Unit VI: Plant Health

Lesson 1: Greenhouse Pests and Diseases

The very features that nourish greenhouse crops - warmth, moisture, humidity, and controlled lighting - also encourage destructive pests and support diseases. This unit examines various issues concerning plant health. Lesson 1 identifies greenhouse pests, describes their effects on plants, outlines causes of diseases, and gives examples of infections that attack plants.

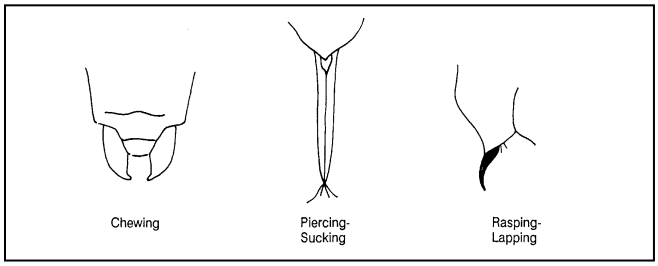
Descriptions of Pests

A greenhouse pest is any life-form that causes injury or loss to plants. The major pests are insects, arachnids (eight-legged invertebrates, e.g., mites, spiders, millipedes, and centipedes), nematodes, rodents, mollusks, weeds, and disease-causing organisms. Of those listed, insects and mites pose the greatest threat to greenhouse crops. These pests gain access to cultivated crops through open doors, when new produce arrives, and through ventilation ducts.

Effects of Insects and Mites

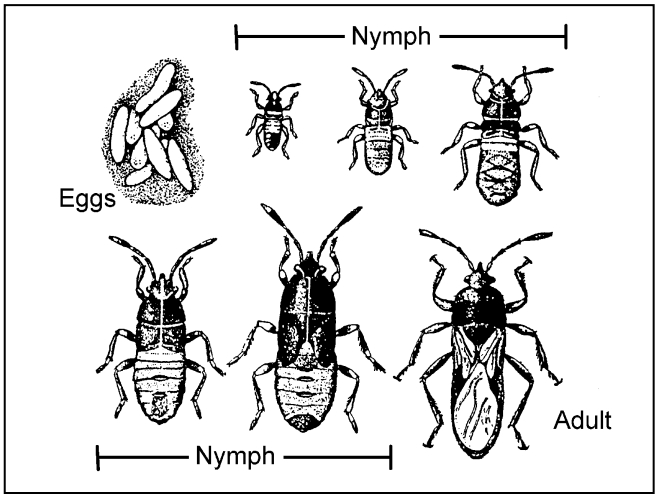
By attacking the plant's vascular system, leaves, and roots, insects and mites interfere with vegetative functions and reduce the rate of development. A defining characteristic of these pests is how they feed on plants, which is determined by the shape and movement of their mouth parts, as shown in Figure 6.1. Chewing insects like grasshoppers devour leaves and roots and destroy the plant's tissues. Piercing-sucking and rasping-lapping pests puncture the plant and then suck out life-sustaining sugary sap from the phloem cells. Vector pests introduce diseases.

Figure 6.1 - Types of Mouth Parts



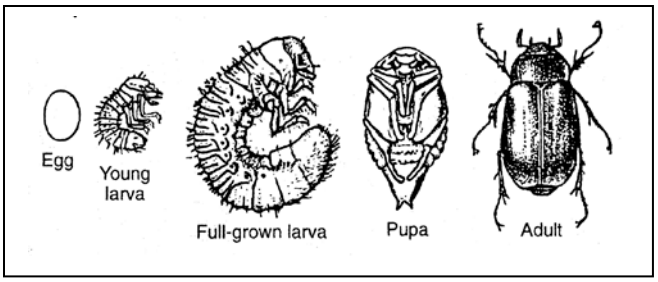
Identifying the specific stage of the pests' life cycle helps determine when to apply the appropriate treatment. Some pests invade crops as adults; others are destructive as larvae or nymphs. This growth process, known as metamorphosis, can be gradual or complete. During gradual metamorphosis, the pest undergoes three phases: egg, nymph, and adult. The insect molts several times during the nymph stage until it reaches adulthood, as illustrated in Figure 6.2.

Figure 6.2 - Gradual Metamorphosis



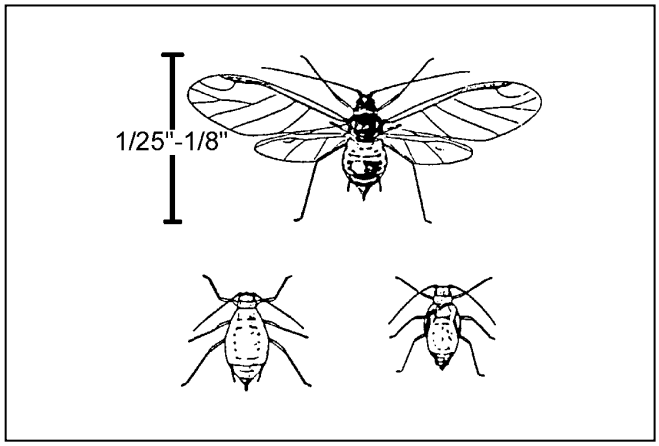
Egg, larva, pupa, and adult are the four stages of complete metamorphosis (see Figure 6.3).

Figure 6.3 - Complete Metamorphosis



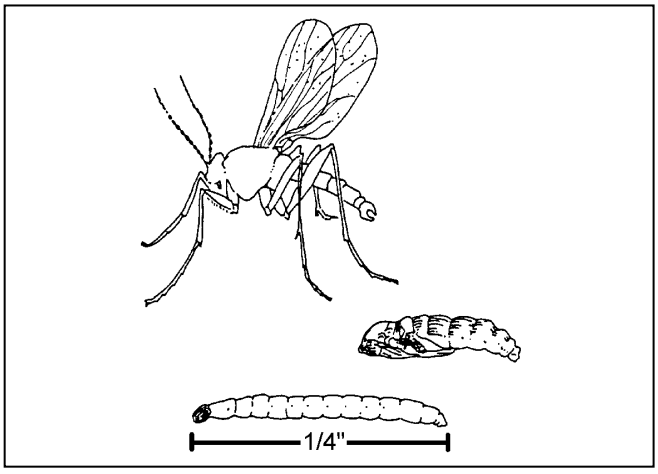
Aphids are common pests in the greenhouse. The species most prevalent is the green peach aphid that not only harms leaves but also spreads bacteria and viral diseases. Adults are 1/25-1/8 inch (1-3 mm) long. Their piercing-sucking mouth parts suck plant sap from the phloem cells. This stunts and distorts new shoots. Tiny yellow spots appear on the foliage, and a sugary substance develops called “honeydew” (not to be confused with melon). The honeydew nourishes black sooty mold. Because females can reproduce as many as 100 offspring within 3 days, aphids are an ever-present threat to ornamentals and vegetable crops. (See Figure 6.4.)

Figure 6.4 - Aphid



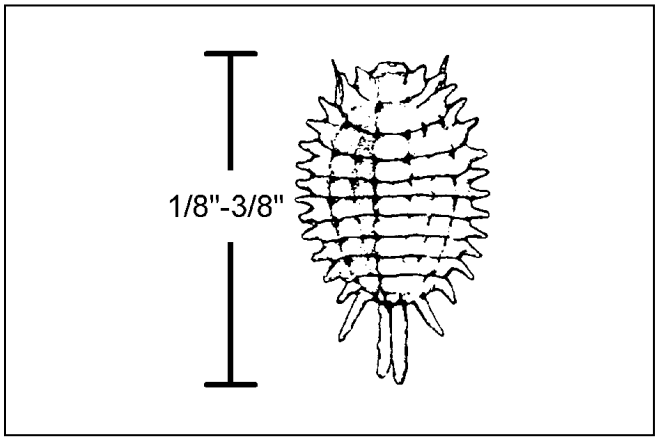
It is during its larval, not adult, stage that fungus gnats damage plants. At 1/4 inch (6 mm), these larvae, which live in the soil, use their chewing mouth parts to demolish roots, root hairs, and crowns of bulbs or plants. The harmful results are evident in seedlings: stunted growth, lack of plant vigor, wilted leaves, leaf drop, and yellow foliage. The female adult spends her 10-day life span producing 300 eggs, which are laid in moist, fertile soil. Figure 6.5 illustrates the life stages of the fungus gnat.

Figure 6.5 - Fungus Gnat



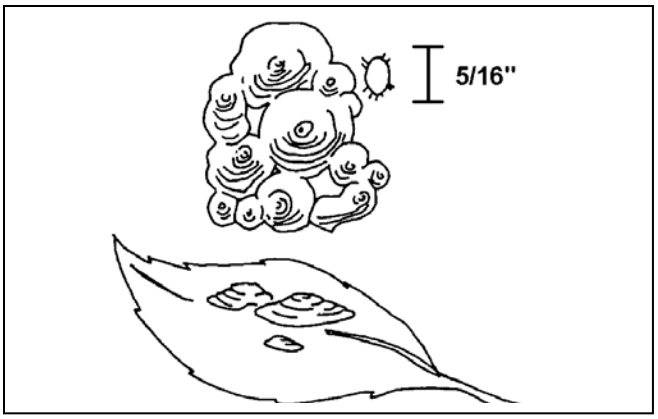
Adult mealybugs are 1/8-3/8 inch (3-4 mm) long. They use their piercing-sucking mouth parts to drain the sap, resulting in diminished plant vigor, yellow and deformed foliage, and leaf drop. Covered with a waxy, white powder, mealybugs lay their eggs in leaf axils and under leaves. When the egg clusters develop, they look like tiny cotton balls. Figure 6.6 shows an adult mealybug.

Figure 6.6 - Mealybug



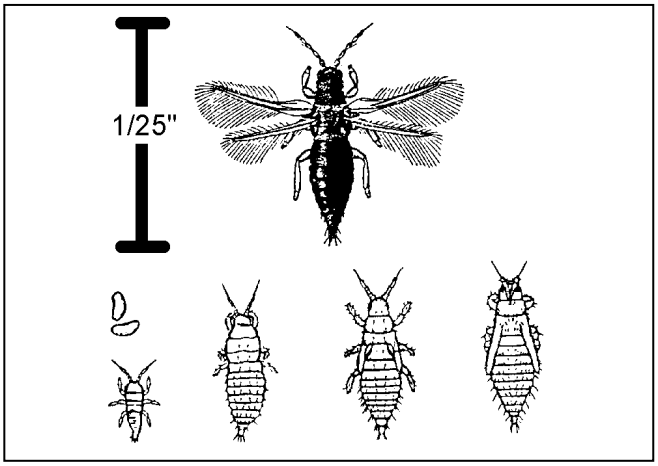
Other pests that use piercing-sucking mouth parts are scale insects. Adults are 5/16 inch (8 mm); some have a round, hard shell that has a waxy, rubbery coating. Hard-coated scale insects exude honeydew. When a plant is attacked by scale, symptoms include a lack of vigor, stunted growth, and yellowed leaves. See Figure 6.7.

Figure 6.7 - Scale



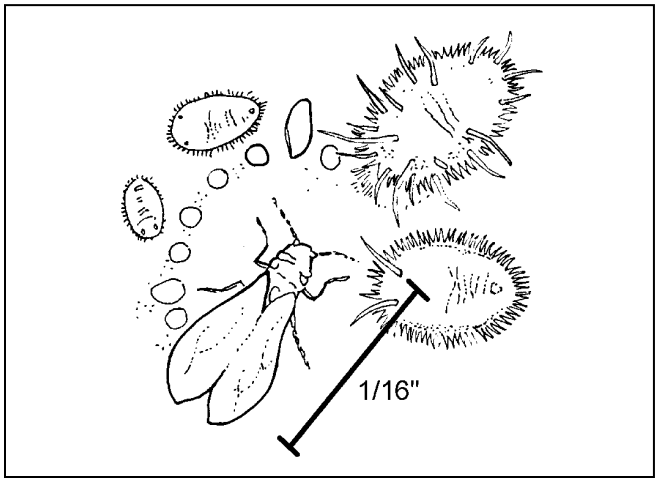
When it is warm outside, huge quantities of thrips may gather and fly into the greenhouse at the first opportunity. Adults are only 1/25 inch (1 mm); they use their rasping-lapping mouth parts to scrape leaf surfaces and petals and then drink the sap that is released. New growth and flowers become malformed, flower petals get streaked and turn brown, and eventually the leaves and flowers drop off. When thrips invade, they can spread viral diseases among plants. Figure 6.8 shows the life cycle of thrips.

Figure 6.8 - Thrips



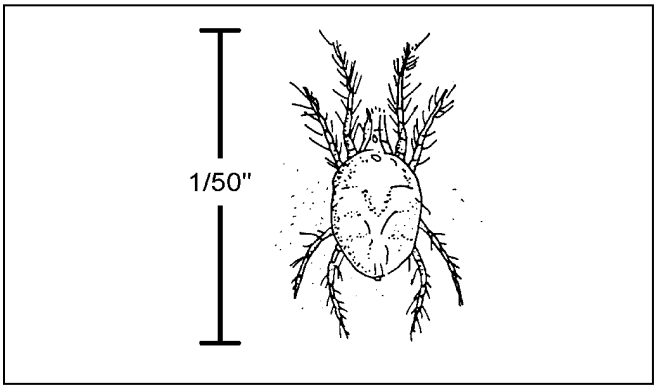
Whiteflies look like tiny moths and feed on popular greenhouse plants: poinsettias, chrysanthemums, and bedding plants. Adults are 1/16 inch (2 mm) and have piercing-sucking mouth parts. Evidence of damage from whiteflies is tiny yellow spots on foliage. They also can spread disease among plants by emitting honeydew. See Figure 6.9.

Figure 6.9 - Whitefly



Many species of mites (arachnids) injure plants. Mites are very tiny - less than 1/50 inch (0.50 mm) long - and have piercing-sucking mouth parts. Spider mites (illustrated in Figure 6.10) are especially prevalent in the greenhouse. Like their namesake, these arachnids weave miniscule webs on the plant that turn the leaves brown. When mites attack, the foliage develops tiny yellow spots, a bronze hue, and it curls up. When the beauty of a plant is marred, the greenhouse owner suffers economic loss. Mites are difficult pests to control because their resilience makes them able to adapt to various temperatures and humidity levels.

Figure 6.10 - Spider Mite

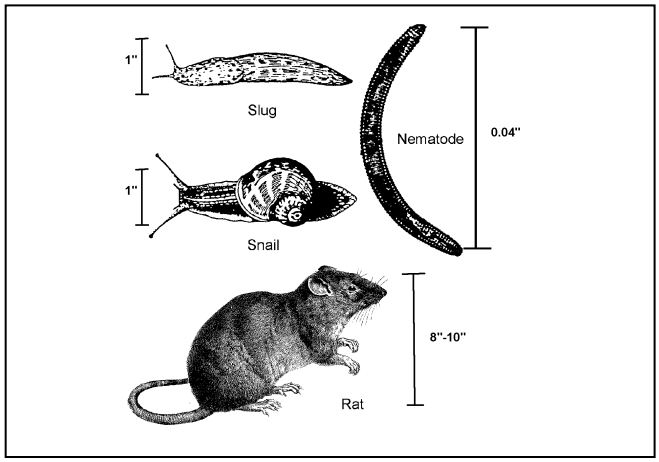


Effects of Other Pests

Nematodes are wormlike invertebrates that live in the soil. Many are plant parasites. Those that are harmless to crops are still a threat because they penetrate root cells, giving fungi and bacteria an opportunity to enter.

Although rodents, birds, and other mammals don't typically enter an enclosed greenhouse, if they do gain access, they harm plants by eating plant parts and digging up the soil. Mollusks such as snails and slugs use their chewing mouth parts to feed on leaves and young stems. With voracious appetites, these pests can devour all the foliage on greenhouse plants if they are not controlled. Creating damage exclusively at night, snails and slugs leave a slimy trail everywhere they go. Figure 6.11 depicts these additional pests.

Figure 6.11 - Other Pests



Weeds are any unwanted plants that grow out of place. The problem with weeds is that they compete with cultivated plants for space, light, water, and nutrients. Additionally, they may support pests and diseases that can infect cultivated plants. The greenhouse owner's profit margin is substantially diminished if weeds are allowed to choke out emerging crops.

Causes and Sources of Disease

There are two basic causes of plant diseases: cultural and parasitic. Cultural diseases result from incorrect applications of chemicals in the growing medium or on the plants, nutritional deficiencies, and physical damage to plant parts. The greenhouse's internal environment may also promote disease. For example, if the humidity is too high, pathogenic spores can germinate. Poor drainage in plant containers also invites disease.

Microorganisms cause parasitic diseases. The parasites are contagious and can sweep rapidly through the greenhouse, devastating valuable crops. Pathogenic microorganisms include viruses, bacteria, and fungi. Viruses cause the most difficult type of disease to control and treat. Plants suffer from stunted growth or die. Viruses usually attack the plant's vascular system. This means that the crop yield and the quality of the produce are substantially reduced. Sucking insects as well as unsterile equipment and tools used during asexual propagation transmit viral infections throughout the greenhouse.

Harmful bacteria enter the plant through openings in the epidermis, flowers, stem, and leaves. Bacteria rob the nutrient solution of life-supporting oxygen.

Fungi are the most common cause of plant disease. Fungal spores grow on and inside of plants and they spread via water, air, and insects. If an ornamental plant is pruned with clippers that have been exposed to a fungus, the plant gets

infected as well. Any wounded plant part is vulnerable to fungal attack.

The greenhouse may contain several potential sources of disease. Infected or poorly drained soil hosts a variety of pathogens. Debris from previous crops may already be infected and could spread disease-bearing organisms via the air. Polluted water or air and pathogenic plant tissues from cuttings may also harbor diseases.

Common Diseases

Greenhouse crops frequently suffer from damping-off. This disease is caused by a complex of organisms that most often includes the soilborne fungi *Phytophthora* or *Rhizoctonia*. Damping-off usually attacks seedlings. The fungi originate in the soil or seed itself. At preemergence, the seed is destroyed before germination. At postemergence, the seedling falls over and is destroyed at the soil level.

Fungi also cause Botrytis blight (gray mold). This is a costly disease because it ruins popular crops such as roses, azaleas, geraniums, and poinsettias. It thrives in a cool, humid environment, which is readily provided in the greenhouse. Plant symptoms are gray spots on the foliage. The tissue under the spots turns soft, then brown, then becomes completely rotten.

Bacteria or fungi cause leaf spot and other foliar diseases. If bacteria are the cause, the plant must be discarded; if fungi are the cause, the plant can be treated. These diseases also develop in a humid environment. Plants with leaf spot have discolored and distorted leaves.

Root rot is caused by bacteria or *Pythium* and *Phytophthora* fungi. Houseplants die most frequently of this disease. Root rot results from overwatering. Overwatering causes damage to the roots and this enables fungi to invade the plant. Consequently, there is a decrease in both the uptake of water and in the root hairs' ability to transmit dissolved nutrients into the plant. When plants get root rot, the roots become brown or black and there are less of them. They become slimy and have a foul odor. The leaves yellow, wilt, and finally drop off.

Summary

The greenhouse environment unfortunately can support a variety of pests. By understanding their life cycle, the greenhouse owner can plan effective treatments for eradication. Viruses, bacteria, and fungi are responsible for causing diseases such as damping-off, Botrytis blight, and root rot.

Credits

Acquaah, George. *Horticulture: Principles and Practices*. Upper Saddle River, NJ: Prentice Hall, 1999.

Boodley, James W. *The Commercial Greenhouse*, 2nd ed. Albany, NY: Delmar Publishers, 1996.

Cooper, Elmer L. *Agriscience: Fundamentals & Applications*, 2nd ed. Albany, NY: Delmar Publishers, 1995.

Greenhouse Operation and Management (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1990.

Lee, Jasper S., Series Editor. *Introduction to Horticulture*, 3rd ed. Danville, IL: Interstate Publishers, Inc., 2000.

Nelson, Paul V. *Greenhouse Operation and Management*, 3rd ed. Reston, VA; Reston Publishing Company, Inc., 1985.

Unit VI: Plant Health

Lesson 2: Pest Control

The last lesson summarized types of insects, mites, animals, and diseases that threaten greenhouse-grown plants. To ensure healthy crop production and a profitable yield, the greenhouse owner must understand how to control these pests. This lesson describes several methods of plant protection.

Pest Control Basics

The purposes of a pest control program are to prevent entrance of pests inside the greenhouse, reduce or eliminate pest populations, protect plants from pests already present, and increase plants' resistance to pests. The basic methods of control are biological, chemical, cultural, and mechanical, as discussed below.

Biological Pest Management

The principle of biological pest management is to use living organisms that are natural predators of pests. For examples, ladybugs prey on aphids. The bacterium *Bacillus thuringinensis* kills harmful worms, and trap plants lure pests away from cultivated crops. Biological controls tend to take longer than the other methods and they do not completely eliminate greenhouse pests.

Chemical Pest Management

Chemical management can be used to protect and treat plants and to destroy pests. Herbicides kill weeds that hinder growth. Chemicals are effective, but several pests have developed resistance to some brands. Also, many types of pesticides are under review by governmental agencies, such as the Environmental Protection Agency (EPA). Because the promulgation of pesticide regulations can occur unnoticed, the greenhouse owner must keep apprised of which chemicals may be used and how those pesticides affect living organisms. An EPA web site (<www.epa.gov/pesticides/label>) displays interactive labels of various pesticides that identify their ingredients and/or risk factors. Types of pesticides designed to eliminate specific pests are listed in Table 1. Please note that each of these chemical controls can be deadly and must be used with extreme caution.

Table 6.1 - Pesticides for Specific Pests

Type of Pesticide	Pests Treated
Acaricide	Spiders, ticks
Aviacides	Birds
Bactericide	Bacteria
Fungicide	Fungi
Insecticides	Insects
Miticides	Mites, ticks
Molluscides	Snails, slugs
Nematicides	Nematodes

Cultural Pest Management

The cultural management approach applies techniques used in the greenhouse to ensure a high-quality growing environment. This involves mulching and pruning plants, pasteurizing growing media, and purchasing quality seeds. Selecting pathogen-resistant plant varieties and planting at suitable times also help control pest attacks. Cultural practices that affect plant growth and potential exposure to pests include fertilization, irrigation, and aeration.

Mechanical Pest Management

Pests can be prevented, removed, and destroyed by mechanical (physical) management. Helpful activities include weeding and mulching, handpicking large bugs from plants, screening out

insects, and hanging flytraps. Maintaining sanitation throughout the greenhouse deters pests. Propagation benches, tools, and the floor must be cleaned frequently. All employees must ensure that they do not contaminate crops by stepping on benches.

Integrated Pest Management

As its name implies, integrated pest management (IPM) is a comprehensive strategy that combines features of biological, chemical, cultural, and mechanical pest management programs. The goals of IPM focus on reducing the following: the number and impact of pests (but not necessarily to eradicate all of them); economic loss due to pests; reliance on pesticides; and safety hazards to humans, animals, plants, and the environment. Operating from an ecological perspective, IPM seeks natural solutions to pest management. IPM strategies develop from careful decision making and planning. Fundamental to IPM is a thorough understanding of pertinent biological information about pests in the greenhouse. This includes knowing the pests' life cycle, behavior, mouth types, and other characteristics. Next, the greenhouse owner must identify the types of pests that injure greenhouse crops and know how to recognize symptoms of plant injury. Then the owner establishes a certain level of damage that is considered unacceptable. This threshold signals when IPM strategies are implemented. At this point, a series of important issues are resolved, as illustrated in Table 6.2.

Table 6.2 - IPM Decision-Making Process

Responses to Unacceptable Levels of Pest Damage
1. Start preventative strategies.
2. Scout plants for symptoms or presence of pests.
3. Determine if pests are present.
4. Identify pests and scope of damage.
5. Treat plants.
6. Evaluate effectiveness of treatment.
7. Evaluate management strategies.

Pest control is achieved through early detection and application of safe eradication measures. Greenhouse owners need to constantly monitor and evaluate the efficiency of IPM by keeping accurate records that track the following:

- Range of daily temperatures
- Amount of pests on plants and their current developmental stage
- Status of plant growth and root health
- pH and soluble salt level of the growing medium

IPM incorporates strategies known as "*best management practices*" (BMPs). The purpose of BMPs is to incorporate scientific techniques and real-world experience to maintain cost-efficient operations and ensure high-quality crops. BMPs are environmentally friendly approaches to pest management. Examples of BMP practices that promote IPM goals are listed in Table 6.3.

Table 6.3 - Best Management Practices That Control Pests

Best Management Practices
Testing growing media
Determining correct time and application of fertilizers
Ensuring proper drainage
Managing irrigation systems
Using controlled-release fertilizers
Using natural (biological) pest controls
Using cultural pest controls

Summary

Protecting greenhouse crops from destructive pests results in commercial success for the greenhouse owner. Biological, chemical, cultural, and mechanical management methods have distinct features for controlling pests. The integrated pest management strategy incorporates aspects of all of these approaches and is ecologically sensitive to the growing environment.

Credits

Acquaah, George. *Horticulture: Principles and Practices*. Upper Saddle River, NJ: Prentice Hall, 1999.

Boodley, James W. *The Commercial Greenhouse*, 2nd ed. Albany, NY: Delmar Publishers, 1996.

Cooper, Elmer. *Agriscience: Fundamentals & Applications*, 2nd ed. Albany, NY: Delmar Publishers, 1995.

Greenhouse Operation and Management (Student Reference). University of Missouri-Columbia: Instructional Materials Laboratory, 1990.

"Integrated Pest Management for Greenhouse Crops." Appropriate Technology Transfer for Rural Areas. <http://www.attra.org/attra-pub/gh-ipm.html> accessed 2/20/02.

Lee, Jasper S. Series Editor. *Introduction to Horticulture*, 3rd ed. Danville, IL: Interstate Publishers, Inc., 2000.

PA IPM News, Volume 3, Number 2, Spring 2000. <http://paipm.cas.psu.edu/NewsLetter/PAIPMnews9.html> accessed 2/20/02.

Unit VI: Plant Health

Lesson 3: Pesticide Use and Safety

As potent weapons in the arsenal against pests, chemical deterrents can systematically destroy vermin from plants. However, personnel authorized to apply pesticides must be keenly aware of the environmental consequences to greenhouse employees, crops, and even to the equipment. This lesson first addresses pesticide use: label information, forms of pesticides, application methods, and modes of action. The discussion then focuses on basic safety issues, beginning with a definition of toxicity levels. Lesson 3 continues to examine safety by defining storage and disposal procedures, personal protection measures, and first aid for accidental poisoning. Finally, sources of pesticide-related information and pesticide certification procedures are provided.

Pesticide Label

One of the most crucial features of a pesticide is its label. Essentially a legal document, the label prescribes acceptable methods of usage, storage, and disposal; it controls how the product is sold and distributed. If poisoning occurs, doctors refer to the label for treatment data.

Authorized pesticide users must scrupulously read and adhere to all label information and directions concerning usage, storage, and disposal. The label warns users where the product could enter the unprotected body. Additional information identifies required personal protective clothing and correct use of equipment. The label also lists environmental, physical, or chemical hazards and indicates toxicity to certain plants or animals. Other information includes the pesticide's EPA classification and a safe reentry time that states when employees can enter the greenhouse without protective clothing and equipment. Figure 6.12 displays a sample pesticide label.

Figure 6.12 - Sample Pesticide Label

7. RESTRICTED USE PESTICIDE
(GROUND AND SURFACE WATER CONCERNS)
FOR RETAIL SALE AND USE ONLY BY CERTIFIED APPLICATORS OR PERSONS UNDER THEIR DIRECT SUPERVISION, AND ONLY FOR THOSE USES COVERED BY THE CERTIFIED APPLICATOR'S CERTIFICATION.

8. Bug-B-Ded Incecticide
14. 6EC

9. Active Ingredient:
Killazine (2, 4, 6 diamizine) 37.4%
Inert ingredients: 62.6%
Total: 100.0%
1 gal. contains 6.0 lb. killazine
10. 2.5 GALLONS
U.S. Standard Measure
11. EPA Reg. No 100-358
12. EPA Est. 34704-MI-1
3. Statement of Practical Treatment
If swallowed, DO NOT induce vomiting. Call a physician or Poison Control Center immediately.
If in eyes, flush with plenty of water.
If on skin, wash with plenty of soap and water.
NOTE TO PHYSICIAN: vomiting should only be induced under professional supervision.

17. Directions for Use
It is a violetion of federal law to use this product in a manner inconsistent with its labeling.

Agricultural Use Requirements
Use this product only in accordance with its labeling and with the Worker Protection Standard, 40 CFR part 170.
Do not enter or allow worker entry into treated areas during the restricted-entry interval (REI) of 4 hours.
PPE is required for early entry to treated areas that is permitted under the Worker Protection Standard and that involves contact with anything that has been treated, such as plants, soil, or water is:
• Coveralls • Waterproof gloves • Shoes plus socks

Cool-season turf: Chinch bugs, fleas and mole crickets: apply 1 ounce of product per 1000 square feet.
Warm-season turf: White grubs: apply 2 ounces product per 1000 sq. ft. and water in with supplemental irrigation. Allow at least 10 days before making a second application.

1. Keep out of the reach of children
2. CAUTION
4. Harmful if swallowed or absorbed through the skin. Causes minor skin irritation.

5. Personal Protective Equipment (PPE):
Applicators and other handlers must wear:
• Long sleeved shirts
• Chemical resistant gloves
• Shoes plus socks
6. Environmental Hazards
This product is toxic to fish. Do not apply directly to water or to areas where surface water is present.
15. Physical or Chemical Hazards
Do not use or store near heat or open flame.
18. Storage and Disposal
Storage: Do not contaminate water, food, or feed by storage or disposal. Store at temperatures above 32°F.
Pesticide Disposal: Wastes resulting from the use of this product may be disposed of on site or at an approved waste disposal facility.
Container Disposal: Triple rinse (or equivalent). Then puncture container and dispose of in a sanitary landfill or incinerate.
16. Limited Warranty and Disclaimer:
The manufacturer warrants that this product conforms to the chemical description on the label; that this product is reasonably fit for the purposes set forth in the directions; that the directions, warnings, and other statements on this label are based upon responsible experts' evaluation of reasonable tests of effectiveness, of toxicity to laboratory animals, and to plants, and of residues on food crops and upon reports of field experience.

13. BUGS-R-US Inc.
1468 North-South Expressway
P.O. Box 5600
Research Triangle Park, NC 123451.

Key to Numbering

1. Child hazard warning.
2. Signal word.
3. Statement of practical treatment
4. Hazards to humans and domestic animals
5. Personal protective equipment
6. Environmental hazards
7. Use classifications
8. Brand (trade) name
9. Ingredient statement
10. Net contents
11. EPA registration number
12. EPA establishment number
13. Name and address of manufacturer
14. Formulation
15. Physical or chemical hazards
16. Limited warranty and disclaimer
17. Directions for use
18. Storage and disposal

Pesticide Toxicity Levels

Each chemical listed on a pesticide label contributes key ingredients that target designated pests. The cumulative effect of all chemicals in a specific pesticide is its toxicity level. Pesticide toxicity levels are measured in terms of LD (lethal

dose). The calculations of LDs are based on test mammal populations. An LD_{50} refers to the amount of pesticide required to kill 50% of a test population within 2 weeks. LD_{50} is expressed in milligrams per kilogram of the test animal's body weight. The lower the LD_{50} value, the higher the pesticide's toxicity. Low LD_{50} values indicate that small amounts of the pesticide provide a lethal dose.

A pesticide's toxicity may be transmitted by the following means: oral (ingested), inhaled (breathed), and dermal (absorbed through skin).

Toxicity levels are communicated by signal words on pesticide labels. "Caution" means the product is slightly toxic and has an LD_{50} of 500-5,000. "Warning" denotes a moderately toxic product; its LD_{50} is 50-500. "Danger" or "Danger - Poison" is the most toxic level. The words are printed in red and accompanied by a skull and crossbones drawing. Its LD_{50} is 0-50. After the signal word on every pesticide label, the following statement must appear in large print: "Keep Out of Reach of Children."

Forms of Pesticides

Pesticides are either liquid or dry. The liquid forms are aerosols, emulsifiable concentrates, encapsulated, or flowable. Table 6.4 summarizes how each form is designated and used.

Table 6.4 - Liquid Forms of Pesticides

Form of Liquid	Designation	Usage
Aerosols	A	Pressured cans or aerosol bombs
Emulsifiable concentrates	EC	Mixed with water in spray tank
Encapsulated	Pesticide sealed in microcapsules	Time release - mixed with water
Flowable	For L	Mixed with water

Dry pesticides come in several forms: bait, dust, granular, soluble powder, wettable powder, and dry flowable, as summarized in Table 6.5.

Table 6.5 - Dry Forms of Pesticides

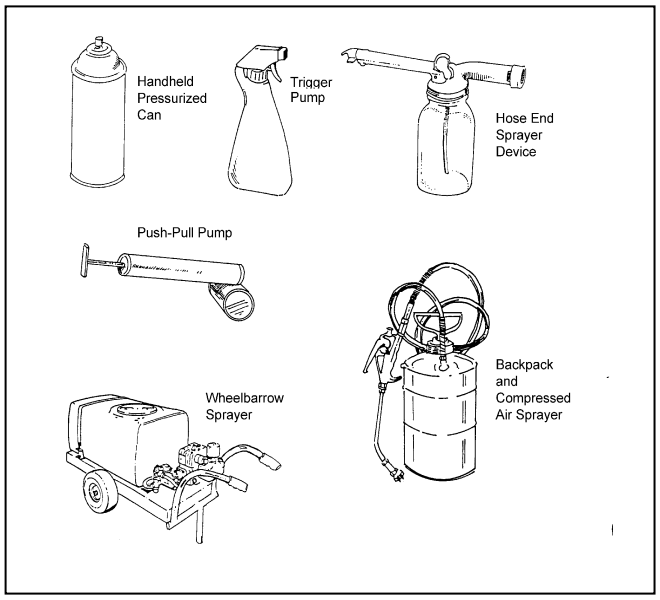
Form of Liquid	Designation	Usage
Bait	B	Pesticide-laden substance that lures pests
Dust	D	Pesticide and inert ingredients ground into dust; applied dry
Granular	G	Same composition as dust, but larger particles; applied dry
Soluble powder	S or SP	Finely ground ingredients; dissolved in water
Wettable powder	W or WP	Mixes with water in spray tank; must be constantly agitated to keep mixed
Dry flowable	DF	Dry granules of pesticide; less dust than powders

Application Methods

Pesticides can be applied at key stages in the plant's growth cycle. Seeds, bulbs, corms, and tubers benefit from applications of pesticides to control soilborne pathogens that rot seeds or induce damping-off. To rid the growing media of nematodes and other soilborne pests, granular and

dust forms of pesticides are effective. If pruning creates a wound in the plant, apply a liquid or dust pesticide directly to prevent further damage to a plant's foliage. To prevent crops from decaying during storage, apply a postharvest pesticide. Figure 6.13 depicts equipment used to apply pesticides

Figure 6.13 - Types of Sprayers Used to Apply Pesticides



Aerosol generators and foggers fill the greenhouse with a mist of pesticides that are either broken down by very fine nozzles under high pressure (cold fogger) or are vaporized by a generator that uses heat.

Authorized personnel maintain a pesticide application log to denote where the pesticide is applied, the active ingredients in the product, its EPA registration number, and dates of application and safe reentry. The log also notes the types of Personal Protection Equipment required. See Figure 6.14 for a sample pesticide application log.

Figure 6.14 - Sample Pesticide Application Log

Procedure	Application #1	Application #2
Area Treated: Location & Description		
Product Name		
EPA Registration Number		
Active Ingredient: Common or Chemical Name		
Date of Application: Month/Day/Time		
Entry Restricted Until: Month/Day/time		
Requirement to Post When Area Is Treated? Yes/No		
Requirement to Give Oral Notification? Yes/No		
PPE Requirements for Handlers		
Early Entry PPE Required for Workers		
Other Label Requirements to Protect Workers and Others		

Modes of Action for Pesticides

Pesticides act in distinct ways. Biological controls, as mentioned in Lesson 2, use living organisms to kill plant pests. Biopesticides are created from cultured microorganisms and plants and are used in aerial sprays to control diverse

soilborne diseases as well as harmful bacteria and fungi.

Several products can eliminate pests. Contact pesticides are fatal to the insects' nervous and respiratory systems and immediately kill them upon exposure. Fumigants are poisonous gases released in a sealed greenhouse and kill insects as they breathe or absorb the chemicals. All employees must vacate the premises when these chemicals are released. Growth regulators that have intense concentrations of specific hormones adversely affect pest development.

Researchers have developed pest deterrents from pheromones. These are natural chemicals that some female insects produce to attract male insects. Scientists manipulate this attraction by using pheromones to lure the male insects into traps where they die. Alone, the females are unfertilized; consequently, the targeted insect population plummets.

Protectants prevent fungal pests from entering or damaging the surface of plants and should be uniformly applied over the entire plant. Stomach poisons kill pests when the insects eat or swallow the treated plant. Systemics are pesticides that the plant absorbs and then translocates to all its parts via the vascular system. The pest is killed as it feeds on the plant.

Pesticide Safety Issues

Because chemical pesticides are powerful substances, they must be handled with extreme caution. Pesticides are potentially lethal to human and animals. Used irresponsibly, pesticides contaminate air, water, and food and they pollute the environment. It is important to adhere to all federal, state, and local laws and guidelines and ensure personal safety and protection of others.

In 1992, the EPA issued the Worker Protection Standard (WPS). This regulation covers pesticides used in agriculture: farms, forests, nurseries, and greenhouses. The goal of the WPS is to reduce the risk of pesticide-related illness and injury. Employers of people handling pesticides are required to provide information on pesticide exposure, protection against exposure, and ways to alleviate exposure to pesticides. For employees, WPS information provides safety training, safety posters, and access to specific information on pesticides used on-site. This regulation also keeps the pesticide handler and other employees from inadvertent exposure. The WPS regulation requires decontamination sites and emergency assistance for a worker or handler who is poisoned or injured by a pesticide.

General Pesticide Storage and Disposal Procedures

Adhering to correct pesticide storage procedures is an important aspect of pesticide safety. Read and follow the pesticide label for storage instructions and be aware of general pesticide storage safety guidelines. Store in the original containers, making sure labels are visible and marked with the date of purchase. Pesticides should not be stored near food, medicine, or other supplies. Keep chemicals away from flammable materials and routinely check containers for leaks or damage. Ensure that cleanup materials are close by.

To dispose of pesticides and pesticide containers, read and follow the label for instructions and precautions. General pesticide disposal guidelines stipulate that pesticides should not be flushed down drains, into sewers, or in waterways. Follow proper disposal procedures for old or unwanted products. Observe mandates from the U.S. Department of Agriculture and the EPA. For specific, local pesticide laws and guidelines, contact the State Department of Natural Resources.

Personal Protection Measures

The first step in personal protection is to obtain proper education and permits for pesticide use. Use Personal Protective Equipment (PPE), which may consist of any or all of the following: goggles, respirator, long sleeves rolled over long rubber gloves, hat, rubber boots, and overalls or coveralls secured with a band over boots.
The following guidelines concern how to apply pesticides safely:

- Select the safest, least toxic substance possible.
- Use approved products only for intended purpose.
- Mix only the amount needed.
- Apply with extreme caution.
- Use proper equipment and clothing.
- Review label carefully.
- Know and follow proper application procedures.
- Know how to handle accidental poisoning.
- Do not eat, drink, or chew anything during or immediately after application.
- Ensure adequate ventilation and clear the area of people, animals, and items.
- Clean all equipment and clothing.
- Thoroughly wash skin with cleaner and water.

Handling Accidental Pesticide Poisoning

If a greenhouse worker accidentally ingests a pesticide, first observe the victim's symptoms, which vary according to the type and amount of pesticide, length of exposure, interval between exposures, and the employee's general health.

External irritants affecting outer tissues may cause pesticide poisoning. Symptoms include stinging in the eyes, ears, throat, nose, mouth, or other external tissues. Internal poisons are absorbed into the body through the mouth or skin and may cause injury to internal body organs.

If either type of pesticide poisoning occurs, immediately follow basic first aid procedures. Act quickly and remove the victim from the contaminated area. Also remove his or her contaminated clothing. Generously flood the affected area with water. Contact a doctor or the poison control center and administer first aid as directed.

Sources of Pesticide Information and Recommendations

The greenhouse owner should maintain current information about the pesticides used in the greenhouse. Reliable sources include university Extension offices, federal and state departments of agriculture, and pesticide suppliers.

Certifications Required to Use Pesticides

In Missouri, certification is required for anyone who wants to use pesticides. Users are designated as certified applicators and operators. These are the various categories: Commercial Applicators, Certified Noncommercial Applicators, Public Operators (government employees), Private Applicator Licenses, Pesticide Technician Licenses, and Pesticide Dealer Licenses.

Applicants seeking certification must pass state pesticide certification examinations that are part of the General Standard of Competence (CORE) examination and at least one category exam that reflects the applicant's specialized technical expertise. In order to take these exams, the applicant must first send the Certified Applicator and Pesticide Dealer Application to the Missouri Bureau of Pesticide Control. To help prepare for these tests, the applicant may buy a study manual from the University of Missouri Extension Publications (800-292-0969).

The applicant has to satisfy additional requirements after passing the exams based on the type of license desired. Specific information is

available from the Missouri Department of Agriculture, Plant Industries Division, Bureau of Pesticide Control, P.O. Box 630, Jefferson City, MO 65102. Phone: 573-751-5504; Fax: 573-751-0005.

Specific information relating to certification expiration and recertification is summarized in Table 6.6.

Table 6.6 - Certification Expiration and Recertification

Type of Certificate	Date of Expiration	Recertification Process
Certified Commercial Applicator	Annually	$50 license fee (as of 2002; check with Bureau of Pesticide Control for updates); submit signed renewal card before expiration
Certified Noncommercial Applicator	Annually	$25 license fee (as of 2002; check with Bureau of Pesticide Control for updates); submit signed renewal card before expiration
Certified Public Operator	Every 3 years	No license fee (as of 2002; check with Bureau of Pesticide Control for updates); submit signed renewal card

By law, every 3 years all Certified Applicators and Operators must renew their certifications. Individuals may take the exams again or enroll in an approved recertification program. Sample facilities offering training are the University of Missouri Cooperative Extension Service (available every January) and various businesses, groups, and associations. The Bureau of Pesticide Control must approve all recertification programs before granting credit. It also provides guidelines for these training programs.

Missouri has reciprocal relationships with several states, as listed in Table 6.7. These agreements enable out-of-state applicants to apply for a license without having to pass Missouri's certification examinations.

Table 6.7 - States Having Reciprocal Relationships With Missouri

State	Type of Agreement
Agricultural Aviation Board of Mississippi	Categories 1A, 2, 5, and 6
Arkansas	All categories except for ornamental, turf pest control, and structural pest control categories
Illinois	All categories administered by the Illinois Department of Agriculture (no agreement with the Illinois Department of Public Health)
Iowa	All categories
Kansas	All categories
Louisiana	All categories except for the structural pest control categories
Nebraska	All categories

Summary

Pesticides are valuable tools for protecting crops from insects, weeds, and other pests. However, because they are made from powerful combinations of chemicals, pesticides must be used wisely. This requires paying careful attention to all instructions and information on the label, observing signal words, following all safety precautions, and understanding how to administer first aid if needed. In the state of Missouri, only certified persons may apply pesticides. Specific procedures and examinations are required to earn certification. Several states have a reciprocal agreement with Missouri's Bureau of Pesticide Control, as cited in Missouri's regulations.

Credits

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