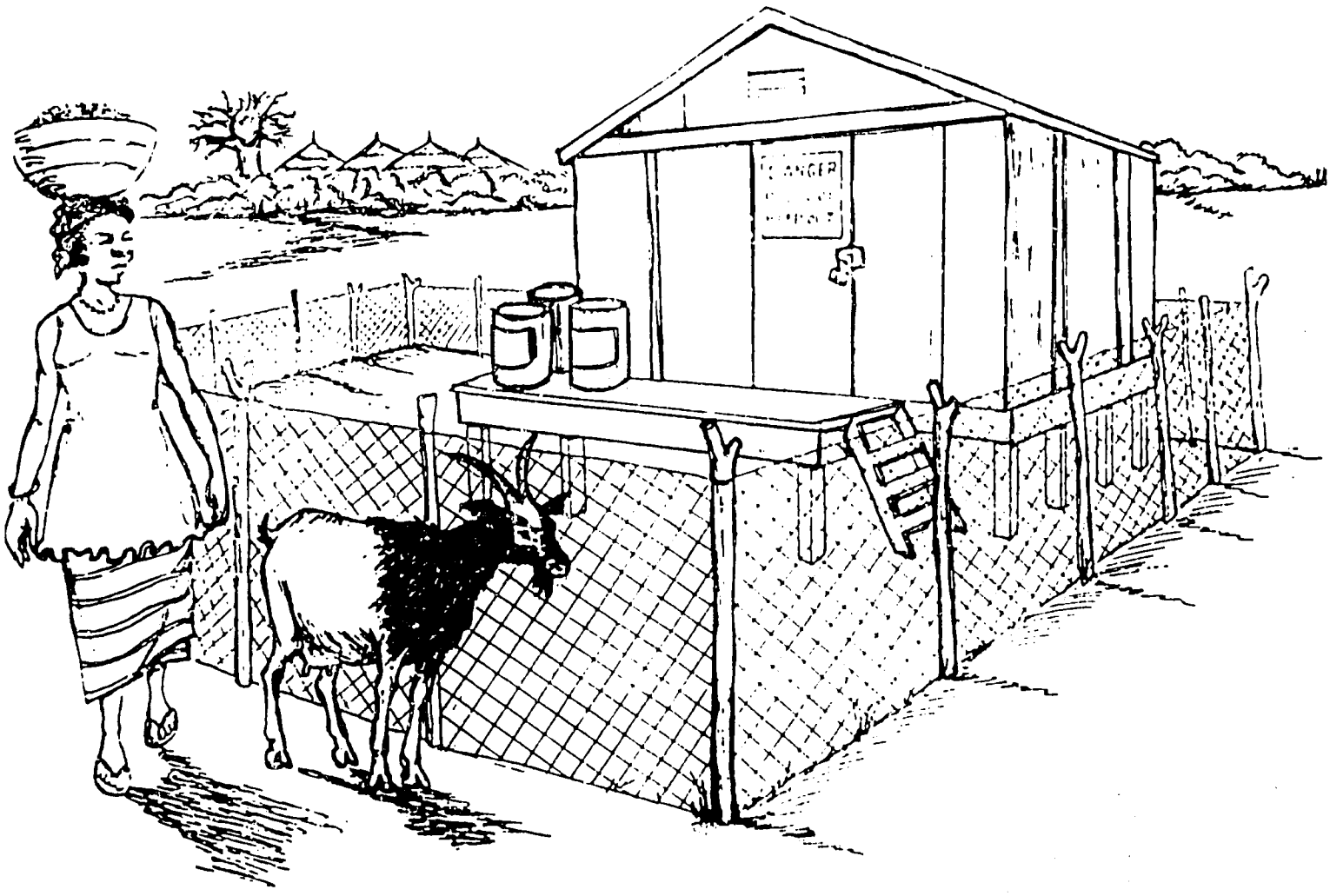
3. Do not abuse containers during unloading operations. If there is an unloading/loading ramp, at the unloading site, use it. If not, the best way to get heavy drums out of a truck is to gently roll them off the end of the truck on to used tires.



4. After unloading, store the pesticides properly.

5. Wash out the vehicle. If pesticides have spilled in the vehicle, clean it and decontaminate. Follow the recommendations in the section of this manual on Cleanup and Decontamination of Spills.

VI. 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 West 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 run-off water from clean-up operations from entering a water source.

Inside the Building

- The various pesticides should be kept separated; this will make loading and unloading easier, 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 shouldn't 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 clean-up operations.

- Brooms and shovels should be available for clean-up 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 1a and 1b 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 record keeping, distribution, and making sure the storage facility is kept locked when not in use.

- The storage area should be outside the village.

- 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 clean-up 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 clean-up 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 informations

- 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 which pesticides enter and leave the warehouse.

- All of this information can easily be kept on forms similar to the example provided in the Appendix. It is advisable to have a separate sheet for each pesticide stored at the warehouse. This will make record keeping 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. For information concerning the language of the label and the stability of the label, see the section of this manual on Pesticide Legislation.

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 don't 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 1000g ULV would have 1000 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 on Formulations.

5. Net Contents of the Package: The net contents tells you how 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 (see section on Pesticide Legislation). As each product is approved, it should be given a registration number. This number should be included on the pesticide label.

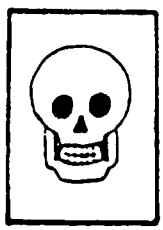
8. Restricted or General Use: Pesticides used in a country should be divided into two groups: one for general use, and one for restricted use (see section on Pesticide Legislation). It should be clearly stated on a pesticide label whether the pesticide is approved for General Use or Restricted Use.

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 W.H.O. system is as follows: (see page 33 for explanation of this system).

Signal Word	W.H.O.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 page 33 .

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 indicte 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 Appenidices 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 the Appendix, you will find examples of labels of pesticides commonly used in West 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 isn't 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 addded 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 on Disposal of Pesticides).

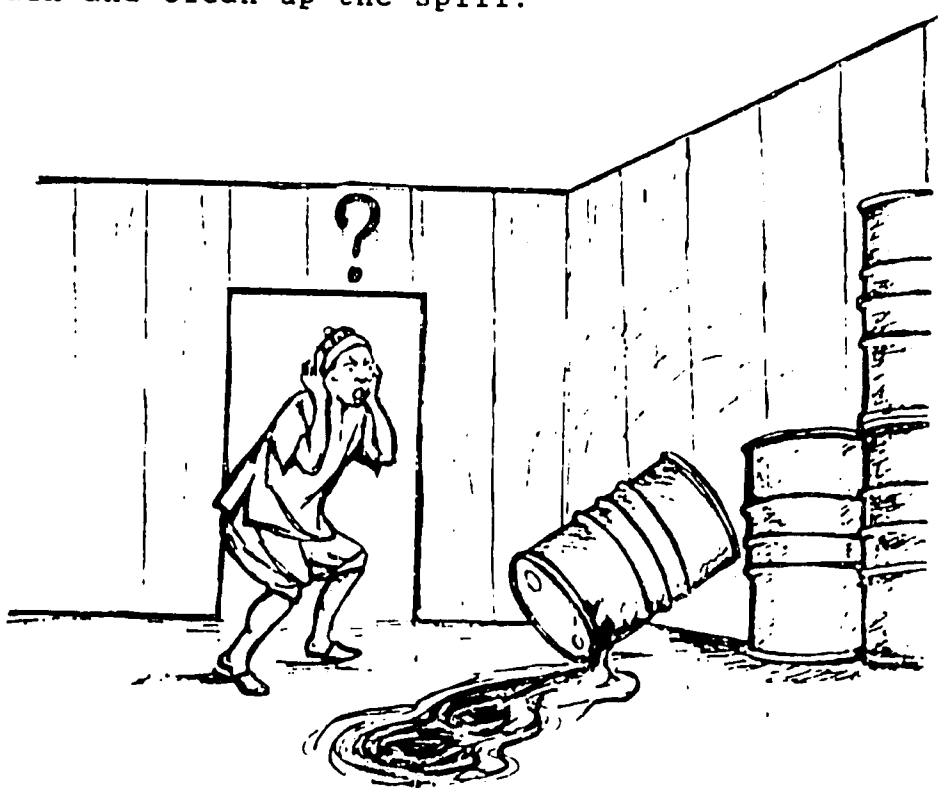
CLEANING-UP PESTICIDE SPILLS

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 don't 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've 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 first aid measures as outlined in the section of this manual on Pesticide Poisoning. 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 fire fighting operations are completed, firemen should remove their clothing and thoroughly wash. The clothing worn during fire fighting operations should be decontaminated before being worn again.

- Runoff water from fire fighting 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 by-standers and any other unauthorized persons away from the spill site.

Clean-up Techniques

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

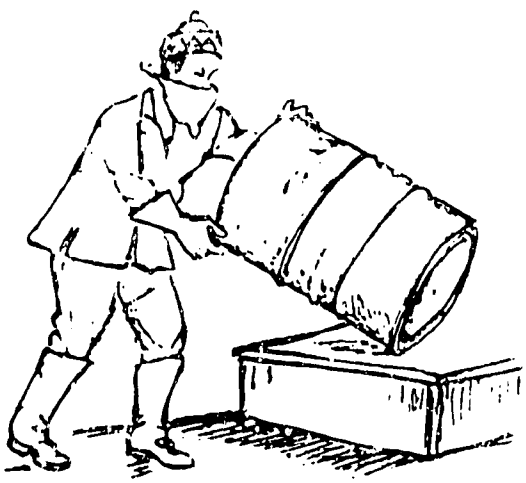
1. Keep the pesticide from spreading. Finely ground

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 on Pesticide Disposal.

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. Don' t 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 on Pesticide Disposal.

DECONTAMINATION OF SPILL SITES

After clean-up 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:

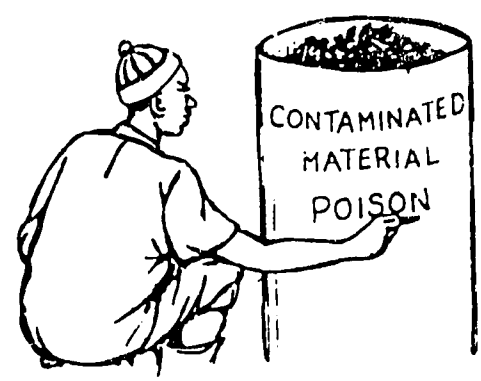
1. Spread the spill as thinly as possible over the spill site.

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 on Pesticide Disposal.



VII. 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 don't 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 quantitites 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.

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 West African countries. Most governments do not have set policies concerning the disposal of empty pesticide containers.

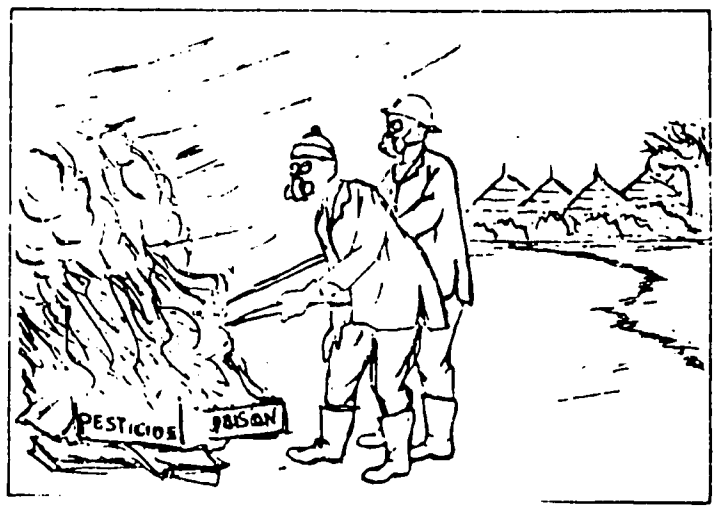
Below are guidelines on how to dispose of empty containers. Reference is also made to the disposal of pesticides, and pesticide-contaminated materials.

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 prefereable 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 don't already exist.

Containers That Won't 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 dilutant to add to various sized containers.

CONTAINERS 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.

After the container has been rinsed, the best thing to do is to return it to the supplier. The supplier can re-use the container if it's 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:

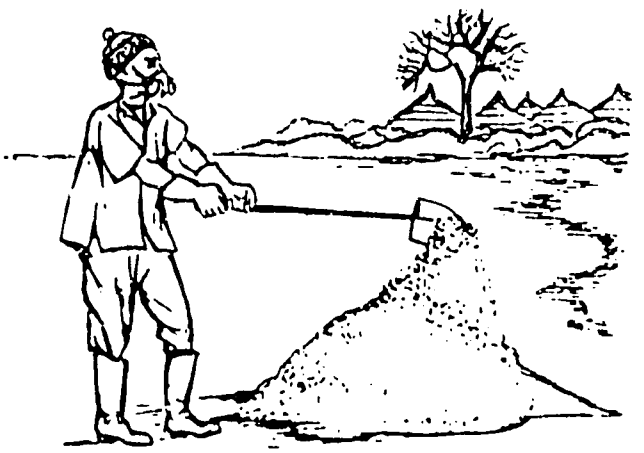
- Break glass containers and crush metal ones. This will assure that they are not used for alternative purposes such as carrying water or food.

- 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 pesticides to be buried should first be mixed with an absorbent material like groundnut husks, sawdust, charcoal, or sand to form a slurry. 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 runoff rather than soak in at the site.

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

VII. PESTICIDE LEGISLATION

Because of the hazardous nature of pesticides, they must be regulated by governments to protect man and the environment. They also should be regulated to protect pesticide buyers from purchasing adulterated or fraudulent products. Most governments is West Africa either already have pesticide legislation or are in the process of developing legislation. This was the subject of a recent workshop in Lome, Togo.

It should be noted that FAO now has adapted an International Code of Conduct on the Distribution and Use of Pesticides. It is a voluntary code and is meant to seve as a point of reference for developing countries, particularly until such time as these countries have established adequate regulatory systems for pesticides.

Also, FAO has published a document titled "FAO Guidelines for the Registration and Control of Pesticides" (including a model scheme for the establishment of national organizations), FAO, Rome, 1985.

This section is presented as a checklist of areas that should be considered in preparing pesticide legislation.

1. Pesticides should be divided into three usage categories according to their acute and chronic toxicities. These categories are: banned from any usage, restricted usage, and general usage.

Recommendation for classifying pesticides as banned:

Extremely toxic pesticides which are in the 1a category of acute toxicity according to the WHO pesticide toxicity classification scheme (see above p. XX)) should be banned unless there is an expressed need for a pesticide in this group which cannot be filled by a less toxic pesticide.

Pesticides which have known adverse chronic effects to living organisms should be banned. Chronic effects include causing cancer (carcinogenic), causing mutations (mutagenic), and causing birth defects (teratogenic).

Pesticides which are not banned should be divided into two categories, those which are acceptable for general use by the public and those which are restricted for use

only by qualified persons. General use pesticides could be purchased and used by any adult person whereas restricted use pesticides could only be used or purchased by persons who have been trained and certified to use them.

Recommendations for classifying pesticides restricted use:

All non-banned pesticides which are in the 1a and 1b categories of the WHO toxicity classification system should be on the restricted use list.

All fumigants.

All ULV formulations.

Recommendations for classifying pesticides for general use:

All pesticides in the II and III categories of the WHO toxicity classification system.

No fumigants should be on the general use list.

No ULV formulations should be on the general use list.

2. Each country should set up a system of certifying persons for the use of restricted use pesticides. This should include a written examination to show that the person has the knowledge necessary to safely handle hazardous pesticides. Government workers should not be exempt from the certification process.

3. A committee should be formed in every country which has the following responsibilities:

- Reviewing all pesticides to determine whether they should be approved for use in that country. Every pesticide that is reviewed and approved by this committee should receive a registration number.

- Determining which approved pesticides should be placed on the general use list and which pesticides should be placed on the restricted use list.

- Changing the status of previously approved pesticides if new information becomes available indicating they should receive a change in status or be banned.

- Overseeing the certification system to assure that the persons being certified for the use of restricted pesticides are qualified.

4. Pesticide suppliers should be required to meet specific provisions for the labeling of pesticide products. This should include:

- Language: Pesticides sold in a country should have labels written in the language of that country. A label in Chinese or German has little value for a person who reads only French.

- Stability: Laws should state that pesticide labels should not deteriorate during transportation or storage and should remain legible for at least two years under normal conditions.

- Information presented on the label: This section of the legislation should list all the information that is required on a pesticide label. For a recommended list of information see the section of this manual on Pesticide Labeling.

5. Pesticide suppliers should be required to meet specific provisions on the packaging of pesticides. For additional information on pesticide container requirements see the section of this manual on Pesticide Contracting.

6. Provisions must be included in legislation to assure that pesticides sold in a country are what they are advertised to be. This is to protect the government and public from the sale of fraudulent or adulterated pesticide products. For example, when a pesticide is labeled as a 50% formulation, then by law the amount of active ingredient should be within reasonable limits above or below 50%. For additional information on pesticide specifications including tolerances for active ingredient content, see the section of this manual on Pesticide Contracting.

7. The disposal of pesticides, pesticide containers, and pesticide contaminated materials must be regulated. (For recommendations see section on Disposal of Pesticides and Pesticide Containers).