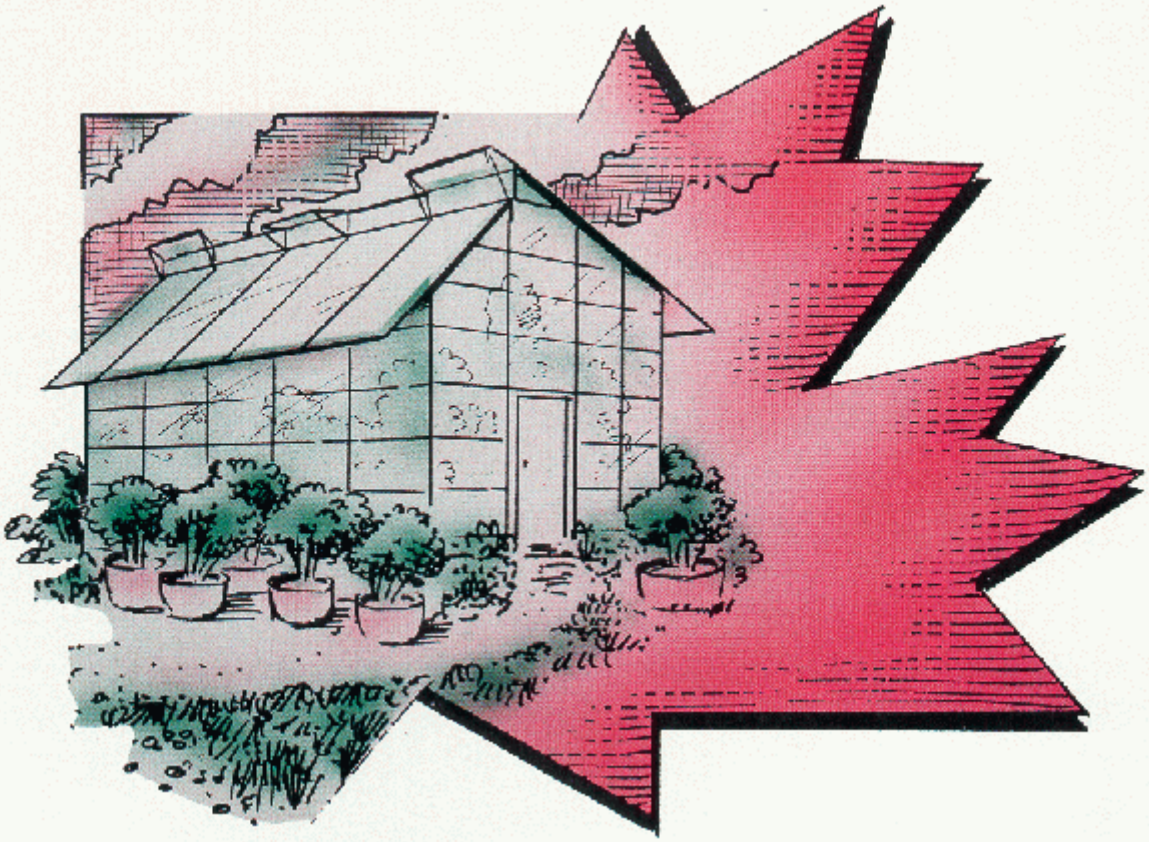

GREENHOUSE MODULE | **MODULE – SERRICULTURE**

BASIC KNOWLEDGE REQUIREMENTS FOR PESTICIDE EDUCATION IN CANADA

CONNAISSANCES FONDAMENTALES REQUISES POUR LA FORMATION SUR LES PESTICIDES AU CANADA

CAPCO

Health Canada Santé Canada

GREENHOUSE MODULE

BASIC KNOWLEDGE REQUIREMENTS

FOR

PESTICIDE EDUCATION IN CANADA

AUSSI DISPONIBLE EN FRANÇAIS

Prepared by the National Task Force on Pesticide Education, Training and Certification

If you would like additional information on the Standard for Pesticide Education, Training and Certification or to be on our mailing list, please write to:

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CONTRIBUTORS TO THE STRUCTURAL MODULE

The first drafts of the structural module were written by P. Pilley, PGP Pest Management Consultants, Lindsay, Ontario.

Project co-ordination and completion was overseen by L. Skillings, Health Canada.

Review and editing of drafts of the complete text, or parts of the text, by the following people, or organizations is gratefully acknowledged:

Members of the National Task Force on Pesticide Education, Training and Certification
R. Lennips, Ontario Pest Control Association
D. Blain, Ontario Pest Control Association
K. Jamieson, Scientific Editor, Forest Pest Management Institute
Sault Ste. Marie, Ontario
S. Shiels, Saskatchewan Institute of Applied Science and Technology
Saskatchewan

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BASIC KNOWLEDGE REQUIREMENTS
FOR PESTICIDE EDUCATION IN CANADA
GREENHOUSE MODULE

The Greenhouse Module includes the use of pesticides (excluding the use of restricted fumigants, which are gases at room temperature) during the storage, display and/or production of agricultural crops including vegetables, ornamentals and mushrooms, as well as forest tree seedlings. This category specific module also includes associated pesticide use on areas immediately surrounding greenhouses.

The knowledge requirements described in this module are additional to the knowledge requirements detailed in the Applicator Core, common to all certification categories. This module adds details to sections of the Core, where it is necessary to include greenhouse specific information. An outline of the knowledge requirement for the greenhouse module is presented on the following page. This outline shows which sections of the Core have been expanded in this module.

The knowledge requirements provided here is the information a trainer would use to provide training to an applicator on the responsible use of pesticides. It is targeted to the trainer for teaching purposes and is not intended as an applicator manual.

In addition to the applicator core, modules have been developed for the following categories:

Aerial
Agriculture
Aquatic Vegetation
Forestry
Fumigation
Greenhouse
Industrial Vegetation
Landscape
Mosquito and Biting Flies
Structural

GREENHOUSE MODULE

CONTENTS

Category: GREENHOUSE

Concept: GENERAL INFORMATION

General Objective: To understand general information on pesticides used in a greenhouse environment.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Using pesticides in a greenhouse is unique because: **- applications are made in enclosed areas;** **- a large number of employees work in a confined space and may be exposed to pesticides;** **- many different crops (e.g., ornamentals) can be grown, requiring a variety of pesticides;** **- pesticides may be volume concentrations (cubic areas) such as fogs, smoke bombs, fumigants, ultra low volume (ULV) or ultra low dosage (ULD) applications.**	**Understand why using pesticides in a greenhouse is unique.**	**List reasons why using pesticides in a greenhouse is unique.**
Formulations		
Disinfectants are pesticides used in empty greenhouses and mushroom houses to kill disease organisms, thus preventing them from carrying over from one season or crop to the next. Formaldehyde, bleach, or quaternary ammonium compounds are the most commonly used disinfectants.	**Know what a disinfectant is and what it is used for.**	**Describe disinfectants and their use in greenhouses.**
A smoke bomb is a formulation of a pesticide, usually an insecticide, which when ignited, is dispersed as a suspended particle (fume) throughout an enclosed building or greenhouse as a visible smoke and allowed to permeate the premises before the area is thoroughly ventilated. A smoke bomb will treat a specific volume (e.g., 300 cubic metres or 10,000 cubic feet.	**Know what a smoke bomb is.**	**Describe what a smoke bomb is and how it functions.**
A fumigant is a chemical that at a specific temperature and pressure, can exist in the gaseous state in sufficient quantities to be lethal to a pest organism. A fumigant is primarily effective in the gaseous state.	**Know the term fumigant.**	**Define fumigant.**

Category: GREENHOUSE

Concept: REGULATIONS

General Objective: To understand pesticide regulations in Canada.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Pesticide Residues Compensations Act		
Under the Pesticide Residues Compensation Act a producer can be compensated for losses incurred when the sale of food products is stopped because the maximum residue limit is exceeded. It must be proven that the residues exist through no fault of the producer and that all label directions were followed.	**Know the limitations for receiving compensation under the Pesticides Residues Compensation Act.**	**Identify the limitations for receiving compensations from the Pesticides Residues Compensation Act.**
A comprehensive program of random residue testing by Health Canada is done to ensure that pesticide residues do not exceed maximum residue limits (MRL). If residues exceed the MRL, the crop could be seized or ordered destroyed and legal action could be taken against the applicator.	**Know what can happen if the maximum residue limits are exceeded.**	**Describe what can happen if the maximum residue limits are exceeded.**
A pre-harvest interval (PHI) is the time between the last application of the pesticide and harvest. Harvesting the crop before the pre-harvest interval can result in excessive residues on the crop. PHI will be noted on the label.	**Understand pre-harvest interval.**	**Define pre-harvest interval.** **Identify the danger of harvesting the crop before the PHI is over.**

Category: GREENHOUSE

Concept: HUMAN HEALTH

General Objective: **To understand acute and chronic toxicity, routes of exposure, factors affecting exposure, reducing exposure and risk. To know exposure symptoms and be able to recognize poisonings.**

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Measuring Acute Toxicity		
There is a perception that insecticides are more dangerous than herbicides. The toxicity of each pesticide is reflected in the LD_{50} number of the specific product. Potential hazard of an acute poisoning should be based on product specific information, such as the LD_{50} number, and not solely on the pesticide's target group.	**Understand why the acute toxicity assessment should not be based solely on the target group.**	**Describe why the acute toxicity assessment should not be based solely on the target group.**
Cholinesterase Testing		
Organophosphate or carbamate pesticides inhibit cholinesterase. Cholinesterase is an enzyme in the blood that affects the nervous system and the way the brain sends messages to different parts of the body.	**Know why cholinesterase testing is done.**	**Describe why cholinesterase testing is done.**
Cholinesterase levels can vary widely between individuals. It is therefore important to know an individual's level of cholinesterase before he or she handles these pesticides. **Applicators who use these pesticides on a regular basis should have:** **1) A baseline test to determine cholinesterase enzyme levels before exposure;** **2) A regular blood test to check cholinesterase levels during the exposure period.**		**Identify when an applicator should have a cholinesterase test.**

Category: GREENHOUSE

Concept: PESTICIDE SAFETY - ATTITUDE AND GENERAL PRECAUTIONS

General Objective: To know the general safety precautions for handling pesticides.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
The following precautions should be taken when applying pesticides in a greenhouse, before, during and after application:	**Know the precautions that should be taken before, during and after an application of pesticides in an greenhouse.**	**List precautions to be taken before, during and after an application of pesticides in a greenhouse.**

Before Application

1) **Notify all staff that pesticides are going to be applied.**
2) **Close all doors, windows and other openings.**
3) **Post warning signs on all doors to the area (ensure that regulations regarding signage are followed).**
4) **Lock or barricade all entrances.**
5) **Read the label. Be aware of the time allowance for re-entry period.**
6) **Advise other workers in adjacent buildings that the area will be treated with a pesticide, which product(s) will be applied and the re-entry time.**
7) **Plan the application procedure.**

During Application

1) **Start at the furthest end of the greenhouse and work toward the exit. Never reenter the treated area to exit. Always wear the proper protective clothing and equipment.**

Category: GREENHOUSE

Concept: PESTICIDE SAFETY - ATTITUDE AND GENERAL PRECAUTIONS

General Objective: To know the general safety precautions for handling pesticides.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
2) When spraying with a wand above the waist level, make a cuff at the top of the glove. Put sleeve of coverall inside the glove to prevent the spray from running down the gloves and onto the arm.		
3) When spraying overhead plants, spray from the next row yet to be treated. Direct the spray into the crop canopy.		
4) When igniting smoke fumigators, use a propane torch to allow for quick lighting and exiting. Work in pairs.		
5) Seal area for time specified on label.		
After Application		
1) If it is necessary to re-enter, wear the proper protective equipment and clothing.		
2) While ventilating, keep workers away from exhaust fans.		
3) Check reentry time for each pesticide and for different formulations of pesticides (smoke, ULV, ULD, sprays).		

Category: GREENHOUSE

Concept: PESTICIDE SAFETY - PROTECTIVE CLOTHING AND EQUIPMENT

General Objective: To know how to select, correctly wear and maintain suitable clothing and equipment for the handling of pesticides.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Respiratory Protection for Fumigation **Respiratory protection is absolutely essential during a fumigation procedure. All fumigants require a minimum of full face protection. Respiratory equipment must fit properly and must be equipped with canisters which are certified to provide protection for the fumigant being used. Canisters have a number of limitations such as maximum gas concentrations for effectiveness, exposure life, gas specific removal and shelf life limitations.**	**Know what protective clothing and equipment is necessary for fumigation activities.**	**Describe the protective clothing and equipment requirements for fumigation.**
Skin Protection for Fumigation **Ensure that fumigant formulations do not come in contact with the skin. Always check the product label to determine if specific protective clothing requirements are identified.**		

Category: GREENHOUSE

Concept: PEST MANAGEMENT

General Objective: To understand pest management principles required to carry out the safe and effective pest control in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Monitoring Insects		
Methods of monitoring insects in the greenhouse include using yellow sticky traps, cards, or tapes, to monitor for flying insects. Yellow is especially good for whitefly, thrips, leafminer, fungus gnats and winged aphids. Blue sticky traps are attractive to western flower thrips. However, if a wide pest complex is present, yellow traps are a better choice. Use one card every 100 to 200 m^2. Cards need to be changed before there are too many insects on them to maintain a weekly record.	**Know the methods of monitoring insects in greenhouses.**	**List methods of monitoring insects in greenhouses.**
Management Methods		
Types of pest management methods used in the greenhouse are: **- cultural;** **- mechanical/physical;** **- biological;** **- genetic;** **- chemical.**	**Know the types of pest management methods used in the greenhouse.**	**List the pest management methods used in the greenhouse.**
Cultural methods involve using varieties resistant to pests, and maintaining healthy crops, more resistant to pests because of good growing conditions (e.g., warm roots in soilless media). Growing conditions in the greenhouse, such as temperature, humidity, light, water, nutrients, $C0_2$ levels, etc. may be controlled by a computer.	**Understand how the various methods of pest management can help manage pests.**	**List and describe how the various methods of pest management.**
Sanitation involves the removal and disposal of plant refuse, cleanliness, disinfection of new stock, bare areas around greenhouse, etc.		
Physical methods involve preventing pests from entering the greenhouse by screening the vents. However, screening may result in undesirable effects (reduced ventilation). Pasteurizing soil with steam to kill harmful insects, disease organisms, weed seeds and nematodes is another physical control.		

Category: GREENHOUSE

Concept: PEST MANAGEMENT

General Objective: To understand pest management principles required to carry out the safe and effective pest control in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Biological methods involve the use of predators and parasites for the control of greenhouse insects. Examples include: **- Parasitic wasp - *Encarsia formosa* - for greenhouse whitefly;** **- Predatory mite - *Phytoseiuhus persimilus* - for the two spotted spider mite;** **- Predatory midge - *Aphidoletes aphidimyza* and *Aphidius matricariae* for aphids;** **- Predatory mite - *Amblyseiums cucumeris* - for thrips;** **- Parasitic wasp - *Dacnusasibirica* or *Diglyphus isaea* for leafminers;** **- Parasitic nematodes - *Steinernema spp*. and mites - *Hypoaspis* mites (*Gedlelaps*) - for fungus gnats.** **Chemical Methods - Fumigation, disinfection, and seed treatments are examples of chemical methods of pest control in the greenhouse. Disinfections involve the use of formaldehyde, bleach, quaternary ammonium compounds or sodium hypochlorite between crops to rid the greenhouse of insects, nematodes, disease organisms, weed seeds, etc. The use of insecticides or fungicides in the crop requires a careful selection of materials in an IPM program to minimize the effect on biological control agents and insects used for pollination (e.g., bumble bees in tomatoes). Use pesticides that are less persistent and less toxic to beneficial organisms.** **Herbicides are used to control weeds around the greenhouses. The best time to do this is when greenhouses are not in use. It is very important not to allow any herbicide to enter the greenhouse through water/fertilizer lines, vents, fans or any form of air exchange. Plant growth regulators are also used in the greenhouse.**		

Category: GREENHOUSE

Concept: PEST MANAGEMENT - WEEDS

General Objective: To understand pest management principles required to carry out safe and effective weed control.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Weeds		
A weed is a plant growing where it is not wanted. Weeds are pests when they: **- compete with cultivated plants for light, water or nutrients;** **- reduce crop yield or quality;** **- harm people or livestock;** **- are alternate hosts for other pests.**	**Know what a weed is.** **Know when weeds are pests.**	**Define what a weed is.** **List examples of when weeds are pests.**
Types of Weeds		
Weeds can be classified according to how long they live.	**Know the weed classification according to how long the weed lives and know the difference between annual, biennial and perennial weeds.**	**Describe how weeds are classified according to how long they live. Describe annual, biennial and perennial weeds.**
Annual weeds complete their life cycle within one year. Most annuals produce many seeds to ensure their survival. Annuals can be divided into two groups: summer annuals, which germinate in the spring, and winter annuals which germinate in the fall. **Biennial weeds live more than one year but less than two years. They grow from seed, which usually germinates in the spring. During the first year of most biennial weeds, the foliage is only a rosette of leaves and food is stored in short fleshy roots. Next season, the plant uses the stored food to grow vigorously and produces seed before dying.** **Perennial weeds are plants that live more than two years. Seed is the primary method by which most perennial weeds reproduce, although many also spread (and some exclusively) by vegetative means.**		

Category: GREENHOUSE

Concept: PEST MANAGEMENT - WEEDS

General Objective: To understand pest management principles required to carry out safe and effective weed control.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Weed Identification		
The following physical structures will aid in the identification of weeds: **- leaf shape and surface;** **- leaf margins;** **- arrangement of leaves on the stem;** **- branching habit;** **- flowering habit.**	**Know the physical features that aid in the identification of weeds and desirable vegetation.**	**List the physical features that aid in the identification of weeds and desirable vegetation.**
Many herbicide labels refer to a specific weed and/or crop leaf stage for application. Application at leaf stages other than those indicated may result in reduced weed control and/or crop damage. Monitor weed growth regularly to determine weed sizes and leaf numbers since they change rapidly.	**Understand why it is important to know how to identify leaf stages of desirable plants and weeds.**	**Identify why it is important to know how to identify leaf stages of desirable plants and weeds.**
Types of Herbicides		
Herbicides are classified according to: **- selectivity;** **- mode of action;** **- timing of application;** **- residual effectiveness.**	**Know the ways herbicides are classified.**	**List the ways herbicides are classified.**
Selectivity describes whether or not a herbicide kills all plants or only some plants. Herbicides can be selective, non-selective or both. Selective herbicides only kill or damage certain plants; non-selective herbicides kill or damage all plants. Some herbicides are both selective and non-selective depending on the pesticide rate.	**Know how to classify herbicides according to selectivity. Know the differences between selective and non-selective herbicides.**	**Describe how to classify herbicides according to selectivity. Identify selective and non-selective herbicides.**
Mode of Action explains how the herbicide kills a plant. Herbicides are either contact or systemic.	**Know how to classify herbicides according to mode of action.**	**Describe how to classify herbicides according to mode of action.**

Category: GREENHOUSE

Concept: PEST MANAGEMENT - WEEDS

General Objective: To understand pest management principles required to carry out safe and effective weed control.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Contact herbicides kill plant parts contacted by the herbicide. There is little or no movement of the herbicide in the plant. Contact herbicides are not effective against perennial weeds as they only "burn off" the tops. **Systemic herbicides enter the roots or above ground parts of plants. These herbicides move in and through the plant (translocated). Effects may not show for a week or more after treatment.**	**Know the difference between contact and systemic herbicides.**	**Identify contact and systemic herbicides.**
Timing of application classifies herbicides according to when they are applied. Herbicides are classified as: **- pre-plant;** **- pre-emergence;** **- post-emergence.**	**Know how to classify herbicides according to timing of application.**	**Describe how to classify herbicides according to timing of application.**
Pre-plant herbicides are applied to the soil before seeding or transplanting. In pre-plant soil-incorporated treatments the herbicide is incorporated into the soil after application. **Pre-emergence herbicides are applied to the soil after planting but before the emergence of the specific crop or weed. Pre-emergence may refer to the germination of either the weed or the crop; check with the label for specific instructions. Pre-emergence herbicides control weeds before or soon after they emerge.** **Post-emergence herbicides are applied after the specific crop or weed has emerged. The application may be soon after emergence or up to a specific height or leaf number. Post-emergence herbicides control established weeds.**	**Know the difference between pre-plant, pre-emergence, and post-emergence herbicides.**	**Describe pre-plant, pre-emergence and post-emergence herbicides.**
Residual effectiveness refers to how long the herbicide remains active and alters weed or crop growth after application. Herbicides are classed as either residual or non-residual. **Non-residual herbicides degrade rapidly and become inactive in the soil after application and do not affect future crops.**	**Know how to classify herbicides according to residual effectiveness.**	**Describe residual herbicides, non-residual herbicides and soil sterilants.**

Category: GREENHOUSE

Concept: PEST MANAGEMENT - WEEDS

General Objective: To understand pest management principles required to carry out safe and effective weed control.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Residual herbicides do not break down quickly and may control weeds for several weeks to several years. Special precautions are required when using residual herbicides. Carefully consider the environmental impacts, future crops and site conditions. **Non-selective residual herbicides (soil sterilants) are applied to soil to prevent growth of plants for an extended period of time (a few months to many years). These products do not sterilize the soil of all micro-organisms or seeds.**		

Category: GREENHOUSE

Concept: PEST MANAGEMENT - PLANT GROWTH REGULATORS

General Objective: To understand the use of plant growth regulators.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Plant Growth Regulators are used to change (speed up, stop, slow down) the vegetative or reproductive growth of plants.	**Know why plant growth regulators are used.**	**Identify why plant growth regulators are used.**
Their effect on growth depends on the: **- rate and concentration of the plant growth regulator;** **- timing of application;** **- method of application;** **- plant's age, growth stage and rate of growth.**	**Know the factors that affect their effect on growth.**	**List the factors that affect their effect on growth.**
Some examples of plant growth regulators include: • **carbaryl** — **blossom and fruit thinning** • **gibberellic acid** — **increasing blossom and fruit set** • **naphthalene acetic acid** — **control of preharvest drop** • **chlormequate** — **control of suckering** • **daminozide** — **control of stem growth** • **maleic hydrazide** — **promoting root growth**	**Know examples of plant growth regulators.**	**List examples of plant growth regulators.**

Category: GREENHOUSE

Concept: PEST MANAGEMENT - INSECTS, MITES AND MOLLUSCS

General Objective: To understand pest management principles required to carry out the safe and effective control of insects, mites and molluscs.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Insects and Mites		
Insects are a group of animals that (as adults) have jointed bodies, 6 jointed legs and an outer skeleton. The adult insect body has three main sections: head, thorax and abdomen. Three pairs of legs and one or two pairs of wings (if present) are attached to the thorax. Insects breath through spiracles (pores) in their outer skeleton.	**Know the general description of an insect and a mite and be able to distinguish between them.**	**Describe the body parts of an insect and mite. List the major differences between the two.**
Mites are a group of animals that (as adults) have jointed bodies, 8 jointed legs and an outer skeleton. Mites differ from insects in that their bodies are not divided into obvious sections and they have only two main body parts: a fused head and thorax and an abdomen. The adult has four pairs of legs. The larval stage only has three pairs of legs. Mites do not have wings. They are generally extremely small (less than 1 mm in length).		
A number of insects and mites affect plants. Insects and mites do most of their damage with their mouthparts in the course of feeding. The mouthparts of pests are adapted for one or more of the following: chewing, sucking, siphoning, and lapping.	**Know which insects and mites are a problem in your province and be able to identify them.**	**List and describe the insects and mites that are a problem in your province.**
	Know how the type of mouthparts an insect or mite has will affect the damage done.	**List the ways that insects and mites uses their mouthparts to feed.**
Insect and Mite Life Cycles		
Insects and mites go through three or four different stages as they mature. The common stages are: egg, nymph or larva, pupa, adult. During the nymphal or larval stage they may moult several times before progressing to the next stage. The stage between each moult is called an instar.	**Know the stages of growth that insects and mites may go through.**	**List and describe the stages that insects and mites may go through.**
The most common life cycles of insects are:	**Know the most common life cycles of insects.**	**List and describe the most common life cycles of insects.**

Category: GREENHOUSE

Concept: PEST MANAGEMENT - INSECTS, MITES AND MOLLUSCS

General Objective: To understand pest management principles required to carry out the safe and effective control of insects, mites and molluscs.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
1. Egg to nymph to adult (gradual development or incomplete metamorphosis). A nymph is similar in appearance to the adult but lacks reproductive organs. Generally, they have compound eyes and externally developing wings; for example, grasshoppers and leafhoppers. These insects do not have a pupal stage. 2. Egg to larva to pupa to adult (complete metamorphosis). The larva is very different from the adult. It is a grub-like feeding stage; for example caterpillars and wireworms. Larvae do not have compound eyes. The pupa is a non-feeding resting stage during which complete change of shape occurs. The adult is the reproductive stage and is usually winged; for example butterflies and beetles.		
Mites generally go through three stages: egg to nymph to adult.	Know the life cycle of mites.	Describe the life cycle of mites.
Molluscs		
Slugs and snails are soft bodied animals that move by means of a single ventral "foot". They have a distinct head with two pair of tentacles. Snails have distinct shells, slugs do not. Terrestrial slugs and snails are active mainly during the evening, at night, on cool overcast days or immediately following a rain. They spend most of the day hiding under damp refuse, rocks and other objects on the soil surface. Often, they will return to the same hiding place day after day, unless disturbed. The route taken out is usually retraced on the return trip, leaving a "slime trail". They will avoid all dusty, dry or sharp objects, if possible.	Know if slugs and snails are a problem in your province and be able to identify them.	Describe the slugs and snails which are a problem in your province.
Life Cycle of Slugs and Snails		
Slugs and snails reproduce by laying eggs. They have three distinct stages in their life cycle: egg, nymph and adults.	Know the life cycle of slugs and snails.	Describe the life cycle of slugs and snails.

Category: GREENHOUSE

Concept: PEST MANAGEMENT - INSECTS, MITES AND MOLLUSCS

General Objective: To understand pest management principles required to carry out the safe and effective control of insects, mites and molluscs.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Control Measures for Insects, Mites and Molluscs		
Insects, mites and molluscs are most effectively controlled in their early stages (larva or nymph). The adults can also be controlled to a lesser extent. Eggs and pupae are generally not affected by insecticides, miticides and molluscicides.	**Know the life cycle stages during which the best insect, mite and mollusc control is usually achieved.**	**Identify the life cycle stages during which the best control of insects, mites and molluscs can be achieved.**
Control of these pests involves one or more of the following methods: exclusion, cultural, mechanical, biological, and chemical. An IPM program should be implemented if possible.	**Know the control methods for insects, mites and molluscs.**	**List and describe the control methods for insects, mites and molluscs.**
Chemical control is the use of insecticides to control insects, miticides to control mites and molluscicides to control slugs and snails.	**Know which insecticides, miticides and molluscicides are registered for the control insects, mites, slugs and snails.**	**List and describe the pesticides registered for the control of insects, mites, slugs and snails.**
Classification		
Insecticides, miticides and mollusicides are classified according to their mode of entry, residual effectiveness, and selectivity.	**Know the ways that these pesticides are classified.**	**List the ways that these pesticides are classified.**
Mode of Entry describes how the pesticide reaches the insect, mite or mollusc and/or how it then affects the pest.	**Know what mode of entry refers to.**	**Describe mode of entry.**
Contact pesticides must come in contact with the pest to be effective. They can be applied to the pest or to surfaces over which the pest moves. Some contact pesticides have a residual effect and can kill the pest for some time after application.	**Understand what contact insecticide/miticide/ mollusicide means.**	**Describe a contact insecticide/miticide/ molluscicide.**
Suffocating pesticides are a specific group of contact pesticides that clog the pest's breathing pores.	**Understand what a suffocating pesticide is.**	**Describe a suffocating pesticide.**
Stomach poisons must be swallowed by the pest to be effective. They are usually applied to the pest's food and taken in with the food. Sometimes stomach poisons are mixed with food to form a poisonous bait.	**Understand what a stomach poison is.**	**Describe a stomach poison.**

Category: GREENHOUSE

Concept: PEST MANAGEMENT - INSECTS, MITES AND MOLLUSCS

General Objective: To understand pest management principles required to carry out the safe and effective control of insects, mites and molluscs.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Systemic pesticides are a specific group of stomach poisons. They are applied to the host plants and are translocated in the plants with the sap or water. The pests suck the poisoned sap or eat poisoned plant parts.	**Understand what a systemic insecticide, miticide/ molluscicide is.**	**Describe a systemic insecticide, miticide/ molluscicide.**
Fumigants are pesticides that work in a gaseous form. The pest breathes in the poisonous fumes. Some pesticides have a fumigant action but are not considered true fumigants. An applicator must possess a fumigation certificate/license to use true fumigants.	**Understand what a fumigant is.**	**Describe a fumigant.**
Attractants are chemicals that attract insects, mites or molluscs. They may attract female insects for egg laying, attract male insects to sticky traps or attract slugs to water traps.	**Understand what an attractant is.**	**Describe an attractant.**
Residual Effectiveness refers to how long the pesticide remains effective after application. Some insecticides remain effective for only a few days, others for several weeks.	**Know what residual effectiveness refers to.**	**Describe residual effectiveness.**
Selectivity refers to which insects, mites or molluscs will be affected by the pesticide.	**Know what selectivity refers to.**	**Describe selectivity.**
Selective pesticides only control certain insects, mites or molluscs. They generally do not harm non target organisms.	**Know what select and non-selective pesticides are.**	**Describe selective and non-selective pesticides.**
Non-selective pesticides may control all insects, mites or molluscs. They may also harm other non target organisms. Extra caution should be taken when using these pesticides.		
Factors Affecting Insecticide/Miticide/Molluscicide Effectiveness		
Factors affecting the effectiveness of the pesticide include: timing of application, pest resistance and weather conditions.	**Know the factors that affect insecticide, miticide and molluscicide effectiveness.**	**List and describe the factors that affect insecticide, miticide and molluscicide effectiveness.**

Category: GREENHOUSE

Concept: PEST MANAGEMENT - INSECTS, MITES AND MOLLUSCS

General Objective: To understand pest management principles required to carry out the safe and effective control of insects, mites and molluscs.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Timing of Application. The pest may need to be present at the time of application. It may need to be in a susceptible stage of development. Generally, the younger the pest is the easier it is to control with contact and stomach poisons.		
Resistance. Some insects, mites and molluscs have developed resistance to specific types of families of pesticides.		
Weather Conditions. Sunlight, temperature, humidity and moisture can affect the effectiveness of pesticides by increasing pest sensitivity or by decreasing the residual activity of the pesticide. Some insecticides are only effective at certain temperatures.		

Category: GREENHOUSE

Concept: PEST MANAGEMENT - DISEASES AND NEMATODES

General Objective: To understand pest management principles required to carry out the safe and effective disease control.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Diseases		
Plants may be diseased when their appearance or function is not normal.	Know when plants are diseased.	Describe how you know when plants are diseased.
Disease symptoms are caused by environmental stress or infection by microorganisms. Similar symptoms may be caused by insect damage (e.g., gall forming insects) or herbicide damage. It is important to correctly identify the cause of the symptoms so that an effective diagnosis and treatment can be chosen.	Know what can cause disease symptoms. Understand why it is important to correctly identify the cause of disease symptoms.	List the major causes of disease symptoms. Identify other things that could cause similar symptoms. Describe why it is important to correctly identify the cause of disease or disease-like symptoms.
Environmental Stress		
Unfavourable environmental conditions that stress plants and cause abnormal growth or disease-like symptoms include extremes of light, temperature, water or nutrients, and toxic chemicals (e.g., air pollutants). Plants weakened by environmental stress are more likely to be infected by pests. Recognizing and relieving the stress will help prevent infectious diseases.	Know environmental conditions that can stress plants and cause abnormal growth or disease-like symptoms. Understand why it is important to recognize and relieve stress on plants.	List the environmental conditions that could stress plants and cause abnormal growth or disease-like symptoms. Describe why it is important to recognize and relieve environmental stress.
Diseases caused by environmental stress cannot be spread from plant to plant.	Realize that diseases caused by environmental stress cannot spread from plant to plant.	Identify that diseases caused by environmental stress do not spread from plant to plant.
Infection by Microorganisms		
Microorganisms can cause diseases. Pest microorganisms include fungi, bacteria, viruses and nematodes. These organisms are usually too small to see. Identification is usually based on the symptoms that can be seen, or on laboratory investigations.	Know pest organisms that can cause diseases. Realize disease identification is based on symptoms and laboratory investigations.	List types of organisms that can cause diseases. Describe how a disease can be identified.
Diseases caused by microorganisms (pest infection) are called infectious diseases. These diseases can spread from plant to plant.	Know what an infectious disease is. Realize that diseases caused by microorganisms can spread from plant to plant.	Define infectious disease. Identify that diseases caused by microorganisms can spread from plant to plant.
Microorganisms are pests when they damage desirable plants.	Know when microorganisms are pests.	Identify when microorganisms are pests.
Fungi		

Category: GREENHOUSE

Concept: PEST MANAGEMENT - DISEASES AND NEMATODES

General Objective: To understand pest management principles required to carry out the safe and effective disease control.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Fungi are the largest group of organisms that cause plant diseases. They are organisms that feed on living or decaying organic matter. This group includes moulds, mushrooms, and rusts.	Know about fungi that cause plant diseases.	Describe what a fungus is. List organisms that are considered fungi.
Most fungi reproduce by tiny spores. When spores germinate, they usually produce threadlike filaments which can infect the host, absorb nutrients, and give off toxins that cause disease symptoms.	Know how fungi reproduce and cause disease symptoms.	Describe how fungi reproduce and cause disease symptoms.
The life cycles of many fungi follow a similar sequence. An example of the sequence is: The fungus stays on a diseased leaf over winter. As the weather becomes warmer in spring, the fungus becomes active and produces spores. The spores are released into the environment and they are moved by wind or water. Some land on healthy parts of a plant. If environmental conditions are poor for spore germination the spores may die, be washed off by rain, or remain dormant. Spores are fairly resistant to fungicides during this stage. If environmental conditions are good, the fungus spores will germinate. The fungus is most vulnerable to fungicides or unfavourable growing conditions between germination and infection. Infection begins when the fungus is able to enter the plant tissues.		Describe the life cycles of a typical fungus.
When the plant responds to infection by growing abnormally it is said to be diseased. Inside the plant the fungus is protected and difficult to control. A systemic fungicide may control the disease if applied before the infection is too severe. Some fungi (e.g., rusts) need 2 different hosts to survive and reproduce. Fungi are spread by spores or tiny pieces of the fungus. Movement of infected plants, plant parts and soil may also spread the fungus.		
Some symptoms that may be caused by fungi include cankers, dieback, galls, leaf spots, rots, ruts and wilts.		List symptoms of a disease that could be caused by a fungus.
Bacteria		

Category: GREENHOUSE

Concept: PEST MANAGEMENT - DISEASES AND NEMATODES

General Objective: To understand pest management principles required to carry out the safe and effective disease control.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Bacteria cause some major plant diseases. Bacteria are one-celled organisms that can only be seen with a microscope. They usually enter a plant through openings or wounds. Under favourable conditions, bacteria reproduce very quickly, using the plant as a source of food.	Know about bacteria.	Describe what a bacteria is. Describe how bacteria can infect plants.
Bacteria are spread by wind, or water, or by contact with contaminated equipment.	Understand how bacteria are spread.	List ways bacteria could be spread.
Some blights, galls and rots are caused by bacteria.	Know about the bacterial diseases in your province.	Describe bacterial diseases in your province.
Viruses		
Viruses are extremely small. They cannot be seen with an ordinary microscope. Viruses cause diseases that often affect plant vigour and crop yields.	Know about viruses.	Describe what a virus is.
Viruses reproduce only in living cells.	Know how viruses reproduce and spread.	Describe how viruses reproduce.
Viruses can be spread by mechanical means (e.g., during pruning or harvesting), in propagation material (seeds, tubers and other plant parts) or by vectors (insects, mites, nematodes, fungi).		List ways viruses can be spread.
Mosaics, rinspot and leaf roll are examples of diseases caused by viruses.	Know about the diseases caused by viruses in your province.	Describe diseases caused by viruses in your province.
No pesticides are available to control viruses directly. However, some pesticides may be used to control virus vectors.	Know that there are no pesticides to control viruses.	Identify that pesticides can not be used to control viruses.
Nematodes		

Category: GREENHOUSE

Concept: PEST MANAGEMENT - DISEASES AND NEMATODES

General Objective: To understand pest management principles required to carry out the safe and effective disease control.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Nematodes are very small organisms that may feed on plant roots, stems, and leaves. They can affect the movement of water and nutrients in a plant and they create wounds, which may allow fungi or bacteria to enter.	**Know about nematodes.**	**Describe what nematodes are.**
Nematodes multiply by producing eggs.		**Describe how nematodes reproduce.**
Nematodes spread by movement of infected plants, animals, and seeds, contaminated soil and water.		**Describe how nematodes spread.**
Some symptoms that can be caused by nematodes are wilting, stunting, lack of vigour, and growth deformities.		**List symptoms that may be caused by nematodes.**
Approaches to Disease Management		
Three things must be present for infectious disease to develop. They are: **1. A disease causing organism (pathogen).** **2. A host susceptible to the disease.** **3. An environment favourable to the disease organism.**	**Know the three things necessary for an infectious disease to develop.**	**List the three things necessary for an infectious disease to develop.**
Taking away or changing any one of these 3 things will control or avoid the disease. For example, a disease problem can be prevented by: keeping the organism out of an area, using strains of plants that are resistant or are not affected by the disease, reducing the population of disease causing organisms, or by manipulating the environment to favour the host but not the pathogen.	**Understand how diseases can be controlled.**	**Describe how diseases can be controlled.**
Fungicides		

Category: GREENHOUSE

Concept: PEST MANAGEMENT - DISEASES AND NEMATODES

General Objective: To understand pest management principles required to carry out the safe and effective disease control.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Fungicides are often described according to how they work (mode of action).	**Know how fungicides work.**	
Protectant fungicides provide a protective film of fungicide on or around the host to prevent fungus spores from germinating. Protectant fungicides must be used before the fungi reach the infectious stage. After the plant is infected the fungicide normally will not kill the fungi inside the plant but it can protect the plant from more infection. New plant growth that appears after treatment is not protected. Therefore reapplication is required. Protectants can be applied to seeds, foliage, flowers, fruit, or to roots.		**Describe how protectant fungicides work.**
Eradicant fungicides kill fungus organisms that have infected but not become well established within the plant. Eradicant fungicides have limited value for fungi that are well established within plants.		**Describe how eradicant fungicides work.**
Systemic fungicides are absorbed by plants and move within them. They may act as protectants, eradicants, or both. Once inside the plant, systemics move to new areas of plant growth.		
Bactericides		
Bactericides are chemicals that are toxic to bacteria. They kill bacteria on contact and must be used before the bacteria infect a plant.	**Know how bactericides work.**	**Describe how bactericides work.**
Nematicides		

Category: GREENHOUSE

Concept: PEST MANAGEMENT - DISEASES AND NEMATODES

General Objective: To understand pest management principles required to carry out the safe and effective disease control.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Nematicides are chemicals that move through the soil as a gas or in soil water and depend on the presence of spaces between the soil particles for their movement. Nematicides may be applied as liquid or granular formulations. They may act by direct contact with nematodes or systemically so that nematodes feeding on or in the diseased plant acquire a lethal dose.	**Know what pesticides are used for nematode control and how they work.**	**Identify the formulations of pesticides are used for nematode control.** **Describe how nematicides work.**
Fumigants		
Fumigants are chemicals that when in a gaseous state are lethal to pest organisms. Fumigants may move through air spaces between soil particles (soil fumigation) or through air in structures (space fumigation).	**Know how a fumigant works.**	**Describe how a fumigant works.**
Factors Affecting Fungicide/Bactericide Effectiveness		
Timing of Application - the fungicide/bactericide should be on or in the plant (in effective concentration) prior to or during the infection period of the fungus/bacteria.	**Know factors affecting fungicide/bactericide effectiveness.**	**Describe how timing of application can affect the effectiveness of fungicides/bactericides.**
Fungus/Bacteria Life Cycle and Weather - the frequency of applications varies depending on the type of fungus/ bacteria, the fungicide/bactericide, and the weather. If the fungus/bacteria has a short life cycle and there are good conditions for its growth it can have many infection periods and many applications may be needed. If the conditions are poor for its growth few applications may be needed. Moisture, rate of plant growth, and type of fungicide/bactericide also affect the frequency of applications. If the fungicide/bactericide is washed off, if new leaves grow or if the fungicide/bactericide breaks down quickly, applications may need to be repeated.		**Describe how the weather and fungus/ bacteria life cycle can affect the effectiveness of fungicides/bactericides.**

Category: GREENHOUSE

Concept: PEST MANAGEMENT - VERTEBRATES

General Objective: To understand pest management principles required to carry out the safe and effective control of vertebrates.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Vertebrate pests include: **- birds;** **- rodents;** **- other regional pests.**	**Know which vertebrate animals are pests in your province and be able to identify them.**	**List and describe the vertebrate animals which are pests in your province.**
Vertebrates are pests when they damage property, crops, feed, food, and when they carry diseases affecting man or animals or birds.	**Know when vertebrates are pests.**	**Identify when vertebrates are pests.**
When planning a control program, consider: **- benefits as well as damage;** **- hazards of the control program to non-targets.**	**Know the factors to consider when planning a control program.**	**List the factors to consider when planning a control program.**
Pest Behaviour and Biology		
Knowing vertebrate pest behaviour and biology is important as it helps you determine the most effective control methods, the best time to implement the control and the best location for control.	**Understand why it is important to know about the behaviour and biology of vertebrate pests.**	**Describe the behaviour and biology of vertebrate pests.**
The selection of effective control methods will depend upon the pest's: **- population density of the pest;** **- mobility of the pest;** **- habitat;** **- availability of preferred foods;** **- physical abilities of the pest;** **- wariness of man and foreign objects;** **- place in the food chain;** **- impact on non-target species;** **- public opinion.**	**Know what should be considered when selecting a vertebrate pest control method.**	**List the factors to consider when selecting an effective control method.**

Category: GREENHOUSE

Concept: PEST MANAGEMENT - VERTEBRATES

General Objective: To understand pest management principles required to carry out the safe and effective control of vertebrates.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
The best time to implement a control will depend upon: **- the availability of food;** **- when migration takes place;** **- when the young are born (population numbers are the lowest before the young are born). Controls should be set in place before this time;** **- when the pests are actively moving about in search of food;** **- whether the pest hibernate.**	**Know what should be considered when selecting the timing for a vertebrate control program or method.**	**List the factors to consider when selecting the time for controlling vertebrate pests.**
The best locations to shoot or poison a vertebrate pest can depend upon finding: **- den;** **- burrow or nest and the exits;** **- regularly travelled routes;** **- feeding routes.**	**Know what should be considered when selecting the location for a vertebrate control method.**	**List the factors to consider when selecting the location for a vertebrate control method.**
Vertebrate Pest Management Methods		
Use integrated pest management whenever possible.	**Understand that integrated pest management should be used whenever possible.**	**Identify that integrated pest management should be used whenever possible.**
Vertebrate pests may be controlled by: **- excluding them from a feeding or breeding area;** **- destroying or changing their habitat;** **- encouraging natural predators;** **- frightening away or repelling them (ultrasonic sound or cannon);** **- shooting them;** **- trapping them;** **- gassing with carbon monoxide;** **- poisoning them with pesticides;** **- preventing pest reproduction with chemosterilants.**	**Know the methods of controlling vertebrate pests.**	**List and describe the methods for the control of vertebrate pests.**
The decision of how to control vertebrate pests will depend on the legal status, cost, and effectiveness of the available control methods.	**Know the factors that have a bearing on the choice of a control method.**	**List the factors which affect the choice of a control method.**
Legal Status of Control Methods		

Category: GREENHOUSE

Concept: PEST MANAGEMENT - VERTEBRATES

General Objective: To understand pest management principles required to carry out the safe and effective control of vertebrates.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Legislation for the protection of wildlife may prevent the destruction of some pests or may require special permits for their control.	**Know how laws may affect the control of vertebrate pests.**	**Identify the laws which affect the control of vertebrate pests.**
Shooting, trapping and pesticides may be limited to specific times and locations. Check with provincial authorities about laws that could affect vertebrate control programs before controlling vertebrate pests.	**Know who to ask regarding laws which affect control programs for vertebrate pests.**	**Identify where to obtain information about laws that may affect proposed vertebrate control programs.**
Pesticides Used for Vertebrate Control		
Avicides kill birds.	**Know the types of vertebrate control products and how they work.**	**List and describe the types of vertebrate control products.**
Rodenticides kill rodents.		
Acute rodenticides kill rodents soon after one feeding. Anticoagulant rodenticides kill rodents over several days by causing internal or external bleeding. They can be single-dose and need one feeding or multiple-dose and need several feedings over several days.		
Predacides kill predatory animals.		
Chemosterilants reduce pest populations by reproductively sterilizing female and/or male adults.		
Chemical repellents are used to frighten away bird pests. A few birds eat the chemical and their strange behaviour, before they die, frightens away other birds.		
Sticky pastes are used to repel birds or to trap rodents.		
Fumigants are used to kill burrowing vertebrate pests.		

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - APPLICATION EQUIPMENT SELECTION

General Objective: To know how to select the application equipment necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Application Equipment		
A variety of application equipment is available for applying a pesticide in enclosed areas, such as greenhouses. Sprayer options include: high volume sprayers, backpack sprayers, low volume sprayers, soil and smoke fumigation equipment, and granular applicators.	**Know about types of application equipment which are used in greenhouse operations.**	**List the types of application equipment used in greenhouse operations.**
Correctly select and operate the application equipment so that the pesticide is applied according to the label directions, environmental conditions and application situation.		
High Volume Sprayers operate at high pressures between 2,000 and 3,000 kPa (300 to 400 psi) and disperse fine spray droplets into the air and onto the foliage. They are designed to apply pesticides to large areas.		**Describe high volume sprayers.**
Backpack Sprayers are used for treating small areas and spot spraying. Backpack sprayers have tank size from 5 to 25 litres and hand-wands (booms) with 1-4 nozzles. The risk of applicator exposure is increased because the spray mixture is carried by the applicator who works in close proximity to the spray.		**Describe backpack sprayers.**
Low Volume Sprayers reduce the volume of pesticide mixture applied. The greenhouse is sealed during application. Fine spray droplets remain suspended in the air to allow thorough penetration of the crop foliage.		**Describe low volume sprayers.**
Soil Fumigation Equipment inject the liquid fumigant into the soil where it will volatilize. Extreme caution must be used when fumigating because highly toxic gases are released.		**Describe soil fumigation equipment.**
Granular Application Equipment is used to apply granular pesticides. The factors to consider in selection are: **- treatment area;** **- pesticide type and size;** **- type of drive and metering mechanism;** **- application type (broadcast or container).**		**Describe granular application equipment.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - APPLICATION EQUIPMENT SELECTION

General Objective: To know how to select the application equipment necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
A wide variety of hopper sizes are used depending on the treatment area and pesticide rate. The type of drive and metering mechanism will influence the application accuracy.		

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - METHODS FOR GREENHOUSE APPLICATION

General Objective: To understand methods of application necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Application methods specific to greenhouse operations can be divided into the following main types: **1) High volume applications;** **2) Low volume applications;** **3) Smoke fumigation;** **4) Granular applications;** **5) Dust applications;** **6) Soil drenches;** **7) Soil fumigation or pasteurization.**	**Know the application methods used in greenhouses.**	**List the methods of application.**
Pesticide application equipment is important to the pest management program in the greenhouse or mushroom growing facility. Proper selection of equipment, calibration, use and maintenance determine effectiveness, efficiency and safety of a pest control program. Types of sprayers vary from dilute high volume to concentrate low volume sprayers. No single sprayer type or application technique will provide adequate delivery systems in any one growing season in one production unit. Managers must consider the pest problem, growing environment, production schedules and economics when choosing application equipment. **A number of pesticide spray mixtures have a tendency to penetrate the materials used for hoses, packings, and gaskets. Therefore, if at all possible, DO NOT USE EQUIPMENT THAT CONTAINED A HERBICIDE TO APPLY INSECTICIDES OR FUNGICIDES.**	**Understand why the selection and use of different application equipment is so important to managing pests in the greenhouse.**	**Identify why the selection and use of different application equipment is so important to an effective IPM program.**
1) <u>High Volume Applications</u> **High volume applications in a greenhouse are usually made with conventional hydraulic sprayers.**	**Understand that high volume applications are usually made with conventional hydraulic sprayers.**	**List which equipment provides a high volume application.**
2) <u>Low Volume Applications</u>		

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - METHODS FOR GREENHOUSE APPLICATION

General Objective: To understand methods of application necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Low volume applications are generally made with: **A) Mist blowers (mechanical aerosol generators);** **B) Thermal foggers (thermal aerosol generators);** **C) Ultra low volume/dosage applicators;** **D) Electrostatic sprayers.**	**Know the equipment used for low volume applications.**	**List the equipment used for low volume applications.**
Low volume sprayers result in small droplet sizes. These fine spray droplets remain in the air much longer than the coarse spray droplets from high volume sprays. Although these droplets remain in the air much longer, low volume applications are usually made in the evening when only the applicator and an assistant are present. The greenhouse remains sealed during the night. Observe the required re-entry period outlined on the label. Ventilate the greenhouse for at least one hour after application. The presence of pesticide residues in the greenhouse will depend on the efficiency of ventilation. Ventilation should be used to replace the standing air in the greenhouse.	**Understand low volume applications and know the safe use of the equipment.**	**Describe low volume applications and the safe use of the equipment.**
A) Mist blowers convert special pesticide formulations (usually liquids and wettable powders) into very small fine droplets (50 to 100 microns)*. This "conversion" occurs when the pesticide is introduced into the path of an "air blast" generated by the mist blower. Although a single droplet cannot be seen, large numbers of droplets are visible as a "fog" or "mist". Air (not water) is the major pesticide carrier. Therefore the concentration of the pesticide spray mixture is high. Care is required to prevent over-application since the high concentration of the pesticide could cause injury to the crop. ***micron = 1/1000 mm**	**Understand mist blower application of pesticides.**	**Describe mist blower application of pesticides and the risk potential.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - METHODS FOR GREENHOUSE APPLICATION

General Objective: To understand methods of application necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Mist sprayers are very useful where thorough penetration of the crop foliage is necessary without unsightly residues remaining on the treated crop. Some greenhouse misters are automatic, therefore, the presence of an applicator is not required which increases the safety of application.		
B) Thermal foggers and mist blowers are often grouped under the same general heading. The primary difference between the two systems is that thermal foggers use heat to break up the pesticide into fine droplets, while mist blowers use spinning discs to break the pesticide into fine droplets. The "fog" produced is a relatively dry type of fog with particle or droplet size ranging from 0.10 to 50 microns. **Fogging solutions are usually formulated at a low concentration of pesticide in an oil based carrier. Oil based solutions are necessary because water based emulsions will not produce the dry fog needed. Thermal foggers produce a dense white cloud that remains visible for a length of time. This makes it possible to know whether or not all areas were treated equally since the operator has an indication of where the pesticide is actually moving and settling.** **Thermal foggers are available as handheld, back pack and automatic models. Follow the manufacturer's recommended use and cleaning procedures carefully.**	**Understand thermal foggers.**	**Describe thermal foggers and the risk potential.** **Identify the primary difference between thermal foggers and mist blowers.**
C) Ultra Low Volume (ULV) or Ultra Low Dosage (ULD) Applicators. Ultra low volume/dosage (ULV/D) applicators reduce the volume of pesticide mixture applied by reducing or eliminating the use of water or any other liquid carrier. Pesticides used are specifically formulated for ULV/D application. Droplets produced by ULV/D applicators remain in suspension for a considerable length of time (2 to 6 hours), therefore the pesticide does not settle out too quickly and sticks to the target insect or pest more effectively. Horizontal air flow (HAF) is necessary in the greenhouse to obtain good coverage.	**Understand the use of ULV/D application of pesticides in enclosed areas.**	**Describe ULV/D pesticide application in a greenhouse.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - METHODS FOR GREENHOUSE APPLICATION

General Objective: To understand methods of application necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
The use of ultra low volume/dosage applications instead of fog or mist applications may be desirable in certain instances. The advantages of ULV/D sprayers include: **- the ULV/D applicators can be placed in the greenhouse and controlled by a time clock to spray at a specific time. (This reduces the possibility of both employee and applicator exposure. Thorough ventilation of at least two hours is necessary prior to re-entry. Check the label for the recommended re-entry period);** **- labour and time saved due to the elimination of water;** **- equal control with possibly less pesticide;** **- deeper insecticide penetration into nook and cracks, therefore providing more thorough control of crawling insects.**	**Know the advantages of using ULV/D applications.**	**List and describe the advantages of using ULV/D applications.**
At present only a limited number of pesticides are registered for ULV/D use. Exposure information involving the use of ULV/D applicators is uncertain. Handling and spraying the concentrated pesticide increases the risk to the applicator. Wear the proper protective clothing and equipment.	**Understand the risks of using ULV/D applicators.**	**Identify the risks of using ULV/D applicators.**
D) Electrostatic sprayers are low volume applicators, which use air to atomize or form the spray droplets and propel them towards the target similar to mist blowers. The charged droplets (+) are attracted to plants (both upper and lower leaf surfaces). Nozzles must be directed at the target for optimum coverage. Leaf movement improves coverage. Droplet size is approximately 30 microns requiring 40 to 120 L/ha spray solution with improved on-target deposition **over other methods. No special pesticide formulations are necessary. However, only a few pesticides are currently registered for this method of application.**	**Understand electrostatic sprayers.**	**Describe the use of electrostatic sprayers in the greenhouse.**

3) Smoke Fumigation

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - METHODS FOR GREENHOUSE APPLICATION

General Objective: To understand methods of application necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Some pesticides are able to withstand intense heat without adverse affects. This property may be used to create combustible formulations that will ignite to form a pesticide smoke, which will penetrate throughout the greenhouse. Particle size is usually less than 10 microns, sometimes even smaller than 0.1 microns. **The use of smoke fumigators requires no special application equipment. The pesticide is contained in a small can, which treats an area of 300 m^3 or 10 000 ft^3. These cans are punctured and ignited and left to burn within the sealed greenhouse.** **Remember to wear gloves, a respirator and coveralls to avoid inhalation of smoke and dermal exposure. It is just as important to wear protective clothing when igniting cans as it is when venting the greenhouse.** **Smoke fumigation in a greenhouse should not be done if the greenhouse temperature is less than 16° C or greater than 33° C. These conditions will limit the effectiveness of the smoke application. Always read the label when using smoke fumigators.**	**Understand smoke fumigators.**	**List the rusks and necessary safety procedures for smoke bomb use.**
Procedure for Smoke Fumigation **1) Read the label to learn if there are any plants that may be injured by the product applied.** **2) Determine the total number of smoke fumigants required. This is done by calculating the total greenhouse volume to be treated and dividing by the volume that one container will treat.** **4) Granular Application**	**Know the procedure for smoke fumigation.**	**Describe the procedure for smoke fumigation.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - METHODS FOR GREENHOUSE APPLICATION

General Objective: To understand methods of application necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Granular pesticide formulations are applied by specific applicators available for either band application, broadcast application or soil injection/incorporation. Spreaders work in several different ways to deliver the pesticide including air-blast; whirling disks; multiple feed outlets; or soil injectors.	**Understand how granular pesticides can be applied.**	**Describe granular application equipment.**
All granular application equipment is designed to apply pesticides without further mixing. Use an applicator that is easy to clean and fill and one that is equipped with mechanical agitation over the outlet holes. This will prevent clogging and helps keep the flow rate constant. Granular applicators are speed sensitive. Therefore, maintaining a constant speed will help obtain uniform distribution of the pesticide.		
The application of granular pesticides requires the use of some specific safety procedures. Stay out of any dust created by the action of the application equipment. Read the label of each pesticide to be aware of any special precautions.	**Know the specific safety precautions.**	**Describe the specific safety precautions.**
5) Dust Applications		
Dusters are used to blow fine particles of pesticide dust onto target surfaces without mixing. The use of dust formulations in a greenhouse is limited because of the visible residue that remains on the plants. Dusts also drift easily and are difficult to control. Dusters range from simple devices to elaborate motorized structures. Mist blower attachments are available for simple conversion to a power duster.	**Understand dust applications.**	**Describe dust applications.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - METHODS FOR GREENHOUSE APPLICATION

General Objective: To understand methods of application necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
All dusters should be emptied frequently and cleaned thoroughly. Moisture in the air will cause dust formulation to harden inside the application equipment if it is not properly cleaned.	**Understand the necessity for thorough cleaning of the equipment.**	**Identify the need to thoroughly clean the equipment.**
Avoid drafts when using pesticide dusts since carry-over to untargeted plants may occur.		
6) Drenches to Soil or Growing Media		
Drenching or flooding involves the use of water as a sealant. The pesticide is applied with water as a carrier. Although drenching does not replace a thorough pasteurization program in the greenhouse, it is useful in preventing recontamination and may also be used as an eradicant to eliminate pathogens in the soil or growing media or basal parts of the plant. Systemic drenches effectively treat the whole plant. As a general rule, apply 12 L of drench per m^2 of bench area or 300 mL of drench per 15 cm pot. Always follow the manufacturer's directions carefully.	**Know what drench applications are.**	**Describe drench applications.**
Types of Soil Fumigation		
Soil fumigation is used to kill weeds, weed seeds, insects and disease-causing organisms, including nematodes, which live in the soil. There are three types of soil fumigation namely:	**Understand where soil fumigation can be used in pest control programs.**	**List where soil fumigation can be used in pest control programs.**
- tractor mounted injectors; - soil incorporation; - fumigation under sheets.	**Know the three types of soil fumigation.**	**List the three types of soil fumigation.**
The most common type used in greenhouse crop production is fumigation under sheets.	**Know the most common type of soil fumigation.**	**Identify the most common type of soil fumigation.**
Fumigation Under Sheets		
Sheets capable of retaining fumigant vapours may be used to cover the soil while the fumigation process is taking place.	**Know how to fumigate soil under sheets.**	**List the major steps sheet fumigation.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - METHODS FOR GREENHOUSE APPLICATION

General Objective: To understand methods of application necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Sheets made of polyethylene or polyvinyl chloride are generally used. Sheets should be at least 0.1 mm (4 mil) in thickness.		
If possible, use one large sheet instead of several small ones. Allow at least 1/2 metre of extra sheeting along the edge to allow for sealing.		
If sheets have to be joined, allow at least 1 metre of overlap, which can then be rolled to form a satisfactory joint.		
Once the release of the fumigant has been completed, the covering sheets should be checked for leakage along all joints and at the edges.		
In those cases where the use of volatile fumigants require sheet sealing of the treatment area, care must be taken when aerating the treated area. Always wear a full face canister respirator when aerating a site.	**Know the precautions to take when aerating the treated area.**	**Describe the precautions to take when aerating the treated area.**
Start by lifting the corner of the sheet to allow for gradual release of the fumigant. After 30 minutes the entire sheet can be removed. No one should work in the treated area until virtually all fumigant is gone.		

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - METHODS FOR GREENHOUSE APPLICATION

General Objective: To understand methods of application necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Factors Affecting Performance		
The basic principle is to apply a fumigant to the soil and to allow it to diffuse through the soil. Several factors influence movement of fumigants within the soil. These include: **- soil moisture;** **- soil compaction;** **- soil temperature;** **- organic matter.**	**Know the factors which influence movement of fumigants within the soil.**	**List the factors that influence movement of fumigants within the soil.**
Soil Moisture		
If the soil is too wet, there is not enough air space within the soil to allow the gas to move about freely. If the soil is too dry, there will be too little moisture around the soil particles to absorb the fumigant. Also, the fumigant will readily escape through the soil and into the air above the soil.	**Understand the relationship between soil moisture and fumigation effectiveness.**	**Describe the relationship between soil moisture and fumigation effectiveness.**
Soil should be moist enough that a handful of soil, when squeezed, just retains its shape but should crumble when touched. Moisture may have to be added to drier or sandy soils.	**Know how to determine if the soil has sufficient moisture.**	**Describe how to determine if the soil has sufficient moisture.**
Soil Compaction		
Heavy or compacted soils are not suitable for fumigation. The fumigant cannot diffuse through the soil.	**Know why soil compaction or very loose soil reduces fumigation effectiveness.**	**Describe why soil compaction or very loose soil reduces fumigation effectiveness.**
The fumigant escapes too quickly from light or sandy soils to allow sufficient residence time for the effect to occur.		
Soil temperature at a depth of 15 to 20 cm should be in the range of 10 to 20EC.		

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - METHODS FOR GREENHOUSE APPLICATION

General Objective: To understand methods of application necessary for proper pesticide application in the greenhouse.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Soil Temperature		
When soil temperatures are below 4EC (at a depth of 15-20 cm) the fumigant converts slowly to a gas. Diffusion also occurs at a very slow rate. At temperatures approaching 25EC and beyond, the fumigant is converted rapidly to a gas and leaves the soil quickly. Residence time for the gas is insufficient to achieve effective pest control.	**Understand how soil temperatures affect fumigation.**	**Describe how soil temperatures affect fumigation.**
Organic Matter		
Organic matter can bind the fumigant and prevent it from diffusing through the soil. Where organic material or crop residues are high, additional fumigant may be required to achieve effective pest control.	**Understand how organic matter reduces the effectiveness of the fumigant.**	**Describe organic matter reduces the effectiveness of the fumigant.**
Maintenance of Soil Fumigation Equipment		
Equipment should be thoroughly washed with water. Be sure to flush all parts of the system. **Once the system has been flushed with water, a final cleaning may be necessary. Check product label for specific instructions.** **Be sure to wear a proper respirator when cleaning the application equipment because fumigant residue may still exist.**	**Know the procedures for cleaning fumigation equipment.**	**Describe the procedures for cleaning fumigation equipment.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - COMPONENTS OF A SPRAYER

General Objective: To understand the basic components of a sprayer.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Parts of a Sprayer		
The parts of a sprayer include: **- tanks;** **- pumps;** **- agitators;** **- filters/strainers;** **- pressure gauges;** **- pipes and hoses;** **- pressure regulator valves;** **- structural framework;** **- clean water tank;** **- nozzles.**	**Know the various parts of a sprayer.**	**List the main parts of a sprayer.**
Tanks		
Tanks hold the spray mix and are available in a variety of shapes, sizes and materials. A tank should be: **- resistant to corrosion;** **- strong;** **- shaped to aid agitation;** **- easy to fill (large screened opening);** **- easy to clean (large drain plug);** **- clearly marked for mixing;** **- equipped with baffles to prevent sloshing.** **The most common shape of tanks are oval and cylindrical. Rectangular tanks and flat bottomed tanks are more difficult to agitate and clean.**	**Know the purpose and desirable features of a spray tank.**	**List desirable features of a spray tank.**
Pumps		

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - COMPONENTS OF A SPRAYER

General Objective: To understand the basic components of a sprayer.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Pumps should be able to supply the volume spray mix from the tank to the nozzles and hydraulic agitator at the desired pressure. Choose a pump suitable for the: **- required output and operating pressure;** **- pesticide properties;** **- carrier properties;** **- power supply.** **The size of the pump depends on the:** **- number of nozzles;** **- largest nozzle size;** **- type of agitation;** **- type of bypass filtration;** **- size of the spray tank.** **The pump should be 20% greater than the capacity needed. This will maintain proper pressure and flow as the pump wears, if nozzle size increases, and if the number of nozzles on the boom increases.**	**Know how to select the correct type and size of pump.**	**List the factors to consider when selecting a pump.**
Agitators		
Agitation mixes the formulated pesticide and carrier together and prevents the suspended pesticides from settling out. The amount of agitation depends on the type of formulation used. Adequate agitation is important both under and over agitation can reduce pesticide performance.	**Know why agitation is required.**	**Identify why agitation is required.**
Two types of agitation systems are commonly used: **- mechanical;** **- hydraulic.** **Mechanical agitation uses paddles to stir the contents of the tank. Hydraulic agitation uses a portion of the pump output to keep the tank contents mixed. Surplus spray mix flows through jet agitators located at the bottom of the tank.**	**Know the types of agitation systems.**	**List and describe the types of agitation systems.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - COMPONENTS OF A SPRAYER

General Objective: To understand the basic components of a sprayer.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Filters and Strainers		
Filters prevent any foreign particles and undissolved pesticides in the spray mix from damaging the pump or plugging the nozzles.	**Know why filtration is required.**	**Identify why filtration is required.**
There are three types of filters: **Tank Screens - at the filler opening (12-25 mesh).** **Suction Line Filters - end of the suction line and top of the tank and end of the suction line and bottom of the tank (15-100 mesh).** **Pressure Line Filters - "in-line" filters and nozzle screens (50-100 mesh).**	**Know the types of filters.**	**List and describe the types of filters.**
Filter mesh size should be scaled from the coarsest at the tank opening, to the finest at the nozzle. Follow nozzle manufacturer's recommendations.	**Know how to select the correct filter.**	**Identify where information on filters can be found.**
Controls		
Two common control systems are: **- pressure control systems;** **- volume control systems.**	**Know the common control systems that can be on a sprayer.**	**List and describe the control systems.**
Pressure control systems use a pressure regulating valve to maintain a constant operating pressure. Volume control systems (volumetric) allow the operating pressure/nozzle flow rate to vary according to forward speed/engine RPM.		
Control systems can be manually or electronically operated. Items such as spray monitors and controllers may improve the application of pesticides by supplying the operator with more information.		
Pipes and Hoses		

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - COMPONENTS OF A SPRAYER

General Objective: To understand the basic components of a sprayer.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Hoses should be at least as large as the pump intake opening. Under-sized hoses and fittings can severely reduce the capacity of any pump. Flow restrictions create a drop in pressure, resulting in a non-uniform nozzle flow rate. Hoses and fittings on the pressure side of the pump must be able to handle the maximum pressure the pump can develop to withstand pressure surges. **Common sources of flow restrictions are:** **- under-sized boom plumbing;** **- under-sized controls or fittings;** **- kinked hoses;** **- under-sized or clogged filters.**	**Understand how pipes and hoses affect the pressure.**	**List common problems of pipes and hoses that affect the pressure.**
Pressure Gauges		
The pressure gauge measures the operating pressure. A pressure gauge is used to initially set the sprayer at the desired pressure and can be observed for changes in pressure as an indicator of problems. The best place to measure pressure is at the boom.	**Know why a pressure gauge is used.**	**Identify why a pressure gauge is used.** **Describe pressure gauges.**
Gauges are available as either liquid filled or dry. A liquid filled gauge dampens pressure pulsations resulting in a steadier reading. Pulsation dampers are available for dry gauges. **The maximum pressure indicated on the gauge should be approximately twice the intended operating pressure. Gauges should sense the pressure as near to the nozzles as possible.**	**Understand pressure gauges.**	**Describe pressure gauges.**
Clean Water Tanks		
All sprayers should be equipped with a clean water tank. They provide a source of clean water for emergencies and to perform routine tasks such as nozzle and hand cleaning.	**Know that a clean water source should be nearby application equipment.**	**Identify the importance of a clean water source nearby the application equipment.**
Nozzles		

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - COMPONENTS OF A SPRAYER

General Objective: To understand the basic components of a sprayer.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Nozzles: **- maintain sprayer output;** **- break the liquid into droplets;** **- spread the droplets in a specific pattern.**	**Understand what a nozzle does.**	**List what a nozzle does.**
Nozzle Parts		
Most nozzles are composed of four parts: **- nozzle body;** **- strainer (screen);** **- tip;** **- cap.**	**Know the parts of a nozzle.**	**List and describe the parts of a nozzle.**
The nozzle body holds the strainer and tip in proper position. The cap is used to secure the strainer and the tip to the body. The nozzle screen or strainer is placed in the nozzle body to filter out debris, which may clog the nozzle opening. The nozzle tip affects the spray pattern.		
Nozzles are available in a wide range of types, sizes and materials. Before buying or using nozzle tips, consider nozzle flow rate, nozzle spray patterns, nozzle pressure, nozzle-to-target distance, spray droplet size and nozzle wear.	**Know the factors to consider when choosing a nozzle.**	**List the factors to consider when choosing a nozzle.**
Nozzle Spray Pattern		
Nozzles are typed according to the shape of the spray pattern. Each nozzle type is available in various nozzle flow rates (L/min) and spray angles. Pesticide labels may recommend specific types and sizes of nozzles.	**Know the nozzles are named (typed) according to the spray pattern.**	**State how nozzles are typed.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - COMPONENTS OF A SPRAYER

General Objective: To understand the basic components of a sprayer.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
The nozzle spray angle is the measurement (in degrees) of the spray angle formed by a single nozzle at a specific pressure. The spray angle will vary with pressure. The most common spray angles in use in greenhouses are 80° and 110°. Other spray angles available range from 65° to 150°.	Know the definition of nozzle spray angle.	Define nozzle spray angle.
The two most common nozzle types are the: - flat fan nozzle (tapered edge or even); - hollow cone nozzle.	Know the most common nozzle types.	List the most common nozzle types.
Tapered edge flat fan nozzles produce an oval pattern with tapered edges. They are used for broadcast spraying at low pressures (between 100 and 400 kPa). These nozzles are intended to be used so that the pattern can overlap 30% to 100% (i.e., one nozzle spray angle overlaps the next nozzle spray angle). Offset the nozzles slightly (10°) from the adjacent nozzle to prevent spray interference.	Know about tapered edge flat fan nozzles.	Describe tapered edge flat fan nozzles and how they are used.
Even flat fan nozzles are available for banding applications and LP flat fan nozzles are available for low pressure applications.	Know that other types of flat fan nozzles are available.	List other types of flat fan nozzles.
Hollow cone nozzles are used when coverage of the plant foliage is required because they produce a fine spray. These nozzles are best suited for use as a directed spray where a uniform application is not priority. They can be operated at a wide range of nozzle pressures (200 to 2000 kPa).	Know when hollow cone nozzles are used.	Describe when hollow cone nozzles are used.

Nozzle Pressure

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - COMPONENTS OF A SPRAYER

General Objective: To understand the basic components of a sprayer.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Pressures ranging from 140 kPa (20 psi) to 350 kPa (50 psi) will produce good sized droplets. Herbicides are usually applied between 150 to 275 kPa (20 to 40 psi) to keep drift at a minimum. Insecticides and fungicides are applied at higher pressures, usually between 300 to 2,000 kPa, (40 to 300 psi) to get thorough coverage in dense foliage. Different nozzle arrangements require different pressures.	**Know the pressure ranges which are used.**	**List the common nozzle pressures used and identify when each is used.**
Spray Droplet Size		
A nozzle produces a range of droplet sizes from very small to large. The number of fine droplets increases as the spray pressure is increased or as the size of the nozzle orifice is decreased.	**Know that droplet sizes vary considerably and that droplet size is affected by pressure and size of the nozzle orifice.**	**Identify what increases the number of fine spray droplets.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - CALIBRATION OF A SPRAYER

General Objective: To understand the calibration procedure to ensure that the correct amount of pesticide will be applied.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
The three objectives when calibrating a boom sprayer are: **- to ensure that the spray mixture will be applied uniformly;** **- to determine the sprayer output and adjust it to meet label requirements;** **- to allow correct determination of the amount of formulated pesticide to add to the spray tank.**	**Know the objectives of sprayer calibration.**	**List the objectives of sprayer calibration.**
Select a calibration procedure that meets these objectives.		
Sprayers should be calibrated: **- when the sprayer is new;** **- at the start of each season;** **- when travel speed, nozzle spacing, or nozzles are changed;** **- when the sprayer output changes;** **- when the sprayer is modified.**	**Know when sprayers should be calibrated.**	**Describe when sprayers should be calibrated.**
Application Uniformity		
Application uniformity affects pesticide performance. Non-uniform application will result in areas of over and/or under application, reducing the pesticide's effectiveness.	**Understand the importance of uniformity in application.**	**Identify the effects of non-uniform application.**
Non-uniform application can occur from either: **- variations on boom, or;** **- localized variations within the total application area.**	**Understand how non-uniformity can occur.**	**List possible causes of non-uniformity.**
Variations on the boom are caused by: **- variations in nozzle flow rates caused by mismatched nozzles;** **- variations in nozzle spacing;** **- incorrect boom position.**		
Variations over the total application area can be caused by: **- variations in sprayer output caused by fluctuating travel speed or pressure;** **- excessive boom movement.**		
Sprayer Output		

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - CALIBRATION OF A SPRAYER

General Objective: To understand the calibration procedure to ensure that the correct amount of pesticide will be applied.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Sprayer output refers to the spray mixture (pesticide and carrier) that is applied to a unit area (i.e., hectare, acre or meter of row). Knowing the sprayer output allows the applicator to calculate the correct amount of pesticide to add to the tank.	Know what sprayer output refers to and why it is important.	Define sprayer output and identify why it is important.
Sprayer output for a boom sprayer can be calculated by measuring the following three factors: - the nozzle spacing; - the travel speed; - the nozzle flow rate.	Know the factors that determine sprayer output.	Identify the factors that determine sprayer output.
Sprayer output = Nozzle flow rate x constant ÷ travel speed ÷ nozzle spacing. L/ha = L/min x 60000 ÷ km/h ÷ cm. L/acre = L/min x 5940 ÷ mph ÷ inches. GPA = gpm x 5940 ÷ mph ÷ inches.	Know how to calculate sprayer output.	Describe how to calculate sprayer output.
Conversion factors can be used to convert any metric unit or measurement into either Imperial or American units.		
The constant in the formula is a conversion factor to account for different units of measurement.	Understand what the constant in the formula refers to.	Describe the purpose of the constant in the formula.
Sprayer output can also be determined by measuring the volume of spray mixture that was applied to a known area. The limiting factor of this approach is that it does not assess the uniformity of the nozzles.	Know the limitations of assessing sprayer output by measuring the volume of spray applied to a known area.	Identify the limitations of assessing sprayer output by measuring the volume of spray applied to a known area.
Factor #1. - Nozzle Spacing		
Nozzle spacing is the difference between nozzles on a boom. For single nozzle units or for hand spraying it is the actual width sprayed.	Know what nozzle spacing refers to for different types of sprayers.	Describe what nozzle spacing refers to for different types of sprayers.
The closer the nozzles are together on a boom, the greater the sprayer output (everything else also being equal).	Understand how nozzle spacing affects sprayer output.	Identify how nozzle spacing affects sprayer output.

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - CALIBRATION OF A SPRAYER

General Objective: To understand the calibration procedure to ensure that the correct amount of pesticide will be applied.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Spacing of nozzles depends on: **- nozzle type and spray angle;** **- type of crop;** **- boom position.**	**Know what nozzle spacing depends on.**	**List the factors to consider for nozzle spacing.**
The nozzle spacing on a boom generally is not adjusted to change the sprayer output. Nozzle spacing on a boom must be equal to ensure application uniformity.	**Know the importance of a consistent spacing across the boom.**	**Identify the importance of a consistent spacing across the boom.**
Factor #2. - Travel Speed		
The travel speed of the sprayer affects the sprayer output. For a given nozzle flow rate, increasing travel speed will decrease the sprayer output.	**Know the importance of determining the speed of the sprayer.**	**Explain the importance of measuring the speed of a sprayer.**
If walking, walk at a steady pace. Walking speed will vary with different operators.	**Know the procedure for determining the speed of a sprayer.**	**Describe the procedure for measuring the speed of a sprayer.**
Measure travel speed: **- in the greenhouse area to be sprayed;** **- with the sprayer approximately half full of water;** **- repeat in both directions, then average the results.**		
Calculate travel speed by using the following equation: **Travel Speed = Test distance ÷ Time x Constant.** **km/h = metres ÷ seconds x 3.6 mph = feet ÷ seconds x 0.68.**		
Factor #3. - Nozzle Flow Rate		

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - CALIBRATION OF A SPRAYER

General Objective: To understand the calibration procedure to ensure that the correct amount of pesticide will be applied.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Nozzle flow rate is the volume of spray mixture a nozzle delivers in a specific period of time. Nozzle flow rate is usually rated in litres per minute (L/min) or gallons per minute (gpm).	**Know what nozzle flow rate refers to.**	**Define nozzle flow rate.**
Nozzle flow rate depends on the nozzle size and operating pressure. Increasing nozzle size and/or operating pressure, increases the nozzle flow rate. It takes a large increase in pressure to get a small increase in nozzle flow rate.	**Understand the factors affecting nozzle flow rate.**	**List the factors affecting nozzle flow rate.**
Manufacturer catalogues provide nozzle flow rate in either metric or American units. Nozzle catalogues do not commonly use Imperial units. Manufacturers usually list nozzle flow rate over the range of acceptable operating pressures.	**Know where to obtain information on nozzle flow rate.**	**Identify where to obtain information on nozzle flow rate.**
Adjusting Sprayer Output		
Adjustments to the sprayer, which change any of the three factors, will change the sprayer output. Small adjustments of sprayer output can be made by fine tuning the pressure or travel speed. Large changes of the sprayer output or excessive nozzle wear may require selecting new nozzles.	**Know how to adjust sprayer output.**	**Describe how to adjust sprayer output.**
Nozzle Wear and Replacement		
The rate of nozzle wear depends on: **- nozzle material;** **- pesticide formulation;** **- operating pressure;** **- nozzle size;** **- the amount of use (time).** **In general, the harder the nozzle material the longer the nozzle will last but the higher the cost. Brass is one of the softest nozzle materials and ceramic is one of the hardest. Other materials such as stainless steel and plastics fall between these two.**	**Know the factors that affect nozzle wear rates.**	**List and describe the factors that affect nozzle wear rates.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - CALIBRATION OF A SPRAYER

General Objective: To understand the calibration procedure to ensure that the correct amount of pesticide will be applied.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Nozzle wear increases with more abrasive formulations, higher operating pressures, smaller nozzle size, and longer use.		
Replace nozzles when they are worn out. The nozzle flow rate and spray pattern changes reducing application uniformity. Compare worn nozzle flow rate to a new nozzle to determine the amount of wear.	**Understand why nozzles must be replaced.**	**Identify why nozzles must be replaced.**
Check nozzle wear by: **1) Measuring the nozzle flow rate (water only) for each nozzle at a constant operating pressure.** **2) Calculating the average output for the set of nozzles. Replace nozzles whose output varies by more than five percent from the average output. Properly maintained nozzles should wear evenly, allowing for replacement of the entire set.** **3) Replacing nozzles whose output is more than 15 percent higher than the manufacturers specified output. Nozzles with streaky or skewed spray patterns should be replaced even if they are not worn.**	**Know how to assess the maximum variation allowed in flow rates for a set of nozzles.**	**Describe how to assess the variation in flow rates for a set of nozzles.**

Selecting New Nozzles

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - CALIBRATION OF A SPRAYER

General Objective: To understand the calibration procedure to ensure that the correct amount of pesticide will be applied.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
New nozzles should be selected when: **- the existing nozzles are worn out;** **- large adjustments in sprayer output must be made;** **- a new piece of application equipment is purchased;** **- a different type of nozzle is required;** **- the spray quality (droplet size) must be changed.**	**Know when to replace nozzles.**	**Identify when to replace nozzles.**
The required output on the new nozzles can be determined if the recommended sprayer output, travel speed and nozzle spacing are known. **Nozzle flow rate = sprayer output x travel speed x nozzle spacing ÷ constant.**	**Know how to determine nozzle flow rate.**	**Describe how to determine nozzle flow rate.**
Select new nozzles from manufacturers' catalogues based on the nozzle flow rate and acceptable operating pressures.	**Know how to select new nozzles.**	**Describe how to select new nozzles.**
Calibrating a Backpack/Hand Held Sprayer **A backpack or hand held sprayer is used to treat small areas. Calibrating checks the sprayer output and spray pattern.** **1. Measure out an area that is 100 m^2.** **2. Fill the spray tank with water. Mark the level on a measuring stick. Pump to the pressure that will be used during the pesticide application.** **3. Spray the water over the 100 m^2 area. Walk at a steady pace as if applying the pesticide.** **4. Measure the amount of water needed to refill the spray tank to the mark on the measuring stick. This amount is the sprayer output per 100 m^2.**	**Know how to calibrate a backpack sprayer.**	**Describe how to calibrate a backpack sprayer.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - CALCULATIONS

General Objective: To understand the calculations necessary to ensure that the correct amount of pesticide will be applied.

COURSE OUTLINE

Pesticide use calculations determine the size of the treatment area, total amount of pesticide required, and the amount of pesticide required for each tank. These calculations are based on the pesticide rate the applicator selects from the label.

Before making a pesticide application, perform the following calculations:

1. Know the size of the treatment area. For a rectangular of square shape:

Treatment Area = length x width.
Hectares = Length(m) x Width(m) ÷ 10000 m^2/ha.
Acres = Length(ft) x Width(ft) ÷ 43560 ft^2/acre.

2. Total pesticide required = treatment area x pesticide rate.

Litres = square metres x litres/100 m^2.
Litres = Hectares x Litres/hectare.
Kg = Hectares x Kg/hectare.
Litres = Acres x Litres/acre.
Kg = Acres x Kg/acre.

3. Area covered per tank = tank size ÷ sprayer output.

Hectares/tank = litres ÷ litres/hectare.
Acres/tank = litres ÷ litres/acre.
Acres/tank = gallons ÷ gallons/acre.

4a. When pesticide rate is expressed as a rate per area.
Pesticide per tank = pesticide rate x area covered per tank.

Litres = Litres/100 m^2 x 100 m^2/tank.
Litres = Litres/hectare x hectares/tank.
Kg = Kg/hectare x hectares/tank.
Litres = Litres/acre x acres/tank.
Kg = Kg/acre x acres/tank.

INSTRUCTIONAL OBJECTIVES

Know how to determine the size of the treatment area, total pesticide required, area covered per tank, amount of pesticide required per tank, total number of tanks, volume of spray mixture required for the final tank, pesticide required for the final tank.

LEARNING OUTCOMES

Describe how to calculate the following: size of the treatment area, total pesticide required, area covered per tank, amount of pesticide required per tank, total number of tanks, volume of spray mixture required for the final tank, pesticide required for the final tank.

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - CALCULATIONS

General Objective: To understand the calculations necessary to ensure that the correct amount of pesticide will be applied.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES

4b. When the pesticide rate is expressed as a dilution factor.
Pesticide per tank = amount of water x dilution factor.

Litres = Litres of water x Litres of pesticide/Litres of water.

4c. When the pesticide rate is expressed as a rate per volume:

number of smoke bombs or mL or grams required = volume to treat (m^3) x rate ($mL/100m^3$).

5. Total tanks = treatment area ÷ area covered per tank.

Tanks = hectares ÷ hectares/tank.
Tanks = acres ÷ acres/tank.

6. Area left to be sprayed = total area - area already sprayed.

Hectares = total hectares - hectares sprayed.
Acres = total acres - acres sprayed.

7. Volume of spray mixture for partial tank = treatment area left to be sprayed x sprayer output.

Litres = hectares x litres/hectare.
Litres = acres x acres/hectare.
Gallons = acres x gallons/acre.

8. Pesticide for partial tank = treatment area left x pesticide rate.

Litres = Hectares x Litres/hectare.
Kg = Hectares x Kg/hectare.
Litres = Acres x Litres/acre.
Kg = Acres x Kg/acre.

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - CALCULATIONS

General Objective: To understand the calculations necessary to ensure that the correct amount of pesticide will be applied.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Area (Ground Beds, Benches) Calculations		
For potted plants or for greenhouse beds, the 1,000 litre solution should cover approximately 5,000 square metre of total greenhouse area. Check that the proper amount of pesticide solution is being delivered to the treatment area. **Area(m^2) = length (m) x width (m)** **hectares = $\frac{\text{length (m) x width (m)}}{10\ 000\ m^2}$**	**Know the amount of drench solution that is usually applied per potted plant or per greenhouse beds.**	**Describe the amount of drench solution that is usually applied per potted plant or per greenhouse beds.**
Volume Calculations		
To establish the amount of fumigant needed, the cubic volume (i.e., m^3) of the greenhouse structure must be determined. Usually one, two or more volume calculations are necessary because of the various shapes and parts of many greenhouse structures. The cubic volume of the individual parts are added together to establish total cubic volume. **Total Volume (m^3) = base volume (rectangular area from floor to roofline) + roof volume.**	**Know how to do volume calculations for greenhouse structures.**	**Describe how to calculate volumes of greenhouse structures.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - CALCULATIONS

General Objective: To understand the calculations necessary to ensure that the correct amount of pesticide will be applied.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES

Even or Uneven Roof Area

$$\text{Volume } (m^3) = \frac{\text{length x width x height}}{2}$$

Ridges of Quonset Roof Area

$$\text{Volume } (m^3) = \frac{\text{length x } \pi \text{ x height (radius)}^2}{2}$$

$$\pi = \frac{22}{7}$$

Rectangular Bases

Volume(m^3) = length x width x height

For Total Volume: Add volume of roof area to volume of lower rectangular area.

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - ENVIRONMENTAL CONSIDERATIONS

General Objective: To understand the influence of environmental conditions on the pesticide and the application equipment.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Water Quality		
Temperature, sediment, pH, and presence of salt in the water that is mixed with pesticides may affect pesticide performance.	**Understand how water quality may affect the performance of the pesticide and the application equipment.**	**Describe how water could adversely affect the performance of the pesticide and the application equipment.**
The pH of a spray solution can have a significant effect on the performance of some pesticides. Alkaline water can reduce the effectiveness of some pesticides. The rate at which breakdown occurs depends on: **- the pH of the water;** **- the amount of pesticide added to a fixed amount of water;** **- the water temperature;** **- the length of time the solution is left in the spray tank.**		
Silt and organic matter in the water can cause: **- premature pump wear;** **- plugging of screens;** **- decreased effectiveness.**		
If you suspect there is a problem with water quality you should: **- have the water tested;** **- seek another source of water;** **- obtain advice on pesticide application.**		
Refer to the pesticide label or to provincial publications for specific recommendations.	**Know where to find specific recommendations for water quality.**	**Identify where to find specific recommendations for water quality.**

Category: GREENHOUSE

Concept: APPLICATION TECHNOLOGY - MAINTENANCE

General Objective: To understand the basic procedure in maintaining sprayers.

COURSE OUTLINE	INSTRUCTIONAL OBJECTIVES	LEARNING OUTCOMES
Proper maintenance of the application equipment minimizes the chance of a breakdown and increases the service life.	**Understand the importance and procedure for a proper maintenance program for application equipment.**	**Identify the importance of properly maintaining application equipment.**
Rinse the equipment thoroughly at the end of each spraying day, by flushing clean water through the pump, hoses, and nozzles. Check all screens, filters and nozzles and clean them if necessary. Assess the sprayer for wear and replace worn or damaged parts. Critical parts to check include agitator, regulator and pressure gauge for accurate operation, couplings and clamps for seal, and hose flex points for wear. Wash the sprayer and dispose of rinsate only where residues will not cause any adverse environmental harm. Follow directions on the label and provincial regulations.		**Describe how to maintain application equipment.**