Horti Nigeria
BUILDING A SUSTAINABLE & INCLUSIVE HORTICULTURE SECTOR

CropLife INTERNATIONAL

SAFE USE & APPLICATION OF CROP PROTECTION PRODUCTS (CPP)

IFDC 50th ANNIVERSARY
EAST-WEST SEED FOUNDATION
KNOWLEDGE TRANSFER
WAGENINGEN UNIVERSITY & RESEARCH
KIT INSTITUTE

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1 Pests and Pesticides Introduction to Pests and Plant Diseases

A pest is considered to be anything that:

- Competes with humans, domestic animals or crops for food and water.
- Injures or damages humans, domestic animals, crops or structures.
- Spreads disease to humans, domestic animals or crops.

There are certain characteristics of pests that we must keep in mind:

- Pests are living things.
- Livings things have basic needs: air, water and food.
- Pests can only survive if their basic needs are met.
- In ideal conditions pests will, like all living things, multiply and increase in numbers.
- Pests can cause massive damage.
- Pests must be controlled.
- Prevention of pests is much better than the cure of pests.

Types of pests

We usually associate a pest with creatures like army worms, aphids, locusts and rats. There are many other types. Some pests we cannot even see with the eye. We can classify them into six basic groups:

1. **Insects:** Army worms, locust, aphids, beetles, caterpillars and many other insects that attack crops.
2. **Micro-organism:** They are also called the silent killer because you can't see them; you only see the damage done by them. They disrupt the normal internal processes of the plant.
   - Fungi or fungal diseases: Plant-like organisms such as yeast, molds, smuts, mushrooms, and toadstools. Fungi cause most of plant diseases in crops.
   - Nematodes: Tiny organisms in the soil that attack the plant roots.
3. Weeds: Grass and broadleaf weeds, and mistletoe aggressively competes with crops for water and food. They use the plant nutrient and the crops suffer.
4. **Mites:** Tiny insect-like organisms that causes big harm to crops.
5. **Molluscs:** Snails and slugs.
6. **Vertebrates:** Vertebrates are any living organisms with a spinal cord or backbone, such as mice. Rodents and birds can do much harm to crops.

The most common pests and diseases in vegetables are:

Insect – White Flies

Damage

The nymph whiteflies cause the most damage to the plant. They suck the juices out of the leaves and flower buds, causing them to turn yellow and drop from the plant. mainly problematic because they transmit tomato viruses.

Insect – Aphids

Damage

- Damage leaves by feeding prepared food
- Production of honeydew
- Transmits virus
- Occurs from seedling to maturity stage

Insect – Bollworm

Damage

Creates holes in fruits which makes them unmarketable

Insect – Fall Armyworm

Damage

Can destroy the whole plant.

Plant Disease – Powdery Mildew

Damage

Leaves will die due to severe infestation.

Plant Disease – Cercospora Leaf Spot

Damage

Will affect the leaves, can reduce fruit size and quality.

Root Knot Nematodes

Damage

Damages the roots of plants, impairing their ability to take up water and nutrients.

Insect –Tuta Absoluta

Damage

Tuta absoluta is known as tomato leaf miner is a moth that causes damage to vegetables especially tomatoes plant through its larvae and eggs.

Most damages is caused by the caterpillars of the miner moth

INSECTS

FUNGI

MITES

WEEDS

NEMATODES

MOLUSCS

VERTEBRATES

2 Integrated Pest Management

Integrated Pest Management (IPM) is about

1. Prevention: there are certain actions you can take to avoid pests and diseases coming to the farm.
2. Monitoring: you need to check your farm regularly (this is called scouting) and be able to identify pests and diseases. We will discuss the details on how to monitor during the session on scouting.
3. Intervention: IPM uses different methods to control pests and diseases. Depending on the situation you decide what method to use.

It uses different control methods and methods to prevent and control pests and diseases. IPM is not a fixed package, which means that every farmer needs to decide for every site what approach to use.

IPM makes use of the following control methods:

- **Cultural control** includes practices that optimize plant growing conditions or produce unfavorable conditions for pests. Optimal growing conditions provide a healthy crop that is more able to resist pest attack. It includes:
  - Land selection (quality of site) and soil texture
  - Crop rotation
  - Land preparation
  - Use of clean, certified seeds and planting materials
  - Time of sowing
  - Plant spacing
  - Timing and quantity of fertilizers
  - Weeding
  - Origin, timing and amount of irrigation water
  - Resistant crop varieties
  - Trap crops: planted around your field to attract (trap) pests
- **Mechanical control** is sometimes called physical control, and involves the use of machines or other tools. It includes:
  - Soil cultivation and tillage, which physically kills some pests, buries them or exposes them to drying conditions on the soil surface or as food for birds or other predators.
  - Soil cultivation also buries and kills weed seedlings, and buries potential food sources for insect pests.
  - Traps, such as rat traps and sticky insect traps.

  - Hand collection of insects, leaves/fruits that are diseased, with insect eggs, or infested with insect pests, etc.
  - Hand weeding.

- **Sanitation** may be included in either mechanical or cultural control. Sanitation helps to prevent and suppress pests by removing or preventing access to sources of infection or sources of food and shelter. Practices include:
  - Removal of infected crop material from fields and orchards.
  - Ploughing-in or burning of crop residues.
  - Removal of food sources such as seed and grain (after both planting and
  - harvesting); cleanliness in the store, house or kitchen, good management of
  - animal manure, etc.
  - Using nets and screens in greenhouses, rodent proof grain stores.
- **Biological control** involves the use of natural enemies of pests – predators and parasites (also called beneficial insects) and disease causing organisms – and encouraging their development. Some pests or, in some cases, non-pest species, must always be available to provide a food supply, and there often is a time lag between the increase of a pest population and the increase of natural enemies. Biological control also includes methods by which the pest is biologically changed.
- **Chemical control** is the use of chemical pesticides, which controls pests and their activity or prevent them from causing damage.

3 Types of Pesticides

A **pesticide** is a chemical that controls pests and diseases. There is a wide range of pesticides. **Every type of pesticides controls a specific pest**. For example, you cannot use an herbicide to control insects or a rodenticide to control fungi.

Always read the label to know which pesticide to use.

Below are the most commonly used pesticides:

Type of pesticide	Controlling	
Insecticides	All insects.	
Fungicides	Fungi (main cause of plant diseases).	
Herbicides	Unwanted plants, such as grasses and broadleaf weeds in crops.	
Miticides	Mites: tiny insect-like organisms that causes much harm to crops.	

Nematicides	Nematodes: tiny organisms in the soil that attack the plant roots.	
Molluscicides	mollusc: Snails and slugs.	
Rodenticides	Vertebrate: Mice and rats.	

Additional characteristics

In addition, each pesticide has some additional characteristics.

- Broad spectrum versus narrow spectrum (applicable on insecticides and fungicides):
  - Broad spectrum pesticide controls a wide range of pests.
  - Narrow spectrum pesticide controls only certain specific pests.

Herbicides

Different types of herbicides

Herbicides can be divided into two major groups of selective and non-selective herbicides.

A. Selective Herbicides

Selective herbicides control a specific type of weed. It will control grass weeds between broadleaf crops or broadleaf weeds between planted pasture or other grass areas like lawns and gardens. The action of the herbicide is for the control of a specific type of weed.

B. Non-selective Herbicides

Non-selective herbicides remove a broad spectrum of plants regardless the type of plant. Grass as well as broadleaf plants will be affected by this type of herbicide. It will also affect crops if it comes into contact with crops.

The above two major groups are further classified into the following groups based upon the **mode of action** (how it works) and **way of application**:

Contact versus Systemic

- **Contact herbicides** affect only the portions of the weeds that come into contact with the herbicide. Proper coverage is very important for proper control. The above ground parts of weeds will be controlled but roots and bulb underground will not be affected because there is very low or no activity in the soil. These herbicides are useful for controlling **annual weeds**.

- **Systemic herbicides** are absorbed through the leaves, stems and roots into the plant where it moves throughout the plant. Systemic herbicides will kill the entire plant, roots and all. These herbicides are useful for controlling **perennial weeds**.

Pre-emergent versus Post-emergent

- **Pre-emergent herbicides** are applied to the field **before** the germination of the weed seeds. This is done early in the season after planting of crop seeds. The herbicide prevents weed seeds to develop and grow after germination. Timing is vital when you apply pre-emergence herbicides.

- **Post-emergent herbicides** are applied **after** the weeds emerge. These herbicides are applied on the growing weeds and are either a contact or systemic herbicide. It is important to achieve good spray coverage of weeds when applying post-emergence herbicides.

Foliage application versus Soil application

- **Foliage application** means you apply the herbicide **directly on the leaves** and stems of the

weeds. This type of application is related to **post-emergence** herbicides, which also include selective or non-selective as well as contact or systemic herbicides.

- **Soil application** means you apply the herbicide **directly on the soil**. Herbicides applied on soil usually need activation either by rain or irrigation to take the herbicide into the soil in order to get contact with germinated weed seeds or weed roots. This type of application is related to **pre-emergence** weed control in crops as well as where industrial areas need to be kept free of plant growth.

4 The Main Types of Pesticide Formulations

Formulations describe the **form** in which a pesticide is prepared by the manufacturer for use by the farmer. The main component of pesticides is the **active ingredient**, which forms a small part of the whole formulation. In order to put the active ingredient in a form which is easy and practical to use, the manufacture puts it in a formulation.

The **main formulations pesticides** are:

1. Liquids
    a. Emulsifiable Concentrate (EC)
    b. Suspension Concentrate (SC)
2. Solids
    a. Dusting powder (DP)
    b. Wettable Powder (WP)
    c. Granules (GR)

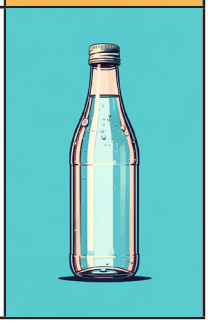
The pesticide formation is indicated on the label.

IMPORTANT NOTICE:

The benefits and drawbacks mentioned below are only broad guidelines. It is still very important to read the label before handling any of these formulations. It is also very important to protect the human body against contact with any of the above formulations regardless if they easily penetrate through the skin or not.

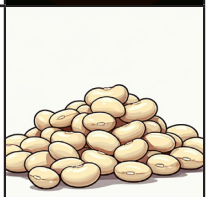
1. Liquid formulations

The most commonly used liquid formulations of pesticides are:

Formulation	Description	Mixing	Advantages	Disadvantages	Drawing
Emulsifiable Concentrate (EC)	• Liquid formulation • Oil based emulsion • Very high concentration	Usually mix with water	• Easy to handle • Easy to measure • Easy to mix • Little agitation needed • Does not to settle down Not abrasive • Does not clog nozzles	• Higher possibility of poisoning • Penetrates easily through skin • Corrosive • Flammable • May damage rubber parts of equipment	
Suspension Concentrates (SC)	• Liquid formulation - Water based suspension • Moderate concentration	Usually mix with water	• Safer to use • Easy to handle • Easy to measure • Easy to mix • Less likely to penetrate through skin	• Needs constant agitation when applying because tend to settle down in the tank • May leave a visible residue • May be abrasive • May clock nozzles	

2. Solid formulations

The most commonly used solid formulations of pesticides are:

Formulation	Description	Mixing	Advantages	Disadvantages	Drawing
Dusting Powder (DP)	• Low concentration • Looks the same as Wettable powder	Ready to use	• Require simple equipment • Easy to apply • No mixing	• Easily drift off target • Difficult to apply evenly and in the correct dosage • High possibility of inhalation	
Granules (GR)	• Solid (dry) formulation • Low concentration	Ready to use	• Ready to use • No mixing required • Less likely to penetrate through skin • Easy to apply • Soil application	• Even application difficult • Apply to soil – slower reaction • May be displaced by movement, strong winds or running water	
Water Dispersible Granules (WG)	• Solid (dry) formulation • Granules mixable with water • Moderate to low concentration	Mix with water	• Easy to handle • Mix easily with water • Less likely to penetrate through skin	• More difficult to measure • Constant agitation – settle down • Abrasive to nozzles • Tend to clog nozzles	
Wettable Powders (WP)	• Solid (dry) formulation • Fine powder mixable with water • Moderate to low • Looks the same as dust	Mix with water	• Easy to handle • Mix easily with water • Less likely to penetrate through skin	• More difficult to measure • Risk of inhalation during mixing - Constant agitation needed because tend to settle down in the tank • Abrasive to nozzles • Tend to clog nozzles	

5 Counterfeit and Illegal Pesticides

Pesticides that are manufactured in a sound, legal way, we call genuine and legal. Genuine and legal products are normally branded products. They are sold with a registered trademark. They can be patent protected but also off-patent. Off-patent are called generics. Those patent protected products and generic product must be approved for import and sales by the local authorities.

Counterfeit and Illegal products

A pesticide is **counterfeit** if it is **not genuine or generic**. Counterfeit products are sometimes called fake or adulterated. **It is prohibited by law to sell, buy or use counterfeit and illegal pesticides**.

A **counterfeit pesticide** can be on the market in different forms:

- It is an identical **reproduction** of the original product but is not approved for production by the local authorities. In this case the product can be of good quality but very often it is of lesser quality.
- The **content** (active ingredient) is different from what the product claims to contain.
- The ingredients are **poor quality**.
- The **label** is different from the original label.
- The **packaging** is different. It is possible that the original product was repackaged.
- They are often **cheaper**.

Illegal

A pesticide is **illegal** if it is **not registered** in the country where it is sold. It is possible that the product is of good quality and sold in neighboring countries, but not approved in the country where it is sold. Or, the product could be in the process of registration or the **expiration date** has passed. Even though the product is genuine, it is illegal to sell.

Consequences for spray service providers when using counterfeit products

Unfortunately, some spray service providers use counterfeit and illegal pesticides to spray the crops of their customers. The consequences could be as follows:

- **Arrest and detention:** Buying counterfeit and illegal pesticides is prohibited by law, and the police can arrest those who commit this crime.
- **Loss of customers:** Counterfeit pesticides usually give bad or inferior results and can even destroy crops. Farmers who use the services of the spray service provider who applied counterfeit product will not be satisfied and will not use the same spray service provider again. They will likely tell others what happened, causing the spray service provider to lose more customers.
- **Closing of the business:** If unhappy customers put in a claim for the loss of their crops, the

spray service provider may have to pay a lot of money or even close his business.

- **Health risks:** Counterfeit and illegal pesticides generally have the wrong instructions or no instructions at all on how to handle the product. This can result in contamination and poisoning.

Consequences for farmers when using counterfeit products

Customers are not always aware that they are buying counterfeit or illegal products. Even then, the consequences can be very severe:

- **Arrest and detention:** Buying counterfeit and illegal products, including pesticides, is prohibited by law. Even if customers claim they were not aware of what they were buying, they may still have to pay a high fine or even spend time in jail.

- **Loss of money:** Applying counterfeit or illegal products does not always control pests and diseases, because the active ingredients are not in the product. The customer must buy another product and apply it again, which means spending money again. It is also possible that the product harms the crop, causing the customer to lose all his/her crops.

- **Health risks:** Counterfeit and illegal pesticides generally have the wrong instructions or no instructions at all on how to handle the product. This can result in contamination.

- **Loss of certification:** Farmers can lose the certification for their crops if counterfeit or illegal pesticides are applied. This means they will no longer receive a premium on top of the normal price.

- **Rejection of crops:** Buyers of crops can reject crops when counterfeit or illegal pesticides are applied. If a farmer is known to have used counterfeit or illegal pesticides it will be very difficult for him to ever sell his crops again.

Buying counterfeit or illegal pesticides, seeds and fertilizers seems like a bargain, but it can turn out to be a very expensive mistake. Beware of counterfeit and illegal pesticides, seeds and fertilizers.

How to Recognize Counterfeit or Illegal Pesticides

Counterfeit and illegal pesticides can be found everywhere in Africa. Examples are:

- **Fake:** The container will claim that it is, for example, herbicides, but inside is water with some color with no benefits to crops.
- **Incorrect formulation:** The container will claim that it has a certain active ingredient but inside there is a different active ingredient.
- **Non-registered:** The product might be of good quality but was not tested or approved by authorities.

How to recognize a counterfeit and illegal pesticide?

It is very difficult to recognize counterfeit and illegal pesticides, because some of the illegal traders even copy the brand names of trusted manufacturers and put their fake pesticides inside the container. The following guidelines will help you but do not guarantee that you are safe against these counterfeit and illegal products:

- A national commission or department from the Ministry of Agriculture should have a p**ublished list of** all registered fertilizers and pesticides in your country. If the product is not on the list, it means the product is illegal.
- Each pesticide formulation has **unique colors and textures**. It would be good to have samples from genuine products so you can compare the color and texture of products that are imported.
- The product should have a **label** or indication of what is in the bag or container.
- The product should have a **registration number,** which must appear on the label.
- The **expiration date** should not have been exceeded.
- The package should be **intact and sealed**.
- **Test** a small amount of the product to check if any damage is done to crops.

What else can I do to safeguard myself against counterfeit pesticides?

- Deal only **with well-known and trusted** agri-input dealers and importers.
- Be suspicious of anyone who offers pesticides at **low prices**.
- Be cautious of **unknown brand names** or labels.
- Learn the **characteristics** of the most commonly used registered products in the region and be suspicious if any of these known characteristics are different. Look for:

  - Type of packing
  - Color of content
  - Layout and color of the label
- Insist on proper **paperwork**. Ask for a receipt with the details of the product. Keep the receipts.
- Ask for assistance if in doubt. Contact the Ministry of Agriculture or the local CropLife country association.
- **Report incidents** to the government or police.
- **Do not take any risks!**

6 Reading the Toxicological Band

The toxicological band can be found on the bottom of the pesticide label.

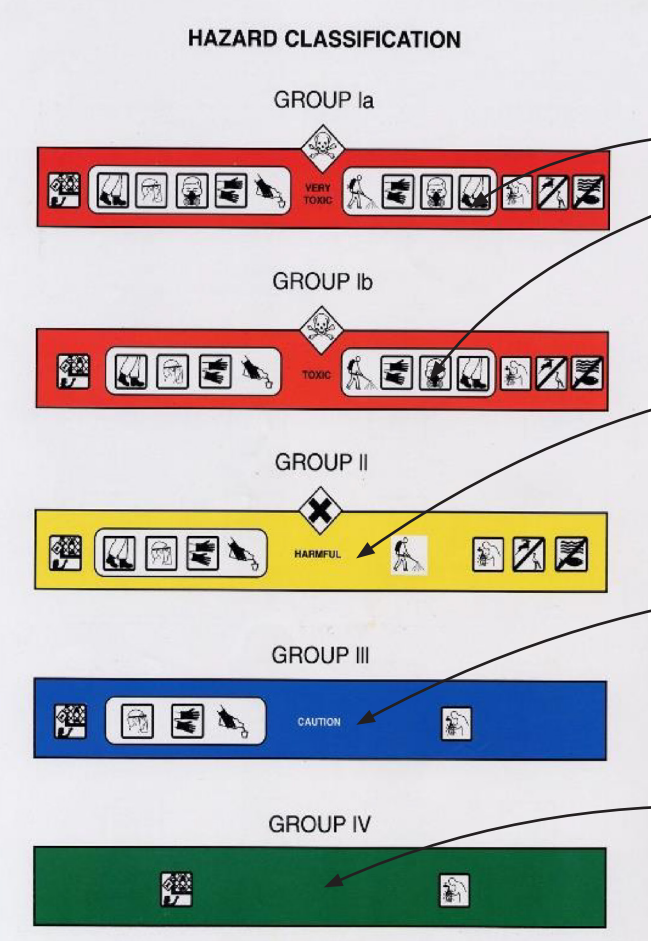
The toxicological band indicates the level of toxicity and instructs how to safely handle the product.

The toxicological band contains two important items:

1. The color band
2. Hazard warning (Symbol and words)
3. The pictograms

The color band

The color band indicates the product's **level of hazard**. There are **5 categories** in **4 different colors**. The categories and colors are internationally accepted.



Color: Red
Group: 1a and 1b
Extremely and highly hazardous

Color: Yellow
Group: II
Moderately hazardous

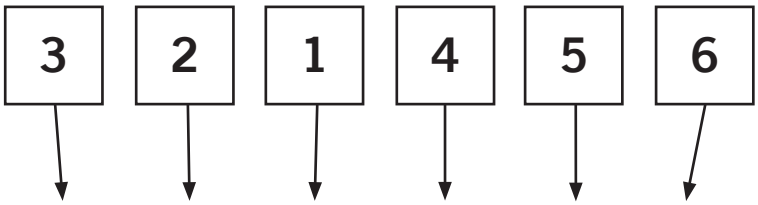
Color: Blue Group: III
Slightly hazardous

Color: Green
Group: IV
Unlikely hazardous in normal use

The pictograms

Pictograms are small drawings that give advice on how to mix, apply, and store the pesticide. They also contain warnings. Pictograms should be read in a specific order:

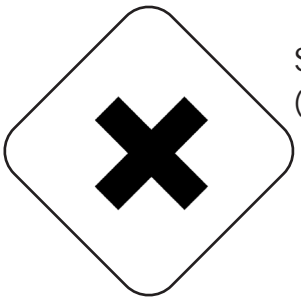
- Start in the **middle** where you will find a pictogram with the **level of hazard symbol (1)**
- Go the **left** side. You will find:
  - **Mixing warnings box (2)** - The pictograms in the box should be read from right to left.
  - Far left: **Storage warning (3)**
- Go the **right** side. You will find:
  - **Application warning box (4)** - The pictograms in the box should be read from left to right.
  - **Wash after use warning box (5)**
  - Far right: **Environmental warnings box (6)**



Each pictogram has its own meaning. The most common pictograms are:

Level of hazard

Extremely or highly hazardous (red color band)



Slightly hazardous (yellow color band)

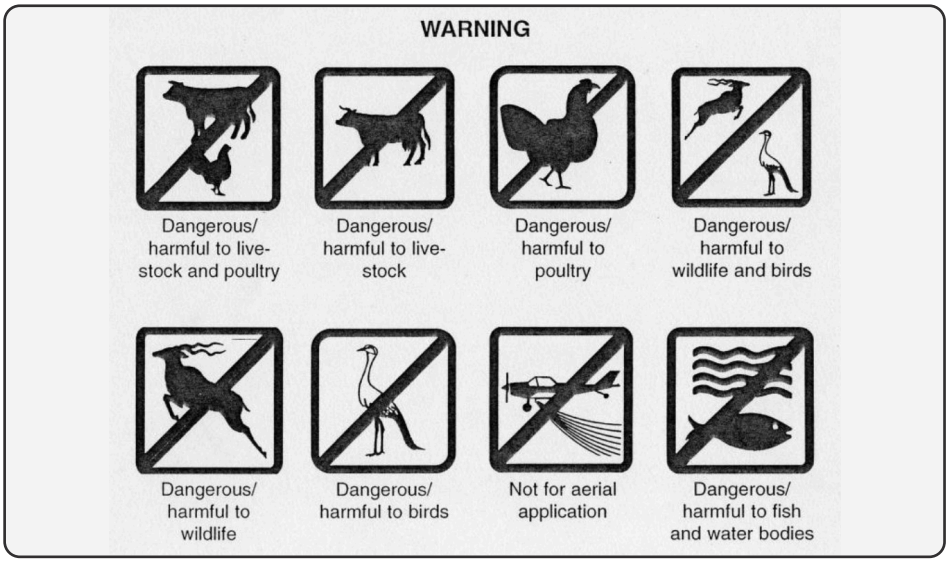
Storage

Keep product locked away so that children and animals cannot reach it

Advice

Wash after use

Warning



Corrosive

Explosive

Inflammable

Protection

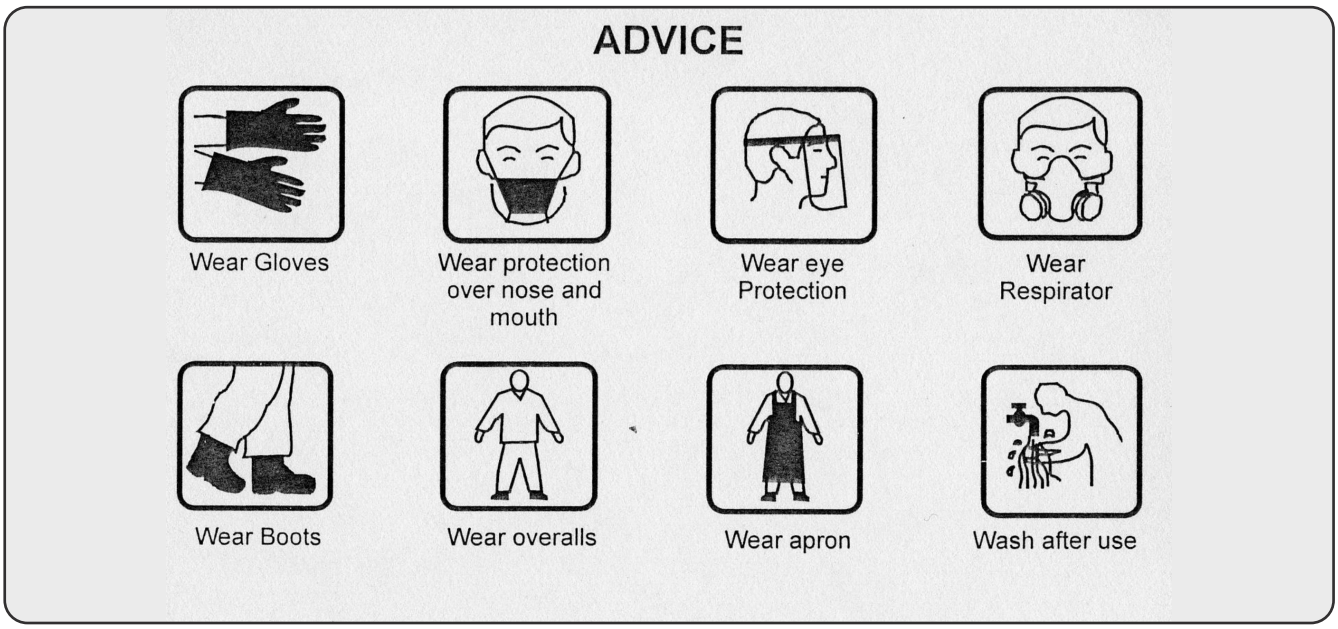
The following pictograms are always used in combination with the advice pictograms.

For example: When mixing, then wear gloves, eye protection, and boots.

When mixing liquid, then...

When mixing powder or granules, then...

When spraying, then...



- could result in the agro-input not being sold beforeits expiration date. If you do not buy enough agro-inputs, you will lose sales by not supplying your customers.
- Consider the **capacity** of your storage space. Ensure that there is enough space to safely store all products.

B. Responsible Use

7 Personal Protective Equipment

The **consequences** of contamination can be very serious.

A. **Skin.** Consequences: itching, burning, or irritation of the skin; serious scars; numbness or weakness of arms, legs, feet, or hands; infertility (refer to the scrotum); and even death.

B. **Eyes.** Consequences: itching or irritated eyes, blurred vision, and even blindness. It can happen when you do not wear eye protection; the input can splash into the eyes (liquids) or be blown by the wind (powder).

C. **Ingestion.** Consequences: dizziness, vomiting, convulsion, coma, and even death. It can happen when you eat, drink, or smoke with contaminated hands.

D. **Inhalation.** Consequences: dizziness, vomiting, convulsion, coma, and even death. It can happen when you work in a closed space or do not wear a respirator.

There are several types of Personal Protective Equipment (PPE) to wear to protect different parts of the body:

Gloves: To protect the hands. It is best to wear long-sleeve gloves.

Boots: To protect the feet. It is best to wear heavy- duty rubber.

Overalls: To protect the legs, arms, and body. It is best to wear heavy- weave cotton or specialist coveralls.

Apron: To protect the front of the body. It is best to wear aprons made of PVC, rubber, or polyethylene (liquids cannot get through).

Hat: To protect the head and forehead. Be aware that the ears and sometimes the forehead are not protected. You can wrap a cloth around your head to protect those parts as well.

Hood: To protect the neck and ears.

Goggles: To protect the eyes.

Face shield: To protect the eyes and face. It is cooler to wear than goggles.

Mask: To protect the nose and mouth. Not recommended for spraying.

Respirator: To protect the nose and mouth.

When to wear what?

Always check the label to learn the appropriate PPE to wear in certain situations. The more toxic a product, the more protective clothing is required.

How to wear Personal Protective Equipment?

Boots: Wear trousers **over** the boots to avoid spillage into the boots.

Gloves should be long and worn over the sleeves. If only short (wrist length) gloves are available they should be under the (elasticated) sleeve.

Remove gloves by making them inside out to ensure that your bare skin is not touching the outside of the gloves.

Order of putting on PPE
Start with overalls or an apron; then put on the mask, goggles, hat, boots, and finally gloves.

Order of removing PPE
Start by washing your gloves (while wearing them) before removing anything. Then remove the hat, goggles, mask, boots, gloves, and overalls. Wash hands with soap and water after you have finished.

Do not wear damaged clothing

Work clothing including footwear must be washed with soap or other detergent after each day's use. It must be washed separately from other clothing and kept in a separate place. Dispose the wastewater in a separate disposal pit away from your farm and domestic are

8 Parts of a Knapsack Sprayer and How They Function

Knapsack sprayers come in all sizes and models, and have different brand names. Theknapsack sprayer is the most frequently used application equipment in Africa. Millions of farmers use it daily to spray their crops.

Different parts of a knapsack sprayer

A knapsack sprayer consists of different parts and each part has its own function.

1. **Shoulder straps**: Knapsack sprayers are fitted with shoulder straps. The straps secure the knapsack on the operator's shoulders. Shoulder straps must be in good condition. A broken shoulder strap may result in damage to the sprayer and spillage of the content.
2. **Tank lid**: The tank has a lid that has to be screwed on top of the tank. It seals tight to keep pressure in the tank. Some lids have a sieve that ensures that no objects or parts other than the liquid can come into the tank and block the supply line or nozzle. The inlet to the tank also has a sieve, which stops solids to go into the tank and block either the outlet or the nozzle
3. **Tank**: The tank is manufactured from sturdy plastic or stainless steel, and holds the liquid that is sprayed. Knapsack sprayers have different tank capacities. The most common used tank size in Africa is 15 liters.
4. **Pump handle**: The pump handle is at hip level of the operator (usually on the left- hand side) and is connected to the pump. It is used to put the pump into action.
5. **Pump**: The pump is the source of pressure. It builds up pressure that forces the liquid into the tank outwards through the hose.
6. 6. Hose or supply line: This is the tube between the tank and the trigger. It is usually made from rubber or reinforced plastic. The main function is to transport the liquid from the tank to the lance.

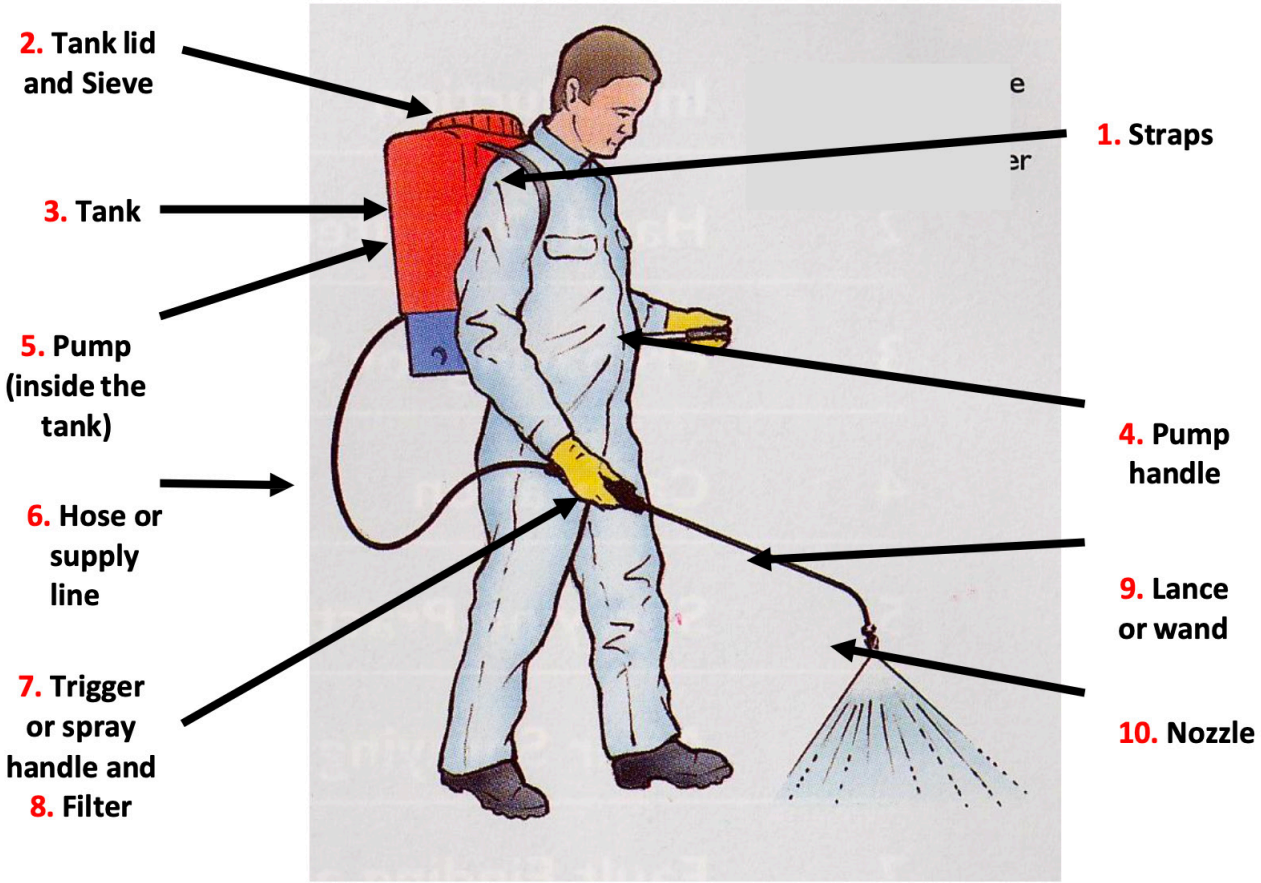
7. **Trigger or spray handle:** The spray handle is connected to the tube and lance and controls the outlet of liquid from the knapsack sprayer. When the trigger is pressed, the liquid in the hose is released and goes through the lance and nozzles out. When the trigger is released, the liquid in the hose is cut off and spraying stopsimmediately.

8. **Filter:** Inside the trigger is an inline filter. This filter takes out all solid particles before the spray liquid enters the lance.

9. **The lance or wand:** The lance is usually made from metal and is the link between the trigger and the nozzle. The length of the lance makes it easy to apply the liquid to the target.

10. **The nozzle:** The nozzle is the most important part of the knapsack sprayer, because it determines how much of the content of the knapsack sprayer is applied to the target area. The nozzle also sprays the liquid in a specific pattern. There are different types of nozzles available for knapsack sprayers, which will be handled separately in another lesson

In general, knapsack sprayers function in the same way. Some have more advanced features than others but basically the following happens when working with a knapsack sprayer:



1. The **tank (3)** is filled with whatever liquid needs to be sprayed. The liquid needs to go through the **sieve (2)** which, solids to go into the tank.
2. The **tank lid (2)** is closed properly.
3. The operator puts the knapsack sprayer on his/her back. The **shoulder straps (1)** secure the pump on his/her back.
4. The operator starts to pump the **pump handle (4)** with up and down movements.
5. The pump handle drives **the pump (5)**, which builds pressure in the tank.
6. The pressure pushes the liquid into the **hose (6)** until it reaches the **trigger (7)** and passes through the **inline filter (8)**.
7. When the operator pushes the spray trigger, the liquid moves into the **lance (9)** up to the nozzle.
8. The nozzle (10) releases the liquid in a specific pattern and drop size.

Closer look at the hidden parts of a knapsack sprayer:

The sieve (2): Stops solids to enter tank

The filter (8): Stops particles to enter lance and block nozzle

O-rings, seals and springs:

These parts are very important. They prevent leakages and let the sprayer works

C. Application

9 Types of Nozzles and Their Uses

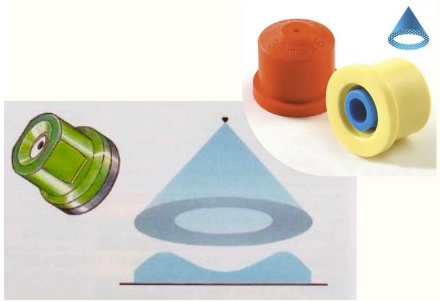
Nozzle functions

The nozzle regulates the liquid coming out of a knapsack sprayer. There are a few things to be taken into consideration when talking about nozzles:

- **Droplets:** The water will come out of the knapsack sprayer in the form of droplets that can vary from being very large in size to a very small size (like a mist).
- **Spray pattern:** A spraying pattern is the shape the liquid forms between the nozzle and the target. Certain spray patterns are more suitable for certain types of pesticide application. Fan-shape patterns are generally used to apply herbicides because of its wide swath, while hollow-cone shapes are more often used for insecticides and fungicides.

Different types of nozzles

There are many types of nozzles. The most commonly used nozzles are:

Nozzle	Used for	Type of sprayer	Spraying pattern	Droplets
Flat fan nozzle 	Herbicides	Boom sprayers and pressurized sprayers.	Fan shaped spray to cover large areas.	Medium to large.
Hollow cone nozzle 	Insecticide and fungicides	Knapsack sprayers	Sprays a circle and is covering the outside of the circle.	Fine droplets.

The different spray applications

In general, labels will describe how the pesticide should be applied. These instructions must be kept in mind when selecting a nozzle. Below are some of the terms found on labels:

- **Spray to wet:** It means you wet the target area up to a point before moisture will start to run down (drip).
- **Spray to run:** It means you wet the target area until drops are starting to run down from the target area.

The Do's and Don'ts of nozzle care:

- Don't open blocked nozzles with a sharp object; you will increase the size of the nozzle hole.
- Don't suck on blocked nozzles; you can seriously harm yourself.
- Don't tap on a rock or boot when the nozzle is blocked.
- Do check regularly for wear and tear and replace damaged nozzles.
- Do clean properly after use with water and a soft brush.
- Do unblock the nozzle using a soft brush (toothbrush).
- Do wear gloves when working with nozzles.

C. Application

10 How to Calibrate a Knapsack Sprayer

What is calibration?

Calibration is to measure the output of your knapsack sprayer under controlled conditions at normal working pressure and pace.

Why do we need to calibrate sprayers?

There are different ways how labels tell users at what rate to apply pesticides. We need the output of the sprayer to do the calculations when measuring and mixing pesticides.

When do I need to calibrate my knapsack sprayer?

It is recommended to calibrate a knapsack sprayer:

- Before you use it for the first time
- At the start of each season
- When you change from either nozzle type or nozzle size
- Any time when you are not sure if your knapsack sprayer works correctly

What do I need to calibrate my sprayer?

You need clean water, a knapsack sprayer, a watch to time you, a measuring cup and measuring tape.

How do I calibrate my knapsack sprayer?

Below are step-by-step instructions for a simple knapsack sprayer calibration:

- **Step 1:** Fill the knapsack sprayer with clean water and fit the right nozzle.
- **Step 2:** Put on gloves and the knapsack sprayer.
- **Step 3:** Spray at normal working pace and pumping speed in the field for 1 minute. Time yourself and stop after the lapse of 1 minute.
- **Step 4:** Measure the area covered with your knapsack sprayer in 1 minute.

Example: The area covered is 4 meters by 3 meters

- **Step 5:** Calculate the square meters of the area sprayed by multiplying length with width

Example: 4 meters x 3 meters is 12 square meters

- **Step 6:** Measure the volume water released by your knapsack sprayer by spraying again for 1 minute at normal pumping speed in the measuring cup. Time yourself andstop after the lapse of 1 minute.
- **Step 7:** Measure the liquid sprayed into the measuring cup. Example: The water released in 1 minute is 1080 ml of water

- **Step 8:** Calculate how much water your knapsack sprayer uses to cover 1 square meter at normal working pace and pump speed by dividing the total area covered (see step 5) into the total amount of water measured (steps 6 and 7).

Example: 1080ml divided by 12 square meters = 90 ml.

This means that this knapsack sprayer with the specific nozzle uses 90 ml of water to cover 1 square meter at normal working pace and pumping speed.

Measuring the field

In general fields are not easy to measure. The best way to measure is to divide the field into small parts or blocks and calculate as best as possible the surface area of each block and add everything to get the total surface area.

C. Application

11 How to Calculate the Pesticide Dosage

The dosage of a pesticide as well as the **rate of application** to the target area is very important. If the dosage is wrong or if you do not follow the instructions on the label, you will end up with either applying too much or not enough pesticides.

Over-application can cause:

- Damage to crops
- Increased hazard to the applicator
- Excess residue on crops
- Higher costs because you use more pesticides than needed
- Increased possibility of resistance by the pest to the pesticide used

Under-application can cause:

- No or less control over the pests
- Crop losses because damage caused by pests continues
- Higher costs because you will need to re-spray
- Higher costs because you will spend extra time for re-spraying

What type of pesticide needs calculations?

There are two types of pesticides:

- **Ready-to-use formulations:** These pesticides do not need any mixing and can be applied to crops right away. The formulations require minimal calculations. You only apply the recommended quantity as described on the label to the target area. Some examples of ready-to-use pesticides are:
  - Dusting powders
  - -Granules
  - Already mixed liquid pesticides for small garden use
- **Concentrated formulations:** These pesticides need mixing before use. To enable correct mixing the user must do some calculations in order to put the right amount of pesticide in the knapsack sprayer to ensure proper application. Some examples of concentrated pesticides are:
  - Emulsifiable concentrates
  - Suspension concentrates

- Wettable powders
- Water dispersible granules

What do I need to get the correct dosage?

In order to get the correct dosage you need the following:

- **The label:** The pesticide label has a lot of information on it. The following information on the label will assist farmers to calculate correctly:
  - Recommended dosage
  - Mixing instructions
- **Know the capacity of your knapsack sprayer.** Most knapsack sprayer have a capacity of 15 liters (you need to check this because some knapsack sprayers are 16 liters).
- **Know the output of your knapsack sprayer:** One of the main actions of maintaining a knapsack sprayer is to calibrate it. Calibration is to measure the output of a knapsack sprayer under controlled conditions (see topic C03 on calibration).
- **Know the size of the area to be treated:** The size of the area to be treated is very important to know how much pesticide is needed for the job. The size of the target area is expressed in square meters (m2). To calculate the size, you need to multiply the length of the area with the width of the area.

Then you will need to know:

- How much **pesticides** do you need to fill **one knapsack sprayer?** Field officers of companies that sell pesticides know the correct dosages of their products. You can contact them to ask for the correct dosage.
- How much pesticide do you need to treat **the whole area**? You can calculate this when you have all information as mentioned above.

Example:

Capacity of the knapsack sprayer	**15 liters**
Output of the knapsack sprayer	**90 ml to cover 1m^2**
Size of the area to be treated	**30 meters by 40 meters**
Recommended dosage per knapsack sprayer	**400 ml**

Calculations

1. Calculate **the total area** you would like to treat: 30m x 40m = 1,200m^2

2. Calculate **the number of knapsack sprayers you need to cover the whole area**. You know this by calibrating your knapsack sprayer. In the session on calibration we have found that as example that we use 90ml to cover 1m^2. The calculations are asfollows:

A. Your knapsack sprayer can carry 15 liters, which is equal to 15,000ml.

B. We use 90ml to cover 1m^2 so with 15,000 ml we can cover 15,000ml / 90ml = 167m^2. This means with 1 knapsack sprayer we can cover 167m^2.

C. That means to cover 1,200m^2 we need 1,200m^2 / 167m^2 = 7.2 knapsack sprayers.

3. We need 400ml per knapsack sprayer, so for 7.2 knapsack sprayers, we will need 400ml * 7.2 sprayers = 2,880 ml = 2.88 liters

C. Application

12 Measuring and Mixing of Pesticides

Correct measuring and mixing of pesticides is important, because incorrect measuring and mixing may result in over or under application of pesticides, which can be costly and dangerous.

Ready-to-use formulations: These pesticides need no mixing. They are ready to use and require only measuring and controlled application to the target area.

Liquids, wettable powders and water dispersible granules need measuring and mixing.

The **measuring and mixing process** consists of three main actions:

- Preparation
- Measuring and mixing:
  - Liquid pesticides
  - Wettable powder pesticides
- Aftercare

1. Preparation for measuring and mixing:

Working with pesticides always involves some risk to the user or environment. Therefore you need to be prepared. The preparation of measuring and mixing consists of:

- Checking the weather. You cannot measure and mix if there is a possibility of rain or strong winds.
- Reading the label to see:
  - - What protective clothing and equipment to wear
  - - What measuring equipment to use
  - - What application equipment to use
  - - The dosage calculation
- Making sure you have the right equipment for the measuring and mixing process: measuring cup or scoop, adequate water and knapsack sprayer.
- Protect yourself by putting on protective clothing and equipment as indicated by the label:



- Making sure you have a spill kit (sand, scoop, broom, etc.) at hand in case of pesticide spills.
- Calculating the dosage and quantity needed for the target area (see topic 5 on how to calculate the correct dosage).

2. The measuring and mixing process:

Measuring and mixing liquid pesticides
Liquid pesticides have a much higher risk of skin contamination and spills than wettable powders. Measuring and mixing liquid pesticides consists of the following steps:

1. Protect yourself according to the label.
2. Fill half of the sprayer tank with clean water. The reason for this action is to avoid pure pesticides to enter the outlet of the sprayer.
3. Open the pesticide container.
4. Measure the right amount of pesticides in a suitable measuring cup. You should have made your calculations before you start mixing (see topic 5 on calculations).
5. Pour measured pesticides into the sprayer tank.
6. Close the pesticide container.
7. Triple rinse the measuring cup and pour the rinse water into the sprayer tank (see topic A16).
8. Agitate the tank to mix the pesticides with the water.
9. Fill the sprayer tank to the required level with water.
10. Close the sprayer tank properly.
11. Agitate the tank again.
12. The sprayer is now ready for application.

Measuring and mixing wettable powder pesticides

Wettable powder pesticides have a much higher risk of dust inhalation than liquid pesticides. Measuring and mixing wettable powder pesticides consists of the following steps:

1. Protect yourself according to label.
2. Fill half of the sprayer tank with clean water. The reason for this action is to avoid pure pesticides to enter the outlet of the sprayer.
3. Open the pesticide container.

4. Measure the right amount of pesticides in a suitable measuring scoop. You should have made your calculations before you start mixing (see topic 5 on calculations).
5. Put the wettable powder in a mixing bucket.
6. Close the pesticide container.
7. Add a bit of water to the bucket and mix until it becomes a smooth paste.
8. Pour the pesticide paste into the sprayer tank.
9. Triple rinse the measuring scoop, mixing spoon, and the mixing bucket, and pour the rinse water into the sprayer tank (see topic A16).
10. Agitate the tank to mix the pesticides with the water.
11. Fill the sprayer tank to the required level with water.
12. Close the sprayer tank properly.
13. Agitate the tank again.
14. The sprayer is now ready for application.

Measuring ready-to-use dusting powders and granules

Dusting powders have a high risk of inhalation of the dust. Measuring dusting powders or granules consists of the following steps:

1. Protect yourself according to label.
2. Open the pesticide container.
3. Measure the right amount of pesticides with a suitable measuring cup. You should have made your calculations before you start mixing (see topic 5 on calculations).
4. Put the dusting powder or granules into a suitable applicator.
5. Close the pesticide container.
6. Clean the measuring equipment by triple rinse and dispose of the rinsing water in a safe way (see topic A16).

3. Aftercare

The aftercare consists of the following steps:

- Put the pesticide container back into a safe storage area or dispose of the empty container in a safe way (see topic A17).
- Clean the mixing and measuring area if there are any spills.
- Clean the protective clothing and equipment in the proper way.
- Do not use any measuring equipment, mixing buckets and mixing spoons for any other purpose than measuring and mixing of pesticides.

C. Application

13 How to Use a Knapsack Sprayer

The knapsack sprayer is the most popular pesticide application equipment in Africa. However, many accidents happen daily because of the incorrect use of the knapsack sprayer.Using a knapsack sprayer involves three steps:

1. Preparing for spraying
2. Working in the field with a knapsack sprayer
3. After working in the field with a knapsack sprayer

1. Preparing for spraying

Before applying pesticides with a knapsack sprayer there are a few important things to do:

- **Read the label** to know how to apply the pesticide, the recommended nozzle type, and the application recommendations.
- **Inspect** the equipment for loose fittings, and signs of wear and tear. Repair any problems before spraying.
- **Check for leakages** by filling sprayer half with water and pumping the water through the system. Potential leaking points are where the supply line is connected with the tank, the trigger assembly, the spray lance and the nozzle. Check that the tank lid closes properly.

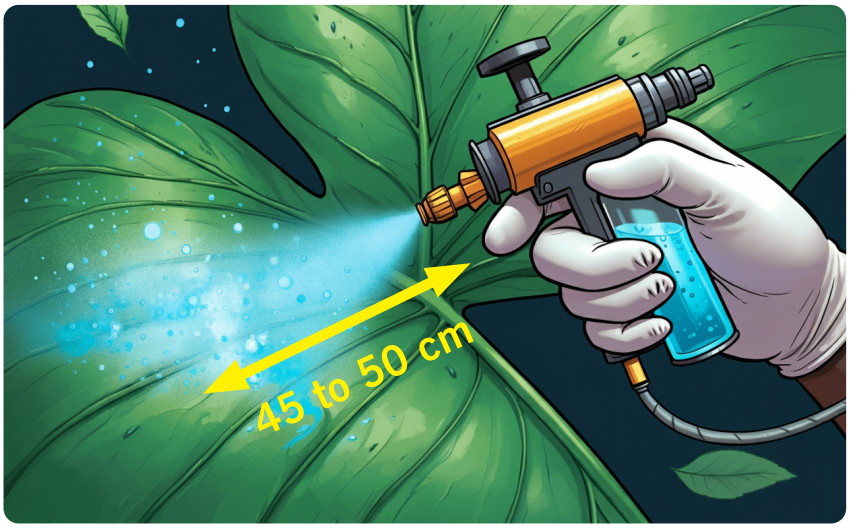
- Select the **correct nozzle** (see topic CO2 on nozzles) and fit it to the sprayer.
- **Check the weather conditions.** Do not spray when it rains (the pesticide will be washed off) or with strong winds (the spray will be blown away).

- Check if the **neighboring field** is growing **organic or certified crops**, and discuss with the owner of the field how to avoid contamination of his/her crops. It is always best to observe a buffer zone of at least 15 meters between the crops you spray and any other field.
- **Plan** the spray activities in the field:
  - Where will you put the remaining water?
  - Are there any animals or people in the area?
- **Check the protective clothing** for signs of wear and tear (see red dots). Fix any problems before putting it on.

- Put the protective clothing on correctly.

2. Working in the field with a knapsack sprayer:

- You are now in the field and ready to start spraying. There are some important things to keep in mind while working with a knapsack sprayer in the field:
- Observe a buffer zone of at least 15 meter between the crops you are spraying and any water body.
- Walk at a steady pace. If you walk too slow or too fast your rate of application will differ from area to area.
- Pump at a steady pace to allow for constant tank pressure.
- Move the nozzle over the target area in a smooth and constant speed.
- Overlap the previous spray area.
- Maintain a distance of 45cm to 50cm between the target and the nozzle. If it is too close the droplets will bounce away to non-target areas. If it is too far away, the droplets will not reach the target area and land in between.



- Constantly **check for leaks** in the supply line. Stop spraying if you see a leak.
- **Monitor the spray pattern of the nozzle.** Any changes may indicate a blocked or damaged nozzle.

3. Aftercare

After spraying in the field, the following steps should be taken:

- **Empty** the knapsack sprayer completely. Do not apply remaining spray mix to the target area because you will over-apply. Rather spray it out on the area around your field where pests may be located.
- **Clean** the knapsack sprayer by **triple rinsing** with clean water. Leave your protective clothing on while cleaning the knapsack sprayer.
- Clean the **nozzle** with a soft brush.
- Leave the equipment to **dry**.
- **Remove** your protective clothing.
- **Clean** the protective clothing and equipment. Wash protective clothing separately from other washing.
- Wash yourself properly under running water – Do not sit in a tub or bath.

C. Application

14 Pesticide Residues

When applying pesticides, residues can be left on the crops. Residues are portions the pesticides that are on the crop or in the crop. Often residues cannot be seen by the naked eye.

Residues can be toxic. If residues are left on crops, the consequences can be severe:

- Farmers and buyers handling the crops can be contaminated.
- People that eat the crops can get contaminated.
- Crops offered by farmers can be rejected by buyers.
- Crops offered for export can be rejected by receiving countries, which can result in lower prices for from your country.
- If certified, farmer groups can lose their certification (fair-trade or organic) and premium.

To avoid residues, a pre-harvest interval or period is needed in order to allow time for the pesticide to degrade and for the crop to be safe to eat. A pre-harvest interval is the number of days between the pesticide application and harvesting. For example, if you spray on Monday and the pre-harvest interval is 4 days, you can safely harvest on Saturday.

To avoid that the farmer will get contaminated by residues, re-entry intervals or periods must be observed. Re-entry intervals are the number of days between the pesticide application and the moment a treated field can be entered. For example, if you spray on Friday and the pre-harvest interval is 5 days, you can safely enter the field again on Thursday.

Pre-harvest intervals and re-entry intervals can be found on the label. The length of the intervals depends on the toxicity of the pesticide and its persistence.

When applying pesticides:

1. Look at the label to see how many days the pre-harvest interval is.
2. If the crop will be harvested within the pre-harvest interval, do not spray!
3. Inform the farmer how many days (s)he cannot harvest his/her crop (pre-harvest interval).
4. Inform the farmer how many days (s)he cannot enter his/her field (re-entry interval).
5. Put up warning signs to warn people that the field has been treated.

Warning:

- When the measuring and mixing is not done correctly, the pre-harvest and re-entry interval cannot be trusted anymore.
- The pre-harvest and re-entry interval can be different if the pesticide is being used for different crops than it is meant to be used.

C. Application

15 Do's and Don'ts of Pesticide Application

There are certain do's and don'ts that will help the farmer or spray service provider to better apply pesticides. These do's and don'ts will also protect the environment and the person who operates the knapsack sprayer and handles the pesticides

Do's of pesticide application:

- Do read the label before applying pesticides.
- Do wear protective clothing and equipment at all times.
- Do wash hand before and after nature's call.
- Do keep people and domestic animals away from the field while spraying.
- Do take regular breaks to rest and concentrate on the job you are busy with. Mistakes can be dangerous.
- Do mix only enough for today.
- Do check regularly for leakages.
- Observe a buffer zone of at least 15 meters between the crops you spray and any waterbody.
- Do clean up after applying pesticides.

Don'ts of pesticide application:

- Don't apply pesticides when it is windy.
- Don't spray during extremely hot periods of the day.
- Don't spray when rain is anticipated.
- Don't eat, drink or smoke while applying pesticides.
- Don't spray during the extreme heat of the day.
- Don't spray overhead. There will be a high risk of drift and pesticide contact.
- Don't suck on blocked nozzles or unblock nozzles with a sharp object.
- Don't spray left-overs on crops, because this might lead to over-application.

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