TVET CERTIFICATE IV in Forestry

PESTS AND DISEASES CONTROL TECHNIQUES

FORPD 401

Apply Pests and diseases control techniques

Competence

Credits: 12

Learning hours: 120

Sector: Agriculture and Food processing

Sub-sector: Forestry

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Purpose statement

Pest and diseases are among different threats to decrease agricultural production. This module provides skills and knowledge required to identify and treat pests and diseases, select and use appropriate tools and equipment. It will allow the learner of level 4 to handle chemicals, follow instructions and precautions for their good application, monitor and evaluate treatment efficiency. It is important for a learner to know different ways of pests and diseases control in order to increase forest production.

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Learning Unit 1 – Identify pest and diseases

Introduction to pests and diseases

All plants eventually have some types of problems. Identifying diseases or pests is the first step to correct sick plants. There will always be pests and diseases in the garden; it is part of nature. The trick is to catch the problem early, before it spreads.

Some problems will disappear with better weather and other will need human intervention. Therefore, pests and diseases are associated terms because pest can transmit diseases. A plant disease may therefore be defined as: Any harmful deviation or change from the normal functioning of physiological processes.

It is also defined as: a malfunctioning process that is caused by continuous irritation which results in suffering. A plant is diseased when its systems are not normal and, therefore, it is not producing as well as it should according to normal expectations of the farmers**.**

This manual is going to help the trainees to:

- Identify pest and diseases
- Conduct pests and diseases survey
- Select tools and equipment's
- Prepare phytosanitary products
- Apply pest and diseases control methods

LO 1.1 – Perform pests collection.

- **Topic 1 Collection methods**

The methods used for collecting insects may be divided into two categories: **Active collection** and **Passive collection.**

In **active collecting**, the collector is involved in an active search in finding out the insects either by hand or by using the apparatus suited according to one's needs.
In passive collecting, the traps of different kinds are employed to do the work, and the collector participates only passively. Such traps are established at sampling stations in the field, and are serviced at given intervals.
In sampling the biodiversity of insects, there is more use of the passive methods than the active methods, although the latter proves valuable in collecting certain insect groups. Large number of insects might be collected, if the collector chooses for passive methods.

1.1.1. Active Collecting Method:

When insects are collected by hand then one should have good knowledge or proper information as to which insects bite and which sting, and how far such attack can prove to be poisonous. "Caterpillars with spines or hairs on their bodies should be avoided because some of these have venom associated with these structures.

In case of collection by hand, the collector should be well equipped with tools like – hatchet, small garden shovel, forceps, brush, gloves hand-lens, pocket knife, etc. Tools like hand axe, shovel and forceps, are a must in their kit, before they set out for collection.

Hand collecting is useful for large but sedentary or slow-moving insects. Insects found in places such as under logs or rocks/ stones or loose bark or in buildings, in crevices or timber, or in dung, or in different parts of the plants or in any other location where using any larger equipment is not possible, must be collected by hand.

- **Techniques used for active collection of pests**
  - ✓ **Foliage Beating or Beat Sampling:**

A beating sheet or beating net is held under vegetation and the foliage firmly tapped with a beating stick to dislodge insects from the branches falling into the net. Insects are collected off the sheet or net using an aspirator or by hand into a container if they are too large to fit through the aspirator tube. This is an effective method for many plant inhabiting insects including beetles, bugs, psyllids, caterpillars, and bug and beetle larvae.

Figure 1foliage beating of pests

- ✓ **Sweep Netting**:

Generally, a net with a long pole and deep mesh bag is used, either to collect large flying insects individually (butterflies wasps, flies, dragonflies) or by sweeping over foliage in a back and forth. many small insects hidden in the foliage will be collected.

Figure 2sweep netting

- ✓ **Hand Collecting or Visual Checking**

A useful method in support of beating and sweeping and plays an important support role in agricultural sampling, being useful for detecting pests such as aphids and silver leaf whitefly. While checking leaves for adult or larval leaf feeding insects, buds and flowers should be separated to search for eggs or small larvae too. This may also

incorporate looking around on the ground for insects and digging around the base of the plant and checking roots of crops. Collect specimen samples into either ethanol or dry containers.

1.1.2. Passive Collecting Method (use of traps)

Anything that impedes or stops the progress of an insect is referred to as a 'trap'. The factors affecting the performance of a trap include construction of the trap, location of the trap, time of the year or day chosen for trapping, weather and temperature on the day of trapping, kind of the attractant used, if any. Due to various reasons for instance, the type of insects being collected and their different habitats, we might have different kinds of traps

Types of Traps for active collection of insects

- ***Light traps***: light traps with or without ultraviolet light attract certain insects. For eg. Grasshoppers and some beetles are attracted to light at a long range
- ***Adhesives traps:*** sticky traps may be simple flat panels or enclosed structures, often baited, trap insects with adhesive substance.
- ***Flight interception traps*** or net-like or transparent structures that impede flying insects and funnel them into collecting. Barrier traps consist of a simple vertical sheet or wall that channels insects down into collection containers.
- **Terrestrial traps**:

Pitfall traps consists of a bucket or container buried in soil or other substrate so that its edge is flush with the substrate. Pitfall traps are used for ground-foraging and flightless arthropods such as beetles and spiders.

- **Aquatic traps**

Involve mesh funnels that or conical structures that guide insect into a jar or bottle for collecting. Aquatic emergence traps are cage-like or tent-like structures used to capture aquatic insects such as mosquitoes and odonates upon their transition from aquatic nymphs to terrestrial adults.

• Topic 2. Conservation methods of different insects

In conservation of trapped insects, a specimen should be quickly fixed as soon as it has been collected, and handled in a way that keeps it clean and undamaged until it can be preserved. The majority of adult specimens are killed in killing bottles or tubes and preserved dry, while immature stages and many soft-bodied adults are killed by immersing them in a fixative prior to preserving them in a liquid preservative.

Important note: Some of the chemicals used for killing and fixing specimens are hazardous if handled improperly. Great care should be taken when handling these chemicals and they must only be used in the manner suggested. Always read and abide by the guidelines set out in the chemical MSDS (material safety data sheet)

For immature stages, mostly being soft bodied, wet preservation is required for the most part. However, some nymphs of hemimetabolous groups such as Hemiptera and Orthoptera have a hard exoskeleton and may be dry preserved and pinned or point mounted.

1. Dry conservation

It is standard practice to place many kinds of insects in small boxes, paper tubes, triangles, or envelopes for an indefinite period, allowing them to become dry. It is not advisable to store soft bodied insects by such methods because they become badly shriveled and very subject to breakage. Dipteran should never be dried in this manner because the head, legs, and most of all the antennae become detached very easily.
Almost any kind of container may be used for dry storage; however, tightly closed, impervious containers of metal, glass, or plastic should be avoided because mold may develop on specimens if even a small amount of moisture is entrapped. Nothing can be done to restore a moldy specimen.

2. Liquid conservation

Preservation of insects in alcohol varies from one group to another. For example, spiders preserve well in ethanol, but tend to become to flaccid in isopropyl.
In general, ethanol and isopropanol mixed with water is the most widely used preservation fluids. Most commonly, a mixture of 75% alcohol to 25% water is used. The water should be distilled to ensure a neutral PH and the solution should be thoroughly mixed since alcohols and water do not mix easily by themselves. Additives should be avoided. Special care should be taken with labels placed in alcohol.

3. Pinning

Any dry insect that is to be pinned must be relaxed, that is, remoistened enough to soften so that it will not break when the pin is inserted or so that parts of the specimen may be rearranged or repositioned. Insects, especially Lepidoptera, that are to have their wings spread should be relaxed even if they have been killed for only a short time.
Eight hours in a relaxing chamber should suffice, but larger specimens may require 24 hours or more. Simply leaving specimens in a cyanide jar for a while sometimes will relax them, but this method is not reliable.

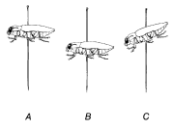


Figure 3 pinning of insects

A) Correct height and position.
B) Specimen too low on pin.
C) Specimen improperly tilted on pin.

4. Labeling

To have any scientific value, specimens must be accompanied by a label or labels giving, as a very minimum information about where and when the specimen was collected, who collected it, and, if pertinent, from what host or food plant. Many collectors keep a field notebook to record more detailed information, such as general ecological aspects of the area, abundance and behavior of the specimens, and any other observations noted at the time of collection.

LO 1.2 – Characterize the pests

- **Topic 1 Description of pests**

A pest is any living organism which is invasive or prolific, harmful, destructive, a nuisance to plants or animals, livestock, wild ecosystems.

A pest is anything that:

- ✓ Competes with humans, domestic animals, or desirable plants for food or water,
- ✓ Injures humans, animals, desirable plants, structures, or possessions,
- ✓ Spreads disease to humans, domestic animals, wildlife, or desirable plants,
- ✓ Annoys humans or domestic animals.

Categories of pests include:

- **Continuous pests** that are nearly always present and require regular control.
- **Sporadic, migratory, or cyclical pests** that require control occasionally or intermittently.
- **Potential pests** that do not require control under normal conditions. but may require control in certain circumstances.

Topic 2 Classification of pests

Types of Pests

Types of pests include:

- ✓ **Insects**, such as roaches, termites, mosquitoes, aphids, beetles, fleas, caterpillars, mites, ticks, and spiders,
- ✓ **Microbial organisms**, such as bacteria, fungi, nematodes, viruses, and mycoplasmas,
- ✓ **Weeds,** which are any plants growing where they are not wanted,
- ✓ **Mollusks**, such as snails, slugs, and shipworms, and
- ✓ **Vertebrates**, such as rats, mice, other rodents, birds, fish, and snakes.

Most organisms are not pests. A species may be a pest in some situations and not in others. An organism should not be considered as pest until it is proven to be one.

Topic 3. Insects

Insects are small organisms that are distinguishable, among other things, by having six legs. Their mouthparts, which can vary widely among others, allow the insect to bites (chew), sting or suck. Insect can cause damage to the roots, leaves, stems, flowers and or fruits of plant.

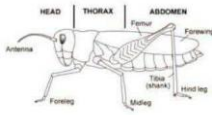


Figure 4parts of insects

Insects vary based on their orders which are: coleoptera, Diptera, Homoptera, Tysanoptera, Isopteran, Lepidoptera, Heteroptera, Hymenoptera, Hemiptera, Orthoptera, Tricoptera, Dermaptera, Odonata)

1) ***Coleoptera (ex:*** beetles***)***

The Coleoptera or beetles, includes many commonly encountered insects such as *ladybird beetles, scarabs, and fireflies*. They live throughout the world (except Antarctica), but are most species in the tropic

Figure 5 example of coleoptera insects

Characteristics of coleoptera

The most distinctive features of beetles are:

- Hardening of the forewings into elytra
- The forewings are opened enough during flight to allow the hind wings to unfold and function.

2) Diptera (ex: true flies, mosquitoes**)**

Figure 6 example of diptera insects

As the name Diptera indicates, most true flies have just one pair of functional wings. A pair of modified wings called halteres replaces the hindwings.

Characteristics of Diptera

Most Dipterans present the following physical features:

- sponging mouthparts to lap juices from fruits, nectar, or fluids from animals
- Sharp, biting mouthparts to feed on the blood of vertebrate hosts.
- Large compound eyes.
- Complete metamorphosis.
- The larvae lack legs.

3) Homoptera (ex: whiteflies**)**

The name Homoptera, derived from the Greek *"homo-"* meaning uniform and *"ptera"* meaning wings, refers to the uniform texture of the front wings.

Characteristics of Homoptera

- The beak (mouth parts) is joined rigidly to the head
- The beak consists of two pairs of stylets (mandibles and maxillae)
- Piercing and sucking mouth parts
- Both pairs of wings are either transparent or slightly thickened,
- The front pair of wings has a uniform structure
- When at rest, the forewings are held rooflike over the dorsum
- The digestive tract is complex, forming a filter chamber in most groups.

4) **Tysanoptera (ex:** Thrips**)**

Characteristics of tysanoptera

- asymmetrical mouthparts with right mandible lost
- wing linear with long marginal setae
- two or three inactive instars

Figure 7 example of tysanoptera insects

5) Isoptera (ex: termites)

Feed on wood and other vegetable matter. They have symbiotic bacteria that secrete enzymes that aid in the digestion of wood

Figure 8 example of isoptera insects

Charactristics of isoptera

- Community, with reproductives, soldiers, and workers of both sexes.
- wings with basal joins allowing them to be shed
- external genitalia undeveloped or lacking

6) Lepidoptera (Butterflies/Moths)

The name Lepidoptera, derived from the Greek words *"lepido"* for scale and *"ptera"* for wings, refers to the flattened hairs (scales) that cover the body and wings of most adults. Most larvae are phytophagous; some eat other insects, a few are ectoparastoids. Most are terrestrial

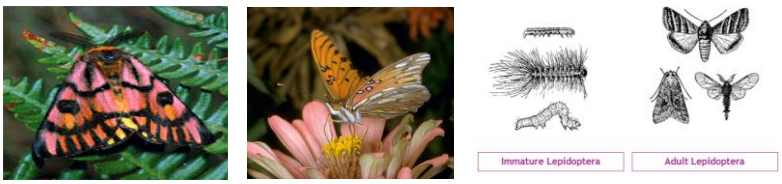


Figure 9 examples of lepidoptera insects

Characteristics of Lepidoptera

Immatures

- Eruciform (caterpillar-like)
- Head capsule well-developed, with chewing mouthparts
- Abdomen with up to 5 pairs of prolegs

Adults

- Mouthparts form a coiled tube (proboscis) beneath the head
- Antennal type
- Front wings large, triangular; hind wings large, fan-shaped
- Body and wings covered with small, overlapping scales

7) Heteroptera (True Bugs)

The name Heteroptera, derived from the Greek *"hetero-"* meaning different and *"ptera"* meaning wings, refers to the fact that the texture of the front wings is different near the base than at the apex.

Figure 10 examples of heteroptera insects

Characteristics of heteroptera

Adults:

- Antennae slender with 4-5 segments
- Proboscis 3-4 segmented, arising from front of head and curving below body when not in use
- Pronotum usually large, trapezoidal or rounded
- Triangular scutellum present behind pronotum
- Wings lie flat on the back at rest, forming an "X".
- Tarsi 2- or 3-segmented

Immatures:

- Structurally similar to adults
- Always lacking wings

8) **Hymenoptera (e.g** Ants / Wasps / Bees)

9) The name is appropriate not only for the membranous nature of the wings, but also for the manner in which they are "joined together as one.

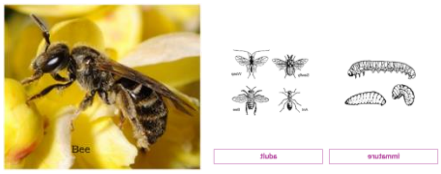


Figure 11 examples of hymenoptera insects

Characteristics of Hymenoptera

Adult insect

- Chewing mouthparts - except in bees where maxillae and labium form a proboscis for collecting nectar.
- Compound eyes well developed.
- Tarsi usually 5-segmented.
- Triangular stigma in front wings.
- Hind wings smaller than front wings, linked together by small hooks**.**

Immature insects

Sawflies: Eruciform (caterpillar-like); well-developed head capsule; chewing mouthparts; fleshy abdominal part.

Bees and wasps: Grub-like; well-developed head; chewing mouthparts; legless and eyeless

Parasitic wasps**:** Body form highly reduced; lacking head, eyes or appendages

10) **Hemiptera: (ex: aphids)**

Referring to the fact that many of its members have the basal half of the fore wings thicker than the distal half.

Figure 12 example of hemiptera insects

Characteristics of Hemiptera

The insects in this order are extremely diverse in their size, shape and color. The name Hemiptera means 'half wing' and all hemipterans share the following features:

- Two (2) pairs of wings, although some species may be wingless and others have only forewings;
- Ranging in size from 1 to 110 millimeters in length;
- Wings are generally membranous but in some species the forewings may be hardened at the base
- Piercing or sucking mouthparts appearing as a sharply pointed tube known as a proboscis or rostrum, which extends from the underside of the head
- Compound eyes of various forms
- Antennae vary and may be either short, or long and conspicuous

11) Orthoptera (Grasshoppers, Crickets)

The name Orthoptera, derived from the Greek "*ortho*" meaning straight and "*ptera*" meaning wing, refers to the parallel-sided structure of the front wings.

Figure 13 example of orthoptera insects

Adults

- Mouthparts mandibulated
- Pronotum shield like, covering much of thorax
- Front wings narrow; hind wings fan-like
- Hind legs usually adapted for jumping (hind femur enlarged)

  Tarsi 3- or 4-segmented

Immature

- Structurally similar to adults
- Developing wing pads often visible on thorax

12) Trichoptera (ex: caddis flies**)**

The name Trichoptera, derived from the Greek words *"trichos"* meaning hair and *"ptera"* meaning wings, refers to the long, silky hairs that cover most of the body and wings.

Figure 14 examples of trichoptera insects

Characteristics of Trichoptera

Immatures

- Eruciform (caterpillar-like) body; abdomen usually enclosed in a case made of stones, leaves, twigs, or other natural materials.
- Head capsule well-developed with chewing mouthparts
- Thread-like abdominal gills usually present in case-makers
- One pair of hooked prolegs often present at tip of abdomen

Adults

- Filiform antennae
- Mouthparts reduced or vestigial
- Two pairs of wings clothed with long hairs
- Wings held tent-like over the abdomen

13) Dermaptera (ex: earwigs)

The name Dermaptera, derived from the Greek *"derma"* meaning skin and *"ptera"* meaning wings, refers to the thickened forewings that cover and protect the hind wings.

Figure 15 examples of dermaptera insects

Characteristics of Dermaptera

Adults:

- Antennae slender, beaded
- Mouthparts mandibulate, prognathous

- Tarsi 3-segmented
- Front wings short and leathery
- Hind wings semicircular and pleated
- Cerci enlarged to form pincers (forceps)

Immatures:

- Structurally similar to adults
- Developing wingpads may be visible on thorax

14) Odonata (ex: Dragonflies)

The name Odonata, derived from the Greek *"odonto-"*, meaning tooth, refers to the strong teeth found on the mandibles of most adults.

Figure 16 examples of odonata insects

Characteristics of odonata

Immatures:

- Labial "mask" adapted for catching prey
- Body robust

Adults:

- Antennae short and bristle-like
- Compound eyes large, often covering most of the head
- Four membranous wings with many veins and crossveins
- Base of hind wing broader than forewing
- Abdomen: long and slender

Topic 4. Rodents

Rodents are mammals that can be identified by their incisor teeth. An interesting fact about rodents is that their front teeth are very prominent and never stop gnawing. Rodents must continuously look for items to chew to help wear down their teeth.

Rodents are experts at gnawing. Provided enough time, rodents such as mice can chew holes and plant roots.

Figure 17 example of rodent

Topic 5. Weeds

A weed is a plant that is planted in wrong place. (it is the unwanted plant). Therefore, plants become a nuisance as weeds when they out-compete desirable plants (for example crops or trees), causing stunted growth, reduced yield, and even death.

Main types of weeds

Weeds are commonly divided into:

a) ***Annuals***, which grow to maturity in one year, setting their seed before dying off. Annual weeds are the easiest to manage, but may be the most expensive to control as they grow rapidly and are so prolific.
b) ***Perennials,*** which survive for several years, and live indefinitely. Perennials, which include many grasses and broadleaved weeds, can reproduce by seed or vegetative, and may be the most difficult weeds to control.

However, some weed plants possess vegetative organs that enable them to reproduce. The most common of these organs are: rhizomes, stolon's and tubers.

Rhizomes: look like roots but are actually underground stems that usually grow horizontally away from the plant sending up vertical shoots that develop into daughter plants. If cut, the individual pieces of rhizome can develop into a new plant.

Stolons: are arching stems that grow along the soil surface (or occasionally under the surface) that form a new rooted plant at the tip.

Tubers: are fleshy swollen stems that function primarily as storage organs that survive underground from season to season.

Characteristics of invasive plants

i. A tendency to produce large quantities of seeds.
ii. High adaptability of spread by several methods, including animals and humans, wind, water and agricultural implements.
iii. High germination rate
iv. An ability to colonize disturbed sites.
v. Producing chemicals that can inhibit the growth of neighboring plants.
vi. High resistance to difficult conditions like soil and climate
vii. Resistance against diseases
viii. Longevity of seeds.

Topic 6. Nematodes

Nematodes are roundworms, similar to the animal parasites encountered in livestock and companions. Soil dwelling nematodes are both good and bad in plant production. The good nematodes, which don't get much press, feed on fungi, bacteria, and other creatures that live in the soil and thereby recycle the nutrients contained in it. Tens of millions of mostly beneficial nematodes live in each square meter of cropland; however, a few of these microscopic roundworms, the plant-pathogenic nematodes give all nematodes a bad name.

How Nematodes Damage Plants Plant-pathogenic nematodes feed only on plants; in fact, they cannot sustain themselves on anything else. When their numbers increase to high levels, they can severely injure or kill plants, especially seedlings. In lower, more typical numbers, they can cause yield losses without causing obvious symptoms and they can be involved in disease interactions with other pathogens, including viruses, fungi, and bacteria. Virtually every field has one or more potentially damaging nematode species. The potential for causing disease depends on several factors:

- ✓ the species and the number of nematodes in the field
- ✓ plant history, especially whether susceptible crops have been grown in the field in the past
- ✓ environmental factors, particularly those influencing the soil environment, such as moisture and temperature

Figure 18 examples of nematodes

Characteristics of nematodes

- Nematodes have piercing mouthparts with which they suck the plant's sap.
- Root knot nematodes produce galls on the roots that are 1-20mm in diameter, and thus visible with the naked eye.
- They are not fond of anaerobic soil conditions, resulting for example from floods or irrigation.
- They also prefer sand soils over clay soils. Nematode's photo)

LO 1.3. Collect affected tree parts

- Topic 1 Physical appearance (Leaves color and form, root, stem, buds, fruits)

Tree and shrub damage may be taking place from disease, insects, and mites. Oftentimes, these problems can become widespread before you even notice them. That's because there is a huge variety of shrub and tree insects and diseases that can cause destruction, and many of them are not very easy to identify

You probably don't know how to tell if your tree has a disease or if insects or mites are causing problems, but there are some common signs you can look for which might help you spot a problem early.

Here are some main symptoms that show a tree which is severely attacked by pests:

1. Chewed Foliage on Trees & Shrubs

If you notice shrub or tree leaves being eaten such as small holes or irregular, jagged edges, you could have a variety of different insect problems at hand. This might be an insect larva, beetle, or even a weevil issue.

Figure 19 leaves damaged by chewing pests

2. Distorted Foliage

Aphids, which are small, soft-bodied insects that tend to multiply quickly, have piercing sucking mouthparts that they use to feed on plant sap. Some trees are sensitive to the saliva that aphids inject during feeding and may respond by puckering or distorting. This can begin to happen with only a few aphids. Because they can spread rapidly, early detection is key to saving your tree.

3. Spots on Trees & Shrubs

If you see a suspicious abundance of white spots on your twigs, branches, or leaves, you may have an infestation of scale insects, which are parasites of plants and feed on internal plant fluids.The white spots that you see are in fact thousands of tiny white bugs

4. Holes in the Bark of Trees & Shrubs

Bark holes, sometimes also accompanied by sawdust coming from these holes, may seem like a telltale sign that your tree being eaten by insects. The common culprit is likely the larvae of wood-boring insect. The flying, adult tree borer insects emerge from inside the tree from small exit holes, and lay their eggs in cracks of bark or at the base of trees When these larvae hatch, they work their way into the tree, tunneling and boring throughout the layer of the tree immediately behind the bark. This activity interrupts the tree's

vascular system, not allowing water or nutrients to pass borer paths. Eventually, this will cause large sections or the entire tree or shrub to die.

Figure 20 tree stem damaged by stem borers

5. Sticky Substances

If you're noticing a black, sooty mold on your landscape plants, what you're actually seeing is the mold growing on "honeydew," a substance excreted from certain insects like aphids, whiteflies or scale insects. These insects create this substance after feeding upon plant sugars and spotting it is a telltale sign that your shrub or tree is being eaten by insects.

6. Yellowing of foliage

If you've witnessed an overall yellowing or even a complete lack of vibrant foliage color, there are a number of potential damages. For one, it could simply be caused by either too much or too little moisture. But yellowing can also relate to pest problems, diseases, or even soil fertility.

7. Stunted leaf growth

There are a number of common culprits for leaves that look sickly or small and it could be related to insects, disease, or other health factors. If you've noticed your leaves are not reaching their full potential, it's worth to seek how to correct this problem.

LO 1.2. Identify viral diseases

- **Definition**

A virus is a sub-microscopic pathogen with protein structure that is not visible with the naked eye. By rapidly multiplying itself in living plant cells, the virus can damage the host plants and considerably reduce its production. Viruses are acellular organisms too small to be seen individually with a light microscope. Their genome is single-stranded or double-stranded RNA or DNA. They also have a protein coat, and occasionally a lipid envelope.

- Topic 1 Symptoms and effects of viral diseases

Symptoms are often confused with mineral deficiency, ozone damage, or drought. Many say that viral diseases in trees are unimportant, for the effects are often subtle.

- leaves are mottled with necrotic and chlorotic lesions,
- ringspots, and yellowing
- stunted growth
- decreased photosynthesis and increased respiration
- reduction in cold tolerance
- rarely, death results

Disease cycle

Viruses are obligate parasites, and require living cells to replicate. Once entry into the cell is obtained, the host's nucleic acids, amino acids, and enzymes are recruited by the virus for replication, placing additional demands on host metabolism

Infection: wounds and often vectors are required for entry into plant cell

Spread:

- ✓ biological vectors: aphids, leafhoppers, fungi, mites, nematodes, beetles
- ✓ others: water, soil, other plants, organic debris

- List out of viral diseases

No	Disease name	Causing agent	symptoms	damage	Propagation	Example of affected species
1.	***Cherry mottle leaf*** 	***Cherry mottle leaf virus***	• Leaf distortion, • leaf mottle, • necrotic spots	• stock-scion incompatibilities • tree death	• infected propagative material like rootstocks, bud or scion • Virus vectors like aphids, leafhoppers, mites, and some species of nematodes. • Some tree fruit viruses can be spread in pollen.	Cherry tree
2.	***Pear stony pit*** 	***Pear stony pit virus***	• necrotic spots, • pits • reduction in quality • distortion in shape	Premature fall down of fruits	• infected propagative material like rootstocks, bud or scion • virus vectors like aphids, leafhoppers, mites, and some species of nematodes • Some tree fruit viruses can be spread in pollen.	Apple tree
3.	***Apple mosaic*** 	***Apple mosaic virus***	• leaf distortion, • leaf mottle, • leaf roll, • necrotic spots,	.Stunted growth .Plant death	• infected propagative material like rootstocks, bud or scion • virus vectors like aphids, leafhoppers,mites, and some species of nematodes • Some tree fruit viruses can be spread in pollen.	Apple tree

4.	**Apple green crinkle** 	**Apple green crinkle virus**	• reduction in size • reduction in quality • distortion in shape • ringspots • pits	Fruit distortion	• infected propagative material like rootstocks, bud or scion • virus vectors like aphids, leafhoppers, mites, and some species of nematodes • Some tree fruit viruses can be spread in pollen.	Apple tree

LO 1.5. Identify bacterial diseases

- **Topic 1 symptoms of bacteria diseases**

Bacteria are microscopic, unicellular organisms. They may have various shapes like spherical, rod-like, spiral, etc.

Bacterial diseases manifest themselves on the leaves, stems, and underground parts of the plant and in and on its fruit.

no	**disease**	Causing agent	symptoms	Damages	Propagation mode	Example of Affected tree
	Root/Stem Galls	*Agrobacterium*	• galls on stems crowns and roots	• Bark wounds • Deformation of affected part • Rotting of stem and fruits	• Human activity, • legs of insects, • movement of dust, • raindrops and irrigation	Eucalyptus spp
	Bacterial blight	*Pseudomonas syringae*	• brown leaf spots • browning of young shoots	• Flower buds die (bud blast)	• wind, rain, insects • pruning tools that are not properly sanitized	*Alnus acuminata*

LO 1.6. Identify fungal diseases

- **Definition**

Fungi are organisms that usually consist of barely visible filament (hyphae). Loose clusters of hyphae (mycelium) are clearly visible with the naked eye and look like very fine cotton wool. These are usually white in color. A fungal infection is often caused by fungal spores that land on leaves, germinate there and penetrate the plant tissue through it stomata (small openings in the epidermis (skin), wounds, or sometimes even directly through the plant's epidermis.

- **Topic 1. Identification of fungal diseases**

no	disease	Causal agent	Symptoms	Damages	Propagation methods	Example of effected tree
1	**Armillaria root rot** 	*Armillaria mellea*	• Foliage turns yellow then brown • Rotting of roots	• Complete mortality • Wood deterioration	Spread occurs when spores through the soil, contact uninfected roots or when uninfected roots contact infected ones.	*Grevillea robusta* Eucalyptus Pines Cypress and Tea
2	**Anthracnose** 	*Colletotrichum spp*	• spotting of the leaves • development of cankers on midribs and veins of leaves, • stunting	• death of transplants	• irrigation water, compost, • seeds, • dust,	Coffee
3	**Powdery mildew**	*Erysiphe spp*	• White powdery appearance of leaves	• Breaks photosynthesis	spores are carried to your plants by wind, insects and splashing water	Mango
4	**Canker**	*Monochaetia spp*	• swollen stem • Bark cracking • Region flow/Gummos	• it lowers the value of the timber • deformed stems are not	• through wounds and • pruning tools which are not disinfected	Cypress *Grevillea robusta*

			is • stem deformation	marketable		
5	**Damping off**	• *Fusarium* • *Pythium* • *Rhizoctonia* • *Phytophtora spp*	• Root rot • Stunting • Low vigour • Wilting on warm day	• rotting of seedlings in the nursery	• irrigation water, compost, seeds, dust, soil splash • airbone spores • humid and shaded environments	
6	Brown Spot Needle Blight 	• *Mycosphaerella dearnessii*	• straw yellow color and develops brown margins • brown spot with a yellow band. • Brown tips. • Needle Killed needles turn reddish brown before dropping off.	Diseased needles often times have brown tips. Both needle spots increase in size over time, resulting in needle death. Longleaf pine seedlings often die while still in the grass stage after repeated defoliations.	New infections occur as spores are spread from infected needles via splashing and wind driven rain. Young succulent needles are more susceptible to infection than older needles and needles need to be wet for infection to occur	Pinus spp

Learning Unit 2. Conduct pests and diseases survey

LO 2.1. Determine affected trees

The only way of determining a diseased tree consists on observing different parts of a given tree for example roots, stems, branches, leaves and fruits. These parts may show symptoms once tree is diseased like distortion and rolling of leaves.

- **Topic 1: Sampling methods (Randomly, systematic and stratification)**

They are three common methods of sampling which are random sampling, systematic sampling and stratified sampling.

Key terms

Population: In statistics, a **population** is a complete set of items that share at least one property in common that is the subject of a statistical analysis.

Sample: a statistical sample is a subset drawn from the population to represent the population in a statistical analysis. Samples are used in statistical testing when population sizes are too large for the test to include all possible members or observations. A sample should represent the whole population and not reflect bias toward a specific point.

A. Random sampling

Is a sampling method in which all members of a group (population or universe) have an equal and independent chance of being selected.

B. Systematic sampling

A method of choosing a random sample from among a larger population. The process of systematic sampling typically involves first selecting a fixed starting point in the larger population and then obtaining subsequent observations by using a constant interval between samples taken. Hence, if the total population was 1,000, a random systematic sampling of 100 data points within that population would involve observing every 10th data point.

C. Stratified sampling

The process of dividing a population into smaller subsets for sampling purposes.

In statistical surveys, when subpopulations within an overall population vary, it is advantageous to sample each subpopulation (stratum) independently.

Stratification is the process of dividing members of the population into homogeneous subgroups before sampling. Then simple random sampling or systematic sampling is applied within each stratum. This often improves the representativeness of the sample by reducing sampling error.

When might you count the entire population?

- When your population is very small
- When you have extensive resources
- When you don’t expect a very high response

- **Topic 2: Incidence rate**

A measure of the frequency with which a disease occurs in a population over a specified time period. "Incidence rate" or "incidence" is numerically defined as the number of new cases of a disease within a time period.

$$\text{Disease incidence} = \frac{(\text{number of infected plant units})X100}{total\ number\ of\ plant\ units\ (infected\ and\ health)}$$

- **Topic 3 Severity level**

This is how severe diseases is on the attacked plant.

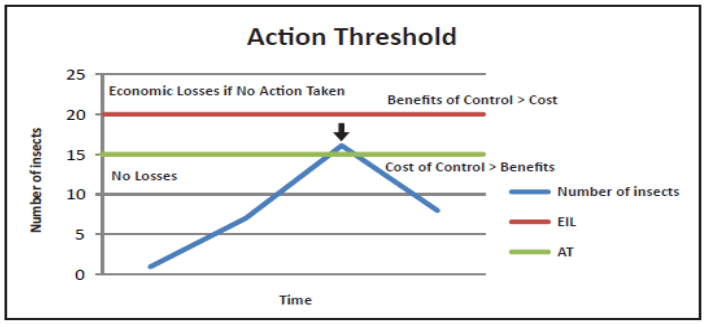
$$\text{Disease severity} = \frac{(\text{area of plant tissues affected by diseases})X100}{total\ area\ of\ plant\ tissues}$$

Economic injury level
This is the lowest population density that will cause economic damages and will vary between crops seasons and areas

Topic 4: Economic threshold

Economic threshold is the population density of an increasing pest population at which control measures should be started to prevent the population from reaching the Economic injury level. In integrated pest management, the **economic threshold** is the density of pests at which a control treatment will provide an economic return.

An **economic threshold** is the insect's population level or extent of crop damage at which the value of the attacked crops exceeds the cost of controlling the pest



LO 2.2. Determination of propagation factors

- **Topic 1 Propagation factors (wind, animals, tools, pests, planting materials and seeds)**

Wind: Is a propagation factor when it moves pollen grains of a diseased to a healthy one or moving seeds of diseased trees from one area to another.

Animals: the effect of animals in diseases transmission is observed when spreading cow dung containing seed or when seeds stick on their skin hairs and fall everywhere.

Tools: Tools propagate tree diseases when they are used in different site without being cleaned.

Pests: propagate tree diseases when they are looking for nutrients from flowering plants or sucking tree sap.

Planting materials and seeds: Transmit tree diseases when they are collected from diseased tree for example grafting materials, cutting or seed from diseased trees.

- **Topic 2. Favorable conditions (soil moisture content, planting density, climate, soil nutrients)**

A. Soil moisture content

High or low soil moisture may be a limiting factor in the development of certain root rot diseases. High soil-moisture levels favor development of destructive water mold fungi, such as species of *Pythium*, and *Phytophthora*. Overwatering, by decreasing oxygen and raising carbon dioxide levels in the soil, makes roots more susceptible to root-rotting organisms.

B. Planting density: When plants show high density, it is easy for a disease to spread.

C. Climate: Here we think about the temperature where most of pathogens are active with their optimum temperature. In addition, different growth stages of the fungus, such as the production of spores (reproductive units), their germination, and the growth of the mycelium (the filamentous main fungus body), may have slightly different optimum temperatures.

D. Soil nutrients: Greenhouse and field experiments have shown that raising or lowering the levels of certain nutrient elements required by plants frequently influences the development of some infectious diseases for example, fire blight of apple, powdery mildew of mango. These diseases and many others are more destructive after application of excessive amounts of nitrogen fertilizer. This condition can often be counteracted by adding adequate amounts of potash, a fertilizer containing potassium.

Conditions for disease development

For a pathogen to cause a disease, the pathogen has to be virulent in the first place; the host has to be susceptible, and the environmental conditions favorable. Disease will not develop if anyone of the 3 conditions is not fulfilled. This is known as the disease triangle.

The disease triangle

Figure 21 disease trianlge

Learning unit 3. Select tools and equipment

L.O.3.1- Identify tools and equipment

- Topic 1: Identification of equipment and tools

A. Personal Protective Equipments (PPEs)

Personal Protective Equipment (PPE) is specialized clothing or equipment worn by employees for protection against health and safety hazards. Personal protective equipment is designed to protect many parts of the body, i.e., eyes, head, face, hands, feet, and ears.

Need for PPE

Personal protective equipment, or PPE, is designed to provide protection from serious injuries or illnesses resulting from contact with chemical, electrical, mechanical, or other hazards. Careful selection and use of adequate PPE should protect individuals involved in chemical emergencies from hazards effecting the respiratory system, skin, eyes, face, hands, feet, head, body, and hearing. No single combination of protective equipment and clothing is capable of protecting against all hazards. Thus PPE should be used in conjunction with other protective methods, including exposure control procedures and equipment.

B. Motorized sprayer

This machines use motor for spraying chemicals to pathogens: like herbicides, insecticides and fungicides. These machines can be used in large area but require skilled man-powers.

Figure 22 motorized sprayer

C. Manual sprayers

These machines are manually used to spray chemicals against plant pests on small area.

Figure 23 manual sprayer

- Topic 2: Specification of tools and equipment

This refers to the set of information about an item; how it is used, maintained and the duration, it can be used in a given period of time.

Specifications for sprayers

There is a bewildering variety of spraying equipment. Dozens of different systems and devices have been developed, each with its own strong points and weaknesses. When making a choice, it is a good idea to keep in mind this basic question: Is this the equipment that will get the pesticide onto my crop in the most efficient way?

In general, good equipment should

1. Spray out the pesticide at a uniform rate;

2. Provide for an adjustable rate of discharge, so that crops get the right number of gallons of spray per acre;

3. Spread the liquid in as wide a swath as possible;

A spray outfit ordinarily has

1. Atank, to hold the pesticide.

2. A pump, to move it out.

3. A piping and control system, to carry the right quantities of liquid from the tank to the boom;

4. A boom-and-nozzle assembly that atomizes the liquid that is, breaks it up into the right-sized spray particles, so that it can be spread properly.

Special jobs may call for special apparatus. Designs are changing constantly. The main thing for you, as a forester, to remember is that spraying is a technical job. before starting any spray, you must make sure that you have the right equipment.

Specifications for PPE

PPE are designed to prevent pesticides from entering the body through the mouth (orally), skin (dermally) and lungs (inhalation) and should consist of the following:

Body covering: Ideally, this should be a coverall made of a woven or laminated fabric. However, any long-sleeved shirt and long-legged trousers made of a similar material may be worn

Shoes and Boots: Footwear should be made of hard plastic, rubber or other material which will not readily absorb pesticides. It should also be resistant to organic solvents which may be present in the pesticide formulation. Trouser legs should be outside of the boots to prevent pesticides running into the boots.

Gloves: Liquid-proof, heavy duty plastic or rubber gloves without fabric lining and long enough to protect the wrist are recommended. For most jobs, the sleeves of your body cover should be outside of the gloves to prevent pesticides running down the sleeves and into the gloves.

Respirator: This must be worn to prevent pesticides entering the lungs. The most readily available respirators in Jamaica are cartridge respirators. These may have one or two cartridges which contain fibre filter pads. As air is inhaled through the respirator, any pesticide present in the air is absorbed. Respirators are usually half-face masks, which cover the nose and mouth. Full-face respirators which cover the entire face are also available but less suitable in hot climates.

Goggles: Goggles should be worn to protect the eyes from pesticide splashes. They should be properly ventilated to avoid fogging under hot tropical conditions.

Hat: A broad-brimmed hat or a hoody made of liquid-proof material will help to keep pesticides off the neck and face.

PPE	Protects	Hazards
Safety Glasses	eyes	chemical liquid splashes, dust
Hard Hat	head	falling material
Ear Protection	hearing	excessive noise
Gloves	hands	corrosives, toxic materials
Respirator	lungs	toxic gases, vapours, fumes or dust
Clothing	skin	toxic or corrosive materials
Footwear	feet	corrosive, toxic materials

L.O. 3.2: Use and maintain tools and equipment

Tools are expensive; tools are vital equipment when the need for their use arises. Their preventive maintenance prolongs their usefulness.

- **Topic 1: Operating tools and equipment**

During pests and diseases control, tools and equipment's are used according to manufacturer guidelines. Oily, dirty, and greasy tools are slippery and dangerous to use.

Before spraying

Calibration
Calibration is the measuring and adjusting of the quantity of pesticide the application equipment and operator will apply to the target area to achieve the recommended application for that pesticide against a specific target organism.

Proper operation and maintenance of spray equipment will lead to safe and effective pest control, significantly reduce repair costs, and prolong the life of the sprayer. Before Spraying at the beginning of each spraying season, fill the tank with water and pressurize the system to be sure all the parts are working and there are no drips or leaks. All nozzles should be of the same type, size, and fan angle Measure the distance between the nozzle tip and the target, and adjust the boom accordingly. In broadcast applications, nozzle height affects the uniformity of the spray pattern. Fill the tank with water that does not have silt or sand in it. Keep the tank level when filling, to make sure the quantity in the tank is correctly indicated. Calibrate the sprayer before using.

During Spraying

Frequently check the pressure gauge to make sure the sprayer is operating at the same pressure and speed used during calibration. Operate the sprayer at speeds appropriate for the conditions. Periodically check hoses and fittings for leaks, and check nozzles for unusual patterns. If you must make emergency repairs or adjustments in the field, wear the protective clothing listed on the pesticide label as well as chemical-proof gloves.

- **Topic 2: maintain tools and equipment**

Is a process removing stains that might be attached on these tools and equipment for example soil particles. Clean tools after each use. Apply a light film of oil after cleaning to prevent rust on tools

Always flush the spray system with water after each use. Apply this rinse water to sites for which the pesticide is labeled. Clean the inside and outside of the sprayer thoroughly before switching to another pesticide and before doing any maintenance or repair work. All parts exposed to a pesticide will normally have some residue, including sprayer pumps, tanks, hoses, and boom ends

Clean the tank daily after spraying. Do not let pesticide remain in it after use. Rinse the sprayer thoroughly with water and then allow to dry. Do not discard the water in a stream, pond or place where it can be reached by humans or animals; a pit latrine or a hole in dry ground, away from water collection points, rivers, ponds or agricultural land, is the best place for disposal.

Remove, rinse and clean the filter assembly at the control valve. Remove the filter from the valve by grasping it at its base, not by its screen. Twist it slightly on pulling it out.

Reassemble all clean parts except the nozzle. Put clean water in the tank, seal the tank and pump air into it. Open the control valve and let the water flow from the lance to flush the hose, filters, control valve and lance. Remove the tank cover and dry the inside of the tank.

Clean the nozzle tip by washing thoroughly with water. Use a pump to blow air through the orifice, then clean and dry it. Remove any dirt from the orifice with a fine bristle from a brush or with a toothpick; never use metal wire. Dirt can also be blown out by pushing the nozzle against the pressure release valve on top of the tank cover.

Principles of cleaning tools and equipment's

1. **Dry clean.** Remove visible and gross soils and debris.
2. **Pre-rinse.** Rinse all areas and surfaces until they are visibly free of soil.
3. **Wash (soap and scrub).** Use the right detergent in the right concentration with the right level of mechanical action in the right water temperature for the right contact time.
4. **Post-rinse.** Rinse away all visible detergents and remaining soil.
5. **Inspect.** Look again at crevices and other contamination traps to ensure they're free of soils and detergents. Determine whether steps 1-4 should be performed again.
6. **Sanitize.** Foam, wipe or spray sanitizing chemicals onto surfaces as per the appropriate instructions.
7. **Dry.** Ensure adequate time is allotted for equipment to thoroughly dry.
8. **Verification.** Gather proof that the cleaning performed achieved the expected level by following facility verification protocols.

- **Topic 3: Simple repairing of tools and equipment's**

Repairing Refers to the simple reparation that can be done on equipment like adjustment fixing screws etc.

Inspect the tank at regular intervals, and replace any worn or damaged part. Inspect the lip of the pump cylinder for cracks that could cause the tank to lose pressure. Check the rubber hose for cracks and weak

spots. After some time, the hose becomes weakened near the point of attachment to the spray-can or cut-off valve. The weak part should then be cut off and the hose remounted. Put a few drops of clean oil on the plunger cup leather to keep the pump cylinder lubricated and to ensure sufficient pressure. Replace the leather if damaged.

Nozzle tips erode during spraying. They should be replaced when worn. An eroded orifice causes an increase in the amount of pesticide delivered. The discharge rate should be measured from time to time by qualified personnel. A simple method is to spray a suspension on to a dark surface: irregularities in the swath indicate that the nozzle tip needs to be replaced.

- **Topic 4: Proper storage of tools and equipment's**

Manufacturers of tools and equipment's specify condition in which these can be stored like dry place for example. Never leave tools scattered about. When they are not in use, store them precisely on racks or in toolboxes. Inventory tools after use to prevent loss.

Storage of sprayers

Check that the tank is empty, put the parts back together and store the tank upside down with the cover lying loosely inside the tank and the plunger locked. Make sure the lance and nozzle cannot fall or be otherwise damaged. Store the cut-off valve locked open.

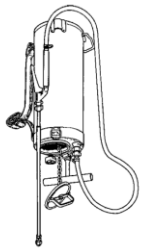


Figure 24 Position of sprayer in store

Learning unit 4. Prepare phytosanitary products

L.O 4.1: Identify phytosanitary products

Definition

Phytosanitary products are those chemical products used to control or to fight against pests and diseases. They are pesticides used to control organisms that are considered to be harmful to human concerns.

- **Topic1: Nature of phytosanitary products**

Pesticide chemicals in their "raw" or unformulated state are not usually suitable for pest control. These concentrated chemicals and active ingredients may not mix well with water, may be chemically unstable, and may be difficult to handle and transport. For these reasons, manufacturers add inert substances, such as clays and solvents, to improve application effectiveness, safety, handling, and storage. Inert ingredients do not possess pesticide activity and are added to serve as a carrier for the active ingredient. Manufacturers will list the percentage of inert ingredients in the formulation or designate them as "other ingredients" on their labels. The mixture of active and inert ingredients is called a **pesticide formulation**. This formulation may consist of:

- The pesticide active ingredient that controls the target pest
- The carrier, such as an organic solvent or mineral clay
- Adjuvants, such as stickers and spreaders
- Other ingredients, such as stabilizers, safeners, dyes, and chemicals that improve or enhance pesticidal activity

The following are different types of pesticides formulations based on their nature:

Pesticide formulation	**example**
Liquid formulation	Dimethoate 40% EC
Solid formulation	Dethane
Gaseous formulation	methyl bromide

1. **Liquid Formulations**

Liquid formulations are generally mixed with water, but in some instances labels may permit the use of crop oil, diesel fuel, kerosene, or some other light oil as a carrier. This section will present more detailed information about the common liquid pesticide formulations.

Emulsifiable Concentrates (EC or E)

Example:

An emulsifiable concentrate formulation usually contains a liquid active ingredient, one or more petroleum-based solvents (which give EC formulations their strong odor), and an agent—known as an emulsifier—that allows the formulation to be mixed with water to form an emulsion. Upon mixing with water, they take on a "milky" appearance

Figure 25 Undiluted and diluted emulsifiable concentrate formulation

Advantages of emulsifiable concentrates include:

- Relatively easy to handle, transport, and store
- Little agitation required; will not settle out or separate when equipment is running
- Not abrasive
- Will not plug screens or nozzles
- Little visible residue on treated surfaces

Their disadvantages:

- High a.i. concentration makes it easy to overdose or underdose through mixing or calibration errors
- Easily absorbed through skin of humans or animals
- Solvents may cause rubber or plastic hoses, gaskets, and pump parts and surfaces to deteriorate
- May cause pitting or discoloration of painted finishes
- Flammable—should be used and stored away from heat or open flame
- May be corrosive

Solutions (S)

Some pesticide active ingredients dissolve readily in a liquid carrier, such as water or a petroleum-based solvent. When mixed with the carrier, they form a solution that does not settle out or separate Formulations of these pesticides usually contain the active ingredient, the carrier, and one or more other ingredients.

Figure 26 Undiluted and diluted solution formulation.

Ready-to-Use Low Concentration Solutions (RTU)

Low-concentrate RTU formulations are ready to use and require no further dilution before application. They consist of a small amount of active ingredient (often 1% or less per unit volume) dissolved in an organic solvent. They usually do not stain fabrics nor have unpleasant odors. They are especially useful for structural and institutional pests and for household use. Major disadvantages of low-concentrate formulations include limited availability and high cost per unit of active ingredient.

Figure 27 Ready-to-use diluted formulation.

2. Dry or Solid Formulations

Dry formulations can be divided into two types: ready-to-use and concentrates that must be mixed with water to be applied as a spray. This section will present more detailed information about the common dry or solid pesticide formulations.

Dusts (D)

Most dust formulations are ready to use and contain a low percentage of active ingredients (usually 10% or less by weight), plus a very fine, dry inert carrier made from talc, chalk, clay, nut hulls, or volcanic ash. The size of individual dust particles varies.

A few dust formulations are concentrates and contain a high percentage of active ingredients. These concentrates are mixed with dry inert carriers before applying.

Advantages of dust formulations include:

- Most are ready to use, with no mixing
- Effective where moisture from a spray might cause damage
- Require simple equipment
- Effective in hard-to-reach indoor areas

Their disadvantages:

- Easily drift off target during application
- Residue easily moved off target by air movement or water
- May irritate eyes, nose, throat, and skin
- Will not stick to surfaces as well as liquids
- Dampness can cause clogging and lumping
- Difficult to get an even distribution of particles on surfaces

Baits (B)

A bait formulation is an active ingredient mixed with food or another attractive substance. The bait either attracts the pests or is placed where the pests will find it. Federal regulations require that certain rodenticide baits must be contained in tamper-resistant bait stations Pests are killed by eating the bait that contains the pesticide. The amount of active ingredient in most bait formulations is quite low, usually less than 5%.

Advantages of baits include:

- Ready to use
- Entire area need not be covered because pest goes to bait
- Control pests that move in and out of an area

Their disadvantages:

- Can be attractive to children and pets
- May kill domestic animals and nontarget wildlife outdoors
- Pest may prefer the crop or other food to the bait
- Dead vertebrate pests may cause odor problem
- Other animals may be poisoned as a result of feeding on the poisoned pests
- If baits are not removed when the pesticide becomes ineffective, they may serve as a food supply for the target pest or other pests
- Laws require that outdoor, above-ground placement of certain rodenticide bait products be contained in tamper-resistant bait stations

Granules (G)

Granular formulations are similar to dust formulations except granular particles are larger and heavier The coarse particles are made from materials such as clay, corncobs, or walnut shells. The active ingredient either coats the outside of the granules or is absorbed into them. The amount of active ingredient is relatively low, usually ranging from less than 1 to 15 percent by weight

Granules are used in agricultural, structural, ornamental, turf, aquatic, right-of-way, and public health (biting insect) pest control operations.

Advantages of granular formulations include:

- Ready to use, no mixing
- Drift hazard is low, and particles settle quickly
- Little hazard to applicator; no spray, little dust
- Weight carries the formulation through foliage to soil or water target
- Simple application equipment needed, such as seeders or fertilizer spreaders
- May break down more slowly than WPs or ECs because of a slow-release coating

Their disadvantages:

- Often difficult to calibrate equipment and apply uniformly
- Will not stick to foliage or other uneven surfaces
- May need to be incorporated into soil or planting medium
- May need moisture to activate pesticide

- May be hazardous to nontarget species, especially waterfowl and other birds that mistakenly feed on the seed-like granules
- May not be effective under drought conditions because the active ingredient is not released in sufficient quantity to control the pest

Wettable Powders (WP or W)

Wettable powders are dry, finely ground formulations that look like dusts.They usually must be mixed with water for application as a spray. A few products, however, may be applied either as a dust or as a wettable powder; the choice is left to the applicator. Wettable powders contain 5%–95% active ingredient by weight, usually 50% or more. The particles do not dissolve in water. They settle out quickly unless constantly agitated to keep them suspended. Wettable powders are one of the most widely used pesticide formulations. They can be used for most pest problems and in most types of spray equipment where agitation is possible. Wettable powders have excellent residual activity. Because of their physical properties, most of the pesticide remains on the surface of treated porous materials such as concrete, plaster, and untreated wood. In such cases, only the water penetrates the material.

Advantages of wettable powders include:

- Easy to store, transport, and handle
- Less likely than ECs and other petroleum-based pesticides to cause unwanted harm to treated plants, animals, and surfaces
- Easily measured and mixed
- Less skin and eye absorption than ECs and other liquid formulations

Their disadvantages:

- Inhalation hazard to applicator while measuring and mixing the concentrated powder
- Require good and constant agitation (usually mechanical) in the spray tank or will quickly settle out if the agitator is turned off
- Abrasive to many pumps and nozzles, causing them to wear out quickly
- Difficult to mix in very hard, alkaline water
- Often clog nozzles and screens
- Residues may be visible on treated surfaces

3. Gaseous formulations

Most of gaseous pesticides are fumigants that form gases or vapors toxic to plants, animals, and microorganisms. Some active ingredients are formulated, packaged, and released as gases others are liquids when packaged under high pressure and change to gases when they are released. Other active ingredients are volatile liquids when enclosed in an ordinary container and, therefore, are not formulated under pressure.

Figure 28 Gaseous fumigant stored under pressure.

Advantages of fumigants:

• Toxic to a wide range of pests

• Can penetrate cracks, crevices, wood, and tightly packed areas such as soil or stored grains

• Single treatment usually kills most pests in treated area

Disadvantages of fumigants:

• The target site must be enclosed or covered to prevent the gas from escaping

• Nonspecific in that they are highly toxic to humans and all other living organisms

• Require the use of specialized protective equipment, including respirators specifically approved for use with fumigants

• Require the use of specialized application equipment

- Topic 2: Classification of phytosanitary products

Target pest group	Pesticides	Examples
Fungi	Fungicides	Mancozeb, copper sulfate
Plant	Herbicides	Allelopathic plants,
Insects	Insecticides	Pentachlorophenol

Rodents	Rodenticides	Warfarin
Nematodes	Nematicides	Methyl bromide

A. Fungicides:

Fungicides are biochemical compounds used to kill or inhibit fungi or fungal spores. Fungi can cause serious damage in plants, resulting in critical losses of yield, quality, and profit.

B. Herbicides:

Herbicides, also commonly known as **weed killers**, are pesticides used to kill unwanted plants. Selective herbicides kill specific targets, while leaving the desired plants relatively unharmed. Some of these act by interfering with the growth of the weed.

Types of herbicides:

1. Natural herbicides.

They are two types of herbicides natural and synthetic herbicides. Natural herbicides are group of allelopathic plants.

What is allelopathy?

Allelopathy is a biological phenomenon where one plant inhibits the growth of another through the release of allelochemicals (toxic substances that are harmfull to neighbouring plants.)

Allelopathic Trees

Trees are great examples of allelopathy in plants. For instance, many trees use allelopathy to protect their space by using their roots to pull more water from the soil so other plants cannot thrive. Some use their allelochemicals to inhibit germination or impede development of nearby plant life.

2. Synthetic herbicides

Are industrial chemical products used to control plant pests. The following are some example of them.

i. **Atrazine (triazine herbicide)** for control of broadleaf weeds and grasses. Still used because of its low cost and because it works well on a broad spectrum of weeds, it is systemic herbicides and selective.
ii. **Brush killer (BK-32):** For control of woody plants and perennial weeds.

C. Insecticides:

An **insecticide** is a substance used to kill insects. They include ovicides and larvicides used against insect eggs and larvae, respectively.

D. Rodenticides:

Rodenticide like rat poison, are typically non-specific pest control chemicals made and sold for the purpose of killing rodents.

Example: Bromethalin

E. Nematicides:

A **nematicide** is a type of chemical pesticide used to kill plant-parasitic nematodes. Nematicides have tended to be broad-spectrum toxicants possessing high volatility or other properties promoting migration through the soil.

Example: Methyl bromide

L.O 4.2: Select phytosanitary product

- Topic 1: Selection criteria of pytosanitary product

When selecting phyto-sanitary products, it is better to choose them based on their action mode. Therefore, the selection of phytosanitary products is based on their action mode. According to their action mode , they are classified as contact and systemic products.

- Contact products

These poisons enter the body directly through the cuticle by contact with the treated surface of the plant parts (foliage, stem or roots). These poisons act on the nervous system of the pest. These may also be applied directly onto the body of the pest as a spray or dust. Some of the known pesticides derived from plants also have contact action.

Examples: *Pyrethrum, Nicotine.*

- Systemic products

These poisons are applied on the plants' surface and are translocated into the plant tissues. Most of the systemic poisons act as stomach poisons, or both as stomach and contact poisons. The parts of the plant where these poisons have been translocated become toxic to the pests feeding on these parts of the plants. Systemic poisons are more effective against sucking pests. They have a selective action with little effect on the predators and parasites directly, unless acting through the food chain.

They act mostly through xylem vessels.

Examples: *Dimethoate*

L.O.4.3: Follow phytosanitary precaution measures

- Topic 1: Application procedures

A. precautions during transport:

during transport of pesticides, it is vital for operator be equipped with personal protective equipments so to avoid any injury.

Always wear coveralls, waterproof boots, waterproof gloves, and a proper hat. Sometimes you will also need to wear eye or face protection, respirator, waterproof pants and jacket. Selecting the correct pesticides and

quantities for your needs, and transporting them safely to your farm helps protect you, your family, and the environment.

B. Precautions during storage

All pesticides must be stored safely, and according to legal requirements. A properly designed and constructed pesticide storage facility will reduce the risk of surface and groundwater contamination, increase user safety in the handling of products, prevent contamination of food and feed, and limit access to authorized persons.

C. Mixing precautions

Mix pesticides in still or low wind conditions.

1. Begin by filling the spray tank 1/3 to 1/2 full with clean water. Never put the chemical in first and then top with water. Start the agitator and then add the required quantity of chemical. Continue agitating while filling the tank.
2. Prevent the excess. Do not leave your tank unattended.
3. Mix and weigh out pesticides on a sturdy level bench or table.
4. Stand on a strong platform when you add the pesticide to the tank.
5. Hold the container below eye level when measuring or adding pesticide into the spray tank to prevent splashing or dropping pesticide in your face or eyes.

D. Precautions after treatment

Empty pesticide containers are considered hazardous waste, by law, unless they are drained and rinsed properly. Plastic, metal and glass containers must be rinsed 3 times. The rinse water must be poured into the sprayer and applied with the pesticide.

The best way to dispose of empty pesticide containers is to take them to a pesticide container collection site. Containers taken to these sites are recycled into other uses in farming activities

E. Use first aid kit in case intoxication

First aid is defined as the provision of emergency treatment and life support for people suffering injury or illness. First aid kit is used to help a patient in imergency before being conducted to the medecin

Examples of some items contained in first AID Kit

1. Scissors are less useful but often included
2. Alcohol pads for sanitizing equipment, or unbroken skin.
3. Irrigation syringe - with tube tip for cleaning wounds with sterile water, saline solution, or a weak iodine solution.
4. Torch (also known as a flashlight)
5. Aspirin as ant-inflammation
6. Thermometer: for detecting temperature.
7. Cotton wool, for applying antiseptic lotions.
8. Safety pins, for holding bandages

9. Gloves which are single use and disposable to prevent cross infection

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L.O 4.4: Mix phytosanitarty products

- Topic 1: Dosage procedures

The dosage of phytosanitary products go under manufacturer's information (label). In this information, they tell you about quantity and ratio you can consider.

Key terms to take into consideration

Capacity of sprayer: Quantity of water required to fill knapsack sprayer **Concentration of pesticide (40% for example):** it means in 100 grams of pesticides there is 40 grams of active ingredients for controlling plant pests and other 60% are protectants. This can be read on pesticide container.

The recommended dose is the amount of a.i (active ingredients) which, by experimental testing, has been found to kill a given pest without waste. The person applying the pesticide must calculate the amount of liquid or dry pesticide formulation that needs to apply on the plot by spraying liquid, dusting or spreading granules.

Before any calculation can be made, the following input are needed:

a) Know the recommended dose of a.i per hectare (in % of a.i or in grams or Volume (litres) per hectare.

b) Know amount of spray liquid per hectare

c) Know Percentage of a.i in commercial pesticides formulation

d) Know Area (Plot size) expressed in hectare to be treated

e) Calculate the amount of a.i required for existing plot size

f) Prepare the pesticide according to the manufacturers instructions

Topic 2: Mixing procedures/precautions

Each commercial insecticide possesses an active ingredient (a.i), the principal chemical compound that acts on the insect. Because this active ingredient is highly toxic it is marketed in a diluted form. In solid formulations such as dust, wettable powder or granules, the active ingredient is mixed with inert material. The concentration is expressed as –

Active ingredient (%) in dust, WP. or granules = $\frac{(\text{Weight of a.i.x } 100)}{total\ weight\ of\ wp,dust,etc!}$

In liquid formulation, the a.i. is dissolved in a solvent with an emulsifying agent. It is expressed as an emulsifiable concentrate (EC). The concentration can be expressed in two ways.

A) Active ingredient (%) in EC = $\frac{weight\ \ of\ a.i\ X100}{volume\ of\ E.C}$

Example: Malathion 20% EC means, 100 mL of commercial product has 20 g of pure Malathion.

Diluent: This is a liquid (water or oil) used to dilute the concentrated active ingredient

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Learning unit 5. Apply pest and diseases control methods

L.O 5.1: Select pest and diseases control methods

- Topic 1: Pest and diseases control methods

Integrated Pest Management: it is a combination of pest management techniques aiming at reducing the use of pesticides. IPM techniques include maintaining healthy plants, which resist insects and diseases better; encouraging natural predators of pests to stay in your yard; and when using pesticides, choosing the least potential impact on the environment.

5.1.1. Biological control of pests

Is a method of controlling **pests** (including insects, mites, weeds and plant diseases) using other living organisms (natural enemies)

Advantages of Biological Control:

Biological control is a very specific strategy. The vast majority of the time, whatever predator is introduced will only control the population of the pest they are meant to target, making it a green alternative to chemical or mechanical control methods. For example, whereas weed killing chemicals can also destroy fruit-bearing plants, biological control allows the fruit to be left uninterrupted while the weeds are destroyed.

Natural enemies introduced to the environment are capable of sustaining themselves, often by reducing whatever pest population they are supposed to manage. This means that after the initial introduction, very little effort is required to keep the system running fluidly. It also means that biological control can be kept in place for a much longer time than other methods of pest control.

Biological control can be cost effective in the long run. Although it may cost a bit to introduce a new species to an environment, it's a tactic that only needs to be applied once due to its self-perpetuating nature.

Most important of all, it's effective. Whatever pest population you want controlled will no doubt be controlled. Because the predator introduced will be naturally inclined to target the pests, very often you'll see the pest population dwindle.

Disadvantages of Biological Control:

Biological control can be fickle. Ultimately, you can't control whatever natural enemy you set loose in an ecosystem. While it's supposed to manage one pest, there is always the possibility that your predator will switch to a different target - they might decide eating your crops instead of the insects infesting them is a better plan! Not only that, but in introducing a new species to an environment, there runs the risk of disrupting the natural food chain.

It's a slow process. It takes a lot of time and patience for the biological agents to work their magic on a pest population, whereas other methods like pesticides work provide immediate results. The upside to this is the long-term effect biological control provides.

If you're looking to completely wipe out a pest, biological control is not the right choice. Predators can only survive if there is something to eat, so destroying their food population would risk their own safety. Therefore, they can only reduce the number of harmful pests.

While it is cheap in the long run, the process of actually setting up a biological control system is a costly endeavor. A lot of planning any money goes into developing a successful system.

5.1.2. Mechanical control:

Mechanical Control is the use of hands-on techniques as well as simple equipment, devices that provide a protective barrier between plants and insects.

One of the simplest methods of physical or mechanical pest control is handpicking insects or hand-pulling weeds. This method works best in those situations where the pests are visible and easily accessible. Physical or mechanical disruption of pests also includes such methods as mowing, hoeing, flaming, soil solarization, tilling or cultivation, and washing.

Devices that can be used to exclude insect pests from reaching crops in organic farming include, but not limited to, row covers, protective nets with varying mesh size according to the pest in question, and sticky paper collars that prevent crawling insects from climbing the trunks of trees. Water pressure sprays can be employed to dislodge insect pests such as aphids and mites from the plant surface. Insect vacuums, on the other hand, could be used to remove insects from plant surface and collect them into a collection box.

Mechanical or physical control methods involve using barriers, traps, or physical removal to prevent or reduce pest problems.

Ex: Handpicking

5.1.3. Chemical methods

This is the last tactic, but it is the most quick method to control pests.their misuse can cause pest resistance to the pesticide, outbreaks of secondary pests, and adverse effects on non-target organisms, unwanted pesticide residues, and direct hazards to the user.

Advantages of chemical pesticides

- ✓ Quick-acting
- ✓ Easy to use
- ✓ Cheap (relatively)
- ✓ Readily available
- ✓ Better for vector-borne diseases

Disadvantages of Pesticides

- ✓ Potentially toxic to humans
- ✓ Impact on non-targets
- ✓ Potential negative environmental effects
- ✓ Unknown cumulative effects
- ✓ Pest resistance

5.1.4. Cultural methods

Cultural methods are the cheapest of all control measures because they are the normal production practices. They don't require extra labor. they are suitable for high acreage of low value crops. this method is friend of environment

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L.O 5.2: Apply biological method

Topic 1: Identification of parasitic auxiliary faunas, repellent plants, botanical product, pathogens, herbivores and predators

TYPES OF NATURAL ENEMIES

Parasites, pathogens and predators are the primary groups used in biological control of insects and mites.

Parasites :A parasite is an organism that lives and feeds in or on a host. Insect parasites can develop on the inside (endoparasites)or outside of the host's body(ectoparasites).

Parasitoids: this is a group of organisms where the immature stage feeds on the host, but the adult (such as many wasps that attack whiteflies) kill their hosts.

The difference between predator and parasites is that parasites kill the host slowly after weakening, but predators kill immediately and eat the fresh of killed organism

Pathogens

Natural enemy pathogens are microorganisms including certain bacteria, fungi, and viruses that can infect and kill the host.

Predators

Predators kill and feed on several too much individual prey during their lifetimes.

Many species of amphibians, birds, mammals, and reptiles prey extensively on insects. Most spiders feed entirely on insects.

Example of Some pests and their natural enemies

Pest	**Natural enemy**
Aphids	Lady beetles, Parasitic wasps
caterpillars (e.g., California oak worm)	*Bacillus thuringiensis*, birds, parasitic wasps
eucalyptus long horned borers	parasitic wasp
Mealy bugs	Mealy bug destroyer, lady beetle
Mosquitoes	*Bacillus thuringiensis*
slugs, snails	Birds, snakes, toads, and other vertebrates

Repellent plants: Those are plants that have capability of keeping away some insects.

Example of repellent plant:

- ***Tagetes minuta :*** it repels insects by using its smells
- ***Iboza riparia*** it repels insects by using its smells
- ***Neem***: It works as both a pesticide and a fungicide when used properly. Neem not only repels insects, but it suppresses feeding and prevents them from molting. It's effective against a broad range of insects, but, if applied when bees are active, it may be harmful to them.
- ***Citrus*****:** products must come in direct contact with pests to be effective, but they can be used right up to the day of harvest.

Examples of chemical control include:

1. Using an herbicide to wipe out weeds,
2. Using an insecticide to control scale insects, or
3. Using a fungicide to control powdery mildew

Topic 2: Application techniques of biological methods

The most common use of biocontrol is the augmentation method, where natural enemies are purchased and released. Greenhouses are the most common place where this method is used. However, because the natural enemies and pests are alive and form dynamic populations, success of biological control in suppressing pests requires attention to certain important factors.

Factors to consider when applying biological method:

- Get the right enemy for the pest species.
- Release them at the right time in the pest population cycle.
- Environmental conditions must be favorable (weather / temperature / moisture).
- Food sources must be present for the natural enemy (adults or larvae in some cases).

L.O.5.3: Apply mechanical method

- **Topic 1 Trapping techniques**

1. **Trapping insect pests**

When trapping insects, the following alternatives are used

- ***Light traps***: light traps with or without ultraviolet light attract certain insects. For eg. Grasshoppers and some beetles are attracted to light at a long range
- ***Adhesives traps:*** sticky traps may be simple flat panels or enclosed structures, often baited, trap insects with adhesive substance.
- ***Flight interception traps*** or net-like or transparent structures that impede flying insects and funnel them into collecting. Barrier traps consist of a simple vertical sheet or wall that channels insects down into collection containers.
- **Terrestrial traps**:

Pitfall traps consists of a bucket or container buried in soil or other substrate so that its edge is flush with the substrate.

Pitfall traps are used for ground-foraging and flightless arthropods such as beetles and spiders.

- **Aquatic traps**

Involve mesh funnels that or conical structures that guide insect into a jar or bottle for collecting. Aquatic emergence traps are cage-like or tent-like structures used to capture aquatic insects such as mosquitoes and odonates upon their transition from aquatic nymphs to terrestrial adults.

- Topic 2. Hand picking

Foliage Beating

A beating sheet or beating net is held under vegetation and the foliage firmly tapped with a beating stick to dislodge insects from the branches falling into the net. Insects are collected off the sheet or net using an aspirator or by hand into a container if they are too large to fit through the aspirator tube. This is an effective method for many plant inhabiting insects including beetles, bugs, psyllids, caterpillars, and bug and beetle larvae. Gaseous fumigant stored under pressure.

Sweep Netting:

Generally, a net with a long pole and deep mesh bag is used, either to collect large flying insects individually (butterflies wasps, flies, dragonflies) or by sweeping over foliage

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L.O.5.4: Apply cultural method

Cultural methods are the cheapest of all control measures because they are the normal production practices. They don't require extra labor. they are suitable for high acreage of low value crops. this method is friend of environment

- **Topic 1: Silvicultural practices**

They include all activities carried out in a forest plantation to maintain its growth for maximum production

Weeding: it is the activity of removing unwanted plants that can compete crops within a plantation

Pruning: it consists of reducing lower branches on trees for maintaining the required sunlight as well as keeping increasing the quality of timber

Thinning: Thinning in forestry is the selective removal of trees, primarily undertaken to improve

the growth rate or health of the remaining trees.

Pollarding: it is a system in which the upper branches of a **tree** are removed, promoting a dense head of foliage and branches. Traditionally, trees were **pollarded** for one of two reasons: for fodder to feed livestock, or for wood.

Coppicing is the process of cutting trees down, allowing the stumps to regenerate for a number of years (usually 7 - 25) and then harvesting the resulting stems.

Clearing: this is the activity of removing all things that can hinder the growth of seedlings .clearing is done before tree plantation

Mulching

Mulching: A protective covering, usually of organic matter such as leaves, placed around plants to prevent the evaporation of moisture, keep the freezing of roots, and avoid the growth of weeds.

Mulching Materials:

a) Seedless grasses like Eragrostis, Vetiver, Temeda,
b) Dried banana leaves
c) Crop residues of any kind devoid of seed plant.

- **Topic 2: Use of resistant tree species:**

Definition of an Insect-Resistant Plant: Definitions of an insect-resistant plant are many and varied. In the broadest sense, plant resistance is defined as "the consequence of heritable plant qualities that result in a plant being relatively less damaged than a plant without the qualities." In practical agricultural terms, an insect-resistant cultivar is one that yields more than a susceptible cultivar when confronted with insect pest invasion. Resistance of plants is relative and is based on comparison with plants lacking the resistance characters, i.e., susceptible plants.

Plant resistance to insects is one of several cultural control methods. Cultural control methods involve use of agronomic practices to reduce insect pest abundance and damage below that which would have occurred if the practice had not been used. In IPM, plant resistance to insects refers to the use of resistant varieties to suppress insect pest damage. Plant resistance is intended to be used in conjunction with other direct control tactics.

Advantages to the Use of Insect-Resistant Varieties:

Use of insect-resistant crop varieties is economically, ecologically, and environmentally advantageous. Economic benefits occur because crop yields are saved from loss to insect pests and

money is saved by not applying insecticides that would have been applied to susceptible varieties. In most cases, seed of insect-resistant cultivars costs no more, or little more, than for susceptible cultivars. Ecological and environmental benefits arise from increases in species diversity in the agroecosystem, in part because of reduced use of insecticides. Increases in species diversity increase ecosystem stability which promotes a more sustainable system far less polluted and detrimental to natural resources.

Plant resistance to insect pests has advantages over other direct control tactics. For example, plant resistance to insects is compatible with insecticide use, while biological control is not. Plant resistance to insects is not density dependent, whereas biological control is. Plant resistance is specific, only affecting the target pest. Often effects of use of insect-resistant cultivars are cumulative over time. Usually the effectiveness of resistant cultivars is long-lasting.

L.O 5.5: Apply chemical method

- **Topic 1 Application techniques**

Pesticide application is the practical way in which pesticides (including herbicides, fungicides, insecticides, or nematode control agents) are delivered to their biological targets (e.g. pest organism, crop or other plant). Public concern about the use of pesticides has highlighted the need to make this process as efficient as possible, in order to minimise their release into the environment and human exposure (including operators, bystanders and consumers of produce).

In pesticide application, the following techniques are used:

Spraying: it is the application of pesticides in liquid form of small particles, ejected from a sprayer.

Fumigation: it is a process of applying pesticides that act in gaseous form to repel or kill some pests

Dusting: it is the process of broadcasting dust pesticides in target areas to repel or kill pests

A farmer should ideally be able to select an adequate type of sprayer and a correct nozzle. A nozzle is correct if it can produce the required spray droplet spectrum for each specific Job. With this equipment a farmer should control harmful insects, diseases and weeds in plantation

Sprayer maintenance

- Don’t forget to wear protective clothing when clearing and checking a sprayer.
- Don’t put aside a sprayer without emptying the remaining pesticide solution inside.
- The spraying equipment should be well cleaned and checked after use (these clearing and cleaning should be done with great care by brush and water but avoid contaminating the surface water).
- Check, repair or replace broken and leaking parts.
- Make sure of technical specifications before ordering or purchasing a sprayer.

Sprayers' nozzle

the distribution of droplet size, or droplet spectrum, of the emitted spray is characteristic for the type of nozzle used in sprayer. The most important part of sprayer is the nozzle. (this is the month piece with small opening, fitted at the end of the spray lance of sprayer). Selecting the correct nozzle for spraying job is very important to obtain the desired droplet size and coverage. The technical information provided by manufacture will help make the application more efficient.

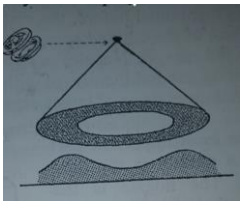

Figure 29 Hollow cone nozzle + droplets pattern

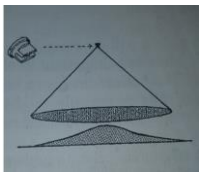

Figure 30 Regular flat nozzle + droplets pattern

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