Category 11: Nursery and Greenhouse Pest Control

Nursery and Greenhouse Pest Control Learning Objectives

After studying this section, you should be able to:

✓ List the sites covered under the Worker Protection Standard (WPS).
✓ List routes of exposure for pesticides.
✓ Explain where information about Personal Protective Equipment (PPE) is found.
✓ List Signal Words and their toxicity levels.
✓ Describe common diseases in the nursery or greenhouse setting.
✓ Describe typical plant symptoms of insect pests in a nursery or greenhouse setting.
✓ Detail weed control methods for the nursery or greenhouse setting.

Category 11, Nursery and Greenhouse Pest Control

Category 11, Nursery and Greenhouse Pest Control, addresses pests, pest control and safe use of pesticides in nurseries or greenhouses. If you own or work in a nursery or greenhouse, your job may put you in close contact with pesticides or pesticide-treated areas. Pesticides are used to control diseases, insects, weeds and vertebrate pests. Disinfectants used to sterilize plant containers, working surfaces and equipment are also considered pesticides. Plant growth regulators are used to keep potted flowering plants compact and are also considered pesticides.

Pesticides come in many forms: liquids, granules, powders or gases. Some are mixed with water before use. Some, like granular pesticides, may be used directly from the container. Pesticides are very useful for growing outdoor nursery stock, field-grown cut flowers, and nursery crops. Insecticides, weed killers or fungicides may occasionally be needed to keep plants damage-free and attractive. Since your job makes it necessary for you to occasionally work...
around pesticides and pesticide-contaminated plants or surfaces, it is important for you to know that pesticides could be dangerous if they are not handled carefully. It's up to you to learn as much as you can about the pesticides used in your nursery or greenhouse and how to protect yourself and others around you.

**Worker Protection Standard**

The Worker Protection Standard (WPS) is a regulation issued by the U.S. Environmental Protection Agency. It covers pesticides that are used in the production of agricultural plants on farms, forests, nurseries and greenhouses. The WPS requires you to take steps to reduce the risk of pesticide-related illness and injury if you (1) use pesticides or (2) employ workers or pesticide handlers who are exposed to pesticides. If you are an agricultural pesticide user and/or an employer of agricultural workers or pesticide handlers, the WPS requires you to provide the following to your employees and, in some cases, to yourself and to others:

**Information about exposure to pesticides:** To ensure that employees will be informed about exposure to pesticides, the WPS requires:

- Pesticide safety training for workers and pesticide handlers.
- A pesticide safety poster be displayed for workers and pesticide handlers.
- Access to pesticide labeling information for pesticide handlers and early-entry workers.
- Access to centrally-located information detailing pesticide applications that have occurred on the establishment.

**Protection against exposures to pesticides:** To ensure that employees will be protected from exposures to pesticides, the WPS requires employers to:

- Prohibit handlers from applying a pesticide in a way that will expose workers or other persons to pesticides.
- Exclude workers from areas being treated with pesticides.
- Exclude workers from areas that remain under a restricted-entry interval (REI), with narrow exceptions.
- Protect early-entry workers who are doing permitted tasks in treated areas during an REI, including providing special instructions related to the correct use of personal protective equipment (PPE).
- Notify workers about treated areas so they can avoid inadvertent exposures.
- Protect handlers during handling tasks, including monitoring while handling highly toxic pesticides and providing special instructions related to the correct use of PPE.

For further information on the WPS, consult the U.S. EPA web publication “How To Comply With the Worker Protection Standard for Agricultural Pesticides: What Employers Need To Know” at [http://www.epa.gov/agriculture/htc .html](http://www.epa.gov/agriculture/htc.html)
Mitigation of pesticide exposures: To mitigate pesticide exposures that employees receive, the WPS requires that:

- Decontamination supplies are available to all workers. Employers must provide pesticide handlers and workers with an ample supply of water, soap and towels for routine washing and emergency decontamination.
- Emergency assistance information is available to all workers. Employers must provide transportation to a medical care facility if an agricultural worker or handler may have been poisoned or injured by a pesticide and must provide information about the pesticide(s) to which the person may have been exposed.

Keeping Safe Around Pesticides

Nursery and greenhouse employees often have a great deal of direct contact with the plants. When a pesticide is applied in the nursery or greenhouse, label instructions require that workers stay out of the treated area for a period of time. This time period is called the “Restricted Entry Interval” or REI. When it is not safe to enter a treated area, there may be a warning sign telling employees to stay out. In some cases, no signs will be posted and you will receive an oral warning not to enter the treated area. If a pesticide drifts onto you or onto any other unprotected person, immediately leave the area and encourage others to do the same. Follow safety procedures and report your exposure to your supervisor.

Individuals exposed to pesticides may experience a variety of symptoms, including headache, skin rash, blurred vision, nausea and dizziness. Severity of symptoms depends on many factors, including the amount and toxicity of pesticide to which they were exposed. The amount of time that the individual was exposed is also a factor.

Routes of pesticide entry: There are three major ways that a pesticide can enter the body:

<table>
<thead>
<tr>
<th>Through the skin or eyes (dermal)</th>
<th>Skin absorption is the most common route of poisoning from pesticides. Absorption will continue as long as the skin remains in contact with the pesticide.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Through the mouth (oral)</td>
<td>Most severe poisonings usually result when pesticides are taken through the mouth. Oral exposure most often occurs when pesticides are taken out of their original containers and stored in food containers.</td>
</tr>
<tr>
<td>Through the lungs (respiratory or inhalation)</td>
<td>Powders, airborne droplets or gases may be inhaled in sufficient amounts to cause damage to nose, throat and lung tissues. Gases produced by fumigants pose the greatest risk.</td>
</tr>
</tbody>
</table>

When it is not safe to enter a treated area, there may be a warning sign telling you to stay out. In some cases, no signs will be posted and you will receive an oral warning not to enter the treated area.

Routes of Exposure:
- Dermal (skin and eyes)
- Oral (by mouth)
- Inhalation (through the lungs)
Pesticide labels and MSDS (Materials Safety Data Sheets) include a section on first aid. Specific first aid instructions are listed for each route of pesticide exposure. Have the product container or label with you when calling the poison control center or the doctor, and when going in for treatment.

The most common route of pesticide exposure for greenhouse and nursery workers is through their skin. Skin exposure can occur if you get sprayed or splashed by a pesticide. Skin exposure can also occur if you handle plants or treated surfaces too soon after a pesticide application. Any opening in the skin, such as a cut, is especially vulnerable to absorbing pesticides.

After a pesticide is applied, a certain amount of time must pass before you or anyone else can enter the treated area without specific training and the proper safety equipment. This is called the Restricted Entry Interval or REI. Because greenhouses are enclosed structures, pesticides persist longer than they do in the open air. Never enter a greenhouse that has been posted with signs that tell you not to enter. If you are the applicator, follow all appropriate label instructions regarding posting and ventilation requirements. Skin exposure is not the only danger involved in entering areas with pesticide residues. If you enter a pesticide-treated area too soon, you can also inhale pesticide dusts or vapors.

Sometimes pesticides are applied through hoses and water lines, or even in irrigation ditches. Don't drink from, or wash with water from any hose or water line unless you know it has not been used for applying pesticides. Swallowing pesticides rarely poisons greenhouse or nursery workers, but it has happened, usually because food or drink has been contaminated with pesticides. Keep food and drink out of the greenhouse and away from areas where pesticides are sold or stored.

Some pesticides can irritate the skin and cause allergic skin reactions. Once you have developed an allergy to a pesticide, even a very small exposure may cause an allergic reaction. Some of the least toxic materials are responsible for many pesticide-related injuries. For example, the commonly used herbicide glyphosate (Roundup®) can cause minor but uncomfortable skin and eye problems.

If a highly toxic pesticide gets on your skin or in your eyes, you will probably experience discomfort immediately. Sometimes, the damage caused by certain pesticides does not show up right away. Avoid low level, ongoing exposure to pesticides by washing your hands after handling treated plants, equipment or surfaces. Always wash before you eat, drink, smoke, apply make-up or use the restroom. Always change your clothes at the end of every working day. Do not wear those clothes again until they are laundered. Launder pesticide-contaminated clothing separate from other clothing.
Sometimes new evidence may show that a pesticide previously thought to be safe can cause serious long-term health effects. Do not be careless, and never encourage your employees or fellow workers to be careless, when working around any pesticide.

**Handling Pesticides Safely**

Always determine how dangerous a pesticide is to you and the environment before you handle the product. Do not depend on someone else – a supplier, boss or co-worker – to explain it to you. **Always read the pesticide label yourself.** Don’t use the product until you have read and understand the whole pesticide label.

**Signal Words**

All pesticide labels have a signal word that describes immediate (acute) toxicity. Signal words help alert users to the risks of a pesticide product.

<table>
<thead>
<tr>
<th>Signal Word</th>
<th>Level of Acute Toxicity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Caution</td>
<td>The pesticide is <strong>slightly toxic</strong> if eaten, absorbed through the skin or inhaled, or it causes <strong>slight</strong> eye irritation.</td>
</tr>
<tr>
<td>Warning</td>
<td>The pesticide is <strong>moderately toxic</strong> if eaten, absorbed through the skin or inhaled, or it causes <strong>moderate</strong> eye irritation.</td>
</tr>
<tr>
<td>Danger</td>
<td>The pesticide is <strong>highly toxic</strong> through <strong>at least one route</strong> of exposure. It may be corrosive, causing irreversible damage to the skin or eyes.</td>
</tr>
<tr>
<td>Danger-Poison (with skull and crossbones)</td>
<td>The pesticide is <strong>highly toxic</strong> through <strong>more than one route</strong> of exposure. It may be corrosive, causing irreversible damage to the skin or eyes.</td>
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**Personal Protective Equipment**

The pesticide label tells you the type of Personal Protective Equipment (PPE) you must wear. It also tells you what kinds of exposure are most harmful. Statements such as "avoid eye contact" or "wear protective eyewear when handling this product" tell you not to get the pesticide in your eyes. Most labels warn you against skin contamination, inhaling the pesticide, or swallowing the pesticide. The label is a legal document and you must comply with label instructions.

Most pesticides require the use of chemical-resistant gloves. The required minimum amount of protection includes a long-sleeved shirt, long pants, eye protection, boots and socks.
As a pesticide applicator, you have the right to protect yourself from pesticide exposure and the responsibility to protect others and the environment from pesticides.

Try to mix only as much pesticide solution as you will need for the application. Dispose of any excess according to the label directions.

If you are applying pesticides overhead, for instance, in hanging baskets in greenhouses or tall nursery trees, your head can be exposed to pesticides. Wear a wide-brimmed nursery tree hat that will protect your face and neck. Always wear a properly fitted respirator when the label indicates the need for respiratory protection. Protect your eyes with goggles, safety glasses or a face mask. Regular glasses or sunglasses are never considered adequate for the purposes of protecting your eyes.

Applying Pesticides in the Nursery

When applying pesticides in the nursery, applicators must read and follow label directions. This ensures that the pesticides are applied in a safe and effective manner. Make sure no one is in the area to be treated. Sometimes tall plants, hanging baskets, tiered benches and equipment makes it difficult to see if there are other people around. Always check the area to be sprayed before you start the application. If you work in a retail nursery, pesticide applications should take place during non-business hours when there is less potential for a customer to be exposed to the pesticide. Curious customers may wander into the application area. Never sell plants that have been sprayed with a pesticide until the spray is completely dried, or according to label directions.

When you are mixing and loading a pesticide, don't leave it unattended. Someone who doesn't realize that the material is hazardous could inadvertently come into contact with the concentrated or prepared material. This is particularly important in a retail nursery setting where customers may become involved.

Never make a pesticide application when the wind will make it possible for the pesticide to drift from the targeted area. Pesticide drift can contaminate adjacent areas, workers, customers and the environment. Do not allow pesticides to drift onto ponds, lakes, creeks and/or rivers.

Leftover pesticides should never be dumped on the ground, as they could easily end up in ground or surface water, creating a danger for people, pets, livestock and wildlife. Try to mix only as much pesticide solution as you need for the application. Dispose of any excess according to label directions.

Special Considerations for Greenhouse Applications

When you apply pesticides:

- Follow all label directions.
- Follow all requirements of the Worker Protection Standard.
- Before you start, consider the conditions in the greenhouse. Wait until later if you need to apply a pesticide to the leaves of plants that are wet
from recent watering, as the pesticide might wash off the leaves without sticking.

- If watering is scheduled to start soon, do not apply a pesticide that could be washed off the treated surface.

- Carefully check and calibrate the application equipment. Make sure there are no leaks, all parts are working properly and the application rate is accurate.

- If you need to fix the application equipment, turn it off first. Remember to keep your protective equipment on while you are fixing the equipment.

- Never apply pesticides in such a way that they can get on people, either directly or through drift.

- Check the area of the greenhouse where you will be working. Make sure no people or pets are nearby.

- You may be required by law to post signs at each entrance to the greenhouse area to be treated. Keep anyone not involved in the application out of the treated area during the pesticide application and during the restricted re-entry period.

- For some types of greenhouse applications, you must keep people out of an area that is larger than the area where you will be applying the pesticide.

- When applying a pesticide that does not require you to wear a respirator, but where you will be spraying fine droplets from a distance of more than 12 inches above the plants, you must keep people at least 25 feet back from the edges of the area while you are spraying. You also must turn off the greenhouse ventilation, or at least down to "low," so the airflow does not cause the pesticide to drift out of the target area.

- When applying pesticides from a lower height - 12 inches or less - using granules, dust or a coarse-droplet spray, you do not have to use the 25-foot setback. People must stay out of the immediate treatment area, but they can walk down nearby aisles or work at nearby benches while the application is taking place. The ventilation system may be left on during this kind of application. This is often necessary in a hot greenhouse to provide air circulation and cooling, and prevent heat stress.

**Fumigants require the greatest number of precautions during their use**

When a pesticide is applied as a fumigant, workers and other persons are prohibited in the entire greenhouse plus any adjacent structure that cannot

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**Application of pesticides in a greenhouse requires some special considerations. See the adjacent list on this page.**

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**Worker Protection Standards require that the person applying a fumigant must be in constant voice or visual contact with another trained pesticide handler during the entire application.**
be sealed off from the treated area until ventilation criteria are met. Ventilation criteria for fumigant use in greenhouses can be found in the EPA manual “How to Comply With the Worker Protection Standard (WPS) for Agricultural Pesticides, www.epa.gov/agriculture/awor.html.

The greenhouse ventilation system must be shut off during a fumigant application.

Worker Protection Standards require that the person applying a fumigant must be in constant voice or visual contact with another trained pesticide handler during the entire application. This second person must have close at hand a set of the same personal protective equipment the applicator is wearing in case rescue is needed.

For some fumigants, the concentration of the pesticide in the air must be below a threshold level before people are permitted to re-enter the greenhouse. Others require specific amounts of ventilation. Read the label to learn what is required.

The only people who may enter the greenhouse during the period when the air is still considered unsafe are trained handlers who are equipped with the required Personal Protective Equipment (PPE).

The EPA "How to Comply With the Worker Protection Standard (WPS) for Agricultural Pesticides” manual is available from the Nevada Department of Agriculture office or at www.epa.gov/agriculture/awor.html.

Common Pest Problems in Nurseries and Greenhouses

Poor plant health and plant damage can often be attributed to living plant pests. However, many plant problems are often caused by non-living (abiotic) factors. The following sections discuss plant pests (biotic) and abiotic causes of plant damage in nurseries and greenhouses.

Living organisms that cause damage include:

- Disease-causing organisms
  - Fungi
  - Bacteria
  - Viruses
  - Nematodes

- Arthropods: Typical damage is caused by feeding or spreading disease-causing organisms.
  - Insects
  - Mites
• Vertebrate pests: Damage in nurseries may be caused by feeding, chewing, burrowing and fecal contamination.
  o Voles
  o Gophers
  o Ground squirrels
  o Mice
  o Birds (pigeons, starlings, sparrows)

The Importance of Preventing Pest Problems

Pest exclusion, or preventing pests from becoming established, is the most important step in avoiding pest problems. Never accept infested stock from suppliers. Isolate or destroy plants that become infested. Install greenhouse screening and plastic drapes over entrances to keep flying insect pests from entering through vents and doors. Take every precaution to prevent the spread of diseases. Plants should not be installed in an interior landscape unless they are pest-free. Promote vigorous, healthy growth to reduce plant disease and insect infestations.

Problem Identification

Once a pest is detected, the pest and the associated plants must be correctly identified. Contact University of Nevada Cooperative Extension professionals, professionals from the Nevada Department of Agriculture, or other nursery and greenhouse professionals for assistance. Consult books, trade publications and fact sheets for help in identifying pests.

After identifying the cause, determine the extent of the problem. How serious is the pest problem likely to become? How expensive are control options? Is the setting appropriate for the suggested management program? Is the pesticide product you are considering registered for use in a greenhouse or nursery setting? Deciding which action to take is based on these considerations and more. Remember that there may be more than one way to correct the pest problem. Pesticides may not always be the most effective, safest or economically sound solution.

Abiotic (Non-living) Factors:
Many non-living factors cause plant problems and most of these problems are preventable.

Proper culture, maintenance and handling of plants in nurseries and greenhouses will prevent most abiotic plant damage. An abiotic event, such as over- or under-watering, stresses a plant and makes it more susceptible to insect and disease organisms.

Abiotic problems are those caused by non-living factors.

Pesticides will not "cure" damage caused by abiotic factors!
The following is a list of common abiotic factors that contribute to plant problems in nurseries and greenhouses. It is important to consider these factors when attempting to solve what you believe to be a pest problem. Pesticides will not "cure" damage caused by abiotic factors!

**Common Abiotic Factors That Can Damage Plants**

- Frost/freeze damage
- Water quality: pH, salinity and toxic element concentrations
- Under-watering
- Over-watering (contributes to root disease)
- Low soil aeration
- Poor drainage (contributes to root disease)
- Wind damage
- Improper maintenance
- Limited root volume: "j" roots, circling roots, girdling roots
- Soil compaction
- Hail damage
- High/low temperatures in air or soil
- Over-fertilization
- Nutrient deficiency
- Chemical injury
- High/low soil pH

**Diseases**

In Nevada, fungi and bacteria cause most infectious diseases. Viruses and nematodes also cause diseases. Some disease organisms attack and invade healthy plants. The majority, however, only invade stressed plants.

Diagnosing the causal agent is often difficult and may require culturing the organism in a laboratory. Check to see which diseases commonly affect the species and review their symptoms.

Chemical control is not necessary or available for some disease problems. Prevention is the most important disease management tool. Learn the growing requirements for each plant species and avoid conditions that stress them. Select disease-resistant varieties whenever possible. If practical, remove or destroy infected plants or plant parts. Prune out infected portions of trees and shrubs. Do not leave infected pruned materials, plants or soil in a greenhouse or nursery. Dispose of them immediately. When using pesticides, rotate products to decrease the chances of developing resistance.

Typical disease symptoms include:
**Leaf Spots:** Leaf spots are localized infections of leaves. Most are caused by fungi or bacteria, but some are caused by hail, insects, pesticide applications or drought stress.

Many fungal spot diseases require free moisture on the leaf surface to germinate and develop. Spots caused by fungi tend to be round in outline, while those of bacteria are often angular. Some fungi, such as those that produce tar spot, produce spots that are uniformly dark. Others develop as circular areas with dark margins. Fungi produce tiny fruiting structures. Many are dark and visible with a hand lens, particularly during periods of high humidity.

To avoid establishment of leaf spot diseases, prevent conditions that encourage extended periods of wet leaves. Encourage air circulation by leaving space between plants, particularly in greenhouses, or by pruning susceptible trees and shrubs to open up the canopy.

**Rusts:** Rusts are diseases caused by fungi and are named for the yellow to reddish spore masses they form on plant surfaces. Rust fungi have multiple spore stages and may require more than one host to complete their lifecycle. The rust-colored pustules break through the surface of leaf and stem tissue. The "rust" is easily rubbed off with your finger. Rust diseases occur on ash, potentilla, rose, chrysanthemum and many other ornamentals and greenhouse crops. Rust spores are spread by wind, splashing water and pruning tools. Fungicides applied at the first sign of the disease reduce its spread to uninfested plants. Some rust species develop black overwintering spores on leaves in the fall. Remove infected leaves from the nursery and greenhouse. Avoid overhead watering on plants if rust is known to be a problem.

**Canker:** Cankers are localized dead areas on twigs, branches and trunks. Hail, sunscald, pruning wounds, damage from improper staking and maintenance, as well as infectious agents, may cause cankers. Cankers caused by disease organisms appear as sunken areas on branches and trunks. The edge of the canker often, but not always, shows a thickened area or margin. Sometimes the bark within the sunken area will split or tear as it dries out. Reproductive structures may appear on the surface of the canker. Eventually the affected bark will fall away. Cankers cause the branch beyond the infection to decline or die. Cankers are considered serious because they kill limbs, or even entire plants. Biotic causes of cankers include fungi and bacteria. Some canker pathogens live only one season, while others are perennial. Some are capable of attacking healthy plants, while others attack only plants under stress.

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**To avoid establishment of leaf spot diseases, prevent conditions that encourage extended periods of wet leaves.**

Rusts are fungal diseases that form yellow to reddish spore masses on plant surfaces.

Cankers caused by disease organisms appear as sunken areas on branches and trunks.
The key to controlling canker diseases is to prevent them from becoming established. Select plants that are well-adapted to the proposed planting site. Keep healthy plants well-watered. Avoid wounding plants. Promptly remove all cankered areas to prevent the spread of the disease to other healthy plants or plant parts. Prune 6 to 8 inches below any sign of the infection. Disinfect pruning equipment between cuts and between plants. Common canker diseases include cytopspora canker, cypress canker and fireblight.

**Root Rots:** Root rots are difficult to diagnose because the affected portion of the plant is underground. Look at the entire root system of container plants and portions of an established system in order to diagnose root rot. When a root system deteriorates as a result of root rot damage, above-ground symptoms may include dieback, wilting, small leaves, dead leaves and increased seed production. These symptoms are similar to the damage caused by several abiotic disorders including over-watering, herbicide damage or mineral toxicity. Most fungi that cause root diseases occur naturally in the soil, and they usually persist for long periods of time. Infected roots may be enlarged, slimy, wet and dark in color. A laboratory analysis is needed to identify a specific root rot pathogen.

Root rots can be avoided by using soil mixes that drain well. Avoid overwatering which causes soggy soils. Reduce soil compaction. Fungicides, fumigation and pasteurization are used to treat potting soils to prevent root rots. New research indicates that some composted soil mixes have the ability to suppress certain root rot organisms. Nursery plants with root rot should not be used in landscapes, as they can introduce the disease into the soil.

**Viral Diseases:** Viral diseases cause changes in plant growth or coloration, and may kill plants. Common symptoms include stunting, mottling, mosaic patterns, lack of or reduced flowering, chlorosis, or changes in the normal development of leaves and buds. Viruses are spread by grafting, handling of diseased plants, insects and fungi. Smokers who pick up the disease on their hands while smoking cigarettes can transmit some viruses, such as tobacco mosaic virus, to healthy plants. Viruses are readily transmitted by knives or pruning tools. Because there is generally no cure for viral diseases, the plants must be destroyed. Tomato spotted wilt (TomSWV), tomato mosaic (TMV), lily fleck, and dasheen mosaic are viruses that may occur on greenhouse, bedding plant crops and ornamentals. Selecting virus-free plants with known resistance to common viral diseases is the best control strategy.

**Other Diseases:** Other diseases include blights, scabs, powdery mildew, smuts, galls and storage rots (commonly found on stored bulbs, corms, rhizomes or tubers). Powdery mildew is a common disease in Nevada. This
fungal disease has a wide host range. The mildew fungi grow over the surface of leaves, buds or fruit and secure themselves to the epidermal layer. A white to gray coating appears on the leaf surface, in some cases causing the affected plant to look as though it has been dusted with white powder. Heavy infestations cause premature leaf drop, stunted growth, "witch's broom" and russetting (brownish spots) of fruit. Many plants are susceptible to powdery mildew, including euonymus, rose, apple, chrysanthemum, numerous greenhouse crops and sycamore. Powdery mildew spreads by windborne spores. Unlike many fungal diseases, the spores do not need free water to germinate. Powdery mildew overwinters on evergreens and fallen leaves. Rain, direct sunlight and good air circulation inhibit the development of powdery mildew. Plants susceptible to powdery mildew should be placed in the nursery or greenhouse where air circulation and light penetration is best. Choose plant varieties that are resistant to powdery mildew whenever possible. Infected plants should be isolated and destroyed. Excessive fertilization and irrigation promote growth that is susceptible to powdery mildew. Avoid both, particularly on plants susceptible to powdery mildew. Once powdery mildew is established, it is usually too late for control measures to be effective. Sulfur or systemic fungicides can be applied at the onset of the disease to prevent its spread to uninfected plants.

Selected Cultural Practices for Managing Plant Diseases in Nurseries and Greenhouses

Become familiar with the common diseases of nursery and greenhouse plants. Act quickly to eliminate them.

- Inspect all plants brought on the premises and refuse to accept diseased plant materials.
- Provide good air circulation around plants.
- Avoid excessive humidity.
- Use soil that is pasteurized or otherwise pathogen free.
- Choose disease-resistant plant varieties.
- Select plants that are well-adapted to Nevada's climate.
- Avoid injuring plants.
- Practice good sanitation.
- Control weeds.
In the natural environment, where a finite number of plant species occur together, insects are normally kept in check by limited food supply, environmental conditions and natural predators. In greenhouses and nurseries, however, some insects may become pests because large numbers of susceptible plants are grown together in close quarters. Abiotic stresses or other injuries make plants more susceptible to insect attack.

Insects and related arthropods are responsible for many kinds of plant disorders. Their damage is often difficult to distinguish from that caused by disease or abiotic problems. Insect injury is confirmed by finding the causal insect. However, the insects you find on an injured plant may have nothing to do with the damage. Sometimes damage is observed only after the responsible insect has completed the damaging part of its lifecycle. It is important to become familiar with insect pests commonly found on plants in the nursery and greenhouse. Effective control measures require correct identification and a thorough understanding of the pest’s lifecycle and biology.

**Typical Symptoms of Insect and Arthropod Attacks**

**Leaf Spots:** Leaf spots are most frequently caused by plant pathogens. Sucking insects, such as leafhoppers, may also cause leaf spots. When an insect’s saliva is toxic to a plant, a dead spot may develop around the feeding site and holes may develop when the damaged tissue becomes brittle and falls out. Holes produced in this way are "BB" to pencil-sized and round. Because of the wounding, plant pathogens invade the tissue, adding to the disease-like symptoms.

**Branch Dieback:** Wood-boring insects, such as the bronze birch borer, damage plant vascular tissues, resulting in dieback of the infested limbs or branches. Branches damaged by other causes and weakened trees in general are particularly susceptible to insect borers. Diseases, environmental stresses, cultural problems, insects or a combination of these factors may cause branch dieback.

**Bronzing:** From a distance, trees heavily infested with spider mites appear discolored. Close examination of infested foliage reveals a bronze discoloration of the leaves. To confirm a diagnosis of spider mite injury, tap infested branches over a white piece of paper. Dislodged spider mites appear as tiny specks moving on the paper. Evergreen trees and shrubs located along dusty roadways, in areas of reflected heat or in windy hot sites, are most susceptible to mite infestations.
**Cankers and Swelling:** Many beetle larvae and caterpillars bore into tree trunks or limbs, causing the infested tissues to swell or form cankers. When these swellings are cut open, insect tunnels and sawdust-like frass is visible. Insect borers attack trees that are weakened or damaged by other causes. In some cases, borers and plant pathogens are associated with the same canker.

Locust borer is an example of a round-headed borer that causes swelling on infested tree trunks and branches of black locust trees.

**Chewed or Skeletonized Leaves:** Leaf beetles and some sawflies chew off one surface of a leaf, leaving the opposite surface and veins intact. This type of insect damage makes the leaves look like lacy skeletons. Elm leaf beetle and pear slugs are two examples of leaf skeletonizers. Most caterpillars and adult beetles chew entirely through leaves, leaving small to large holes or irregularly shaped, jagged leaf edges. If leaves are still growing when a chewing insect feeds, the leaves may later develop smooth edges around the holes. Only insect feeding causes these symptoms.

**Premature Leaf Drop:** Plant pathogens or environmental problems generally cause premature leaf drop. However, heavy infestations of aphids, mites or scale insects can also cause leaf drop.

**Leaf Curling, Puckering or Rolling:** The saliva of some sucking insects, particularly aphids, may cause plant leaves to curl, fold or pucker. These symptoms can be confused with plant diseases that cause similar symptoms. The causal insect may be found by inspecting the damaged area. Some caterpillars, called leaf rollers or leaf tiers, use silk threads to hold leaves in curled or rolled shapes.

**Leaf Miners:** Plants that are heavily infested with leaf miners appear brown, as if the leaves are dying. Leaf miners feed inside leaves between the upper and lower leaf surfaces. Some miners tunnel randomly through the leaf and others form chambers while feeding. Hold the leaf up to a light source and the tunnels will be easily observed. If the chambers are opened up, brown frass and a worm-like larva may be found between the leaf surfaces. Leaf miners frequently occur on greenhouse crops, such as chrysanthemums and cineraria, and on landscape trees, such as birch, alder and poplar.

**Stem and Leaf Galls:** A gall is an irregular growth of tissue by the plant in response to wounding caused by pathogens or insects. The shape of the gall formed is often characteristic of the causative organism. Several arthropods form galls, including gall wasps, gall midges, aphids, adelgids, eriophyid mites and sawflies. Some families of gall-forming insects are so diverse that a gall-forming species exists within the family for almost every common tree.
species. Although stem and leaf galls may be caused by plant pathogens, leaf galls are usually caused by insects or mites. Some gall-formers are tiny and can only be seen with a hand lens or microscope.

**Gumosis or Pitch Flow:** Many trees respond to trunk or twig injury by exuding sap or pitch from the injured area. This pitch flow may be a tree defense mechanism to prevent additional injury from insects and disease. Wood-boring insects and bark beetles often cause plants to exude pitch into the feeding site. Plant pathogens, environmental stress and mechanical injury can also induce pitch flow.

**Root Damage:** Nematodes and the larvae of some insects, such as root weevils, feed on and can seriously damage roots. Because roots are not readily visible, diagnosing insect injury to roots is difficult. The primary symptom is a gradual decline in plant vigor. The characteristic notches that the feeding adults make in leaf margins normally diagnose root weevils. Injury by these pests often provides a route for disease to enter and infect the plant.

**Controlling Insects in the Nursery and Greenhouse**

Predators, parasites and pathogens keep insect pests under control naturally. Ladybird beetles, lacewings, predatory mites, parasitic wasps and other natural enemies devour or parasitize aphids, scales and mites. Disease also reduces insect populations. Without beneficial organisms, populations of pest insects would rapidly increase. Nursery and greenhouse personnel should protect and encourage these beneficial organisms. They should learn to identify the life stages of beneficial organisms and integrate them into the pest management program. Many natural enemies for greenhouse pests are available commercially. Biological control using natural enemies in greenhouses is widely practiced throughout the world.

Sometimes, however, cultural practices and natural enemies do not provide sufficient control of insect pests. In these situations, apply insecticides to suppress pest populations and prevent unacceptable damage. Insecticides are generally broad spectrum in their activity; that is, they will kill a variety of insects, including natural enemies or beneficial insects. Whenever possible, use the least toxic pesticide available, such as horticultural spray oils, microbial insecticides (Bt) or insecticidal soaps.

Even though an insecticide has been applied, the application may not be effective. Below are reasons why insecticide applications may not result in adequate control:

**Correct Timing and Thorough Application:** The best, safest and most effective insecticides available will not control insects effectively if they are not
applied correctly and at the proper time. Insecticides must be applied when pests are present and vulnerable, and at the rates listed on the product label. You must ensure thorough coverage of upper and lower leaf surfaces, branches or trunks.

Correct timing is important. Many insects are easiest to control when they are young. Scale insects are an example of common pests that are effectively controlled immediately after the larvae have emerged, when they are in the vulnerable "crawler" stage. During this stage, which lasts about a week, the crawlers are unprotected and easily killed. Once the larvae secrete protective coverings over themselves, they are difficult to kill. Pesticides applied after this stage are not usually effective.

Incorrect Insecticide: No insecticide controls every insect, and if the wrong chemical is used, you will get little or no control. Make sure you identify the target pest correctly and then select an appropriate pesticide. The product you use must be labeled for use in nurseries and/or greenhouses.

Adverse Weather: Most insecticides do not perform efficiently or give satisfactory results when used at temperatures below 50°F. Rain may wash off insecticides that haven't yet dried. Wind alters spray coverage, preventing sprays from reaching target organisms and carrying insecticides into sensitive areas that should not be treated. It's usually best to apply insecticides when temperatures are above 50°F but below 95°F, and when no rain is expected for at least 12 hours.

**Weeds**

A weed is any plant growing where it is not wanted. Elm trees growing in a landscape may be desirable. Elm seedlings coming up in nursery containers are weeds.

Control weeds while they are small and immature, before they go to seed or develop extensive root systems. If allowed to produce seeds, more weeds will grow next season. Weed seeds can survive for years in the soil. Some seeds require light in order to germinate and grow. Disturbing the soil can bring weed seeds to the surface, resulting in a new crop of weeds. Methods of controlling weeds in the nursery and greenhouse vary with the type of weeds, time of year, the crop grown and the environment conditions present at the time.

**Types of Weeds**

Weed identification is the first step to effective weed control. An excellent weed identification guide is *Weeds of the West*, by Tom D. Whitson, Editor,
which provides an identification key and detailed color photos of hundreds of weeds found in Nevada.

**Annual** weeds sprout, grow, produce seed and die in one growing season. They represent the majority of weeds. Annual weeds reproduce only by seed and do not have underground reproductive roots, rhizomes or bulbs. Annual weeds are normally considered easy to control when small, but are very persistent because of their fast growth and abundant seed production. Winter annual weeds germinate at low temperatures in fall or late winter following rainfall. They grow rapidly and go to seed in spring. Summer annual weeds germinate in spring when soil temperatures rise and produce seed from summer into late fall, depending upon the species. Destroy annual weeds to avoid competition and seed production. Common annual weeds include cheatgrass, crabgrass, pigweed, prostrate knotweed and ragweed.

**Biennial** weeds also reproduce primarily by seeds, but have underground storage roots, crowns, bulbs or other organs to survive during winter. Biennials typically form a short leafy rosette of leaves the first season, store food in a root or crown, and then go dormant for the winter. The next spring, the stem elongates, produces flowers and seeds, and then the plant dies. Biennials, like annuals, are most easily controlled as seedlings. Burdock, bull thistle, wild carrot, wild parsnip, and mullein are common biennial weeds.

**Perennial** weeds are the most difficult to control. They reproduce by seeds and usually also by vegetative parts, such as underground crowns, roots, rhizomes, stolons, tubers and bulbs. Cultivation is not very effective in controlling perennial weeds unless the entire weed, including underground parts, is removed or unless new growth is removed frequently and repeatedly until all root reserves are used up. Cultivation often spreads underground parts that sprout and spread the weed colony. Canada thistle, tall whitetop, bindweed (morningglory) and quackgrass are perennial weeds.

**Weed Control Methods**

There are five basic methods used for weed control: prevention or exclusion, cultural, mechanical, biological, and chemical.

**Prevention or exclusion** control methods are those that prevent weeds from becoming established. Don’t accept plant material or other items that are infested with weeds or weed seeds or roots. One of the most useful methods in the nursery and greenhouse setting for controlling weeds is the use of mulches. Organic and inorganic mulches help control weeds. They prevent light from reaching weed seeds or seedlings. Natural organic materials, such as chipped or shredded bark, grass clippings and pine needles, are often used as mulching materials. Many inorganic mulches are available. To improve the
weed control ability of both, weed control fabric can be used under the mulch. Sheet plastic under mulch is not recommended.

- Gravel and rock are frequently used as mulches. While they do not improve the soil structure or provide nutrients, they last longer than organic mulches. However, weeds can grow between rocks.

- Organic and inorganic mulches should be two to four inches deep to prevent weed growth. Greater depths can be used around trees and shrubs planted in the field, but keep the mulch back about four to six inches from trunks to ensure good air circulation and reduce the potential for crown diseases.

- Woven plastic landscape fabrics can be used as weed barriers under mulch, especially around trees and shrubs. The fabrics allow adequate water and air movement into and out of the soil. They are usually covered with organic mulches or gravel to improve the appearance and increase the life of the fabrics, which are subject to breakdown when exposed to light. Even with the heaviest weed barrier fabrics, however, some weeds penetrate and grow. When mulches cover the fabrics, weed seeds can germinate and grow in the mulch above the weed barrier fabrics.

**Cultural Control:** Cultural controls for weeds include the strategies and methods we use to grow and maintain healthy plants. Cultural practices, such as proper fertilizer application, appropriate watering, soil management, rotating plantings and good sanitation, will help reduce the incidence of weeds and other pests.

**Mechanical Control:** Physical removal or incorporation of weeds reduces weed competition and improves appearance. The main disadvantage is the amount of time, effort and money it takes if weeds are well-established and numerous. Weeding on a regular schedule will help reduce the amount of effort needed.

Weeds are much easier to control while they are small seedlings rather than when their roots become fully established. One chop with a hoe can remove dozen or more seedling weeds, but it may require three or four chops to remove one well established older weed.

The best time to pull weeds is when the soil is loose and moist. If the soil is hard and dry, postpone weed pulling until the day after an irrigation cycle or rain has occurred. Grasp weeds as close to the ground as possible in order to avoid breaking stems. New weed shoots can develop from crown and root sections if the weed breaks off.
A hoe is a cutting tool and the blade should be kept sharp. Hold the blade parallel to the soil and cut weeds right at the soil line, disturbing the soil as little as possible. This avoids bringing buried weed seeds to the soil surface, where they may sprout. Some people prefer double-action hoes designed with sharp edges on both the back and front of the blade, because they can cut weeds with both forward and reverse motions. Double-action hoes are not very effective in hard, dry soils.

Most annual weeds dry up in a few days if left where they are hoed. Do not irrigate immediately after hoeing. Prostrate succulent weeds, such as purslane and spurge, store water in their tissues and can survive several days until they can regrow new roots from stems. Remove these weeds after hoeing. Perennial weeds will usually sprout from underground plant parts and are best controlled by other (non-mechanical) means.

Weed hoes, mowers and tractor-pulled or driver cultivators effectively bury, cut, disk or incorporate weeds. Again, for effective control, cultivate weed-infested areas when the weeds are small. Do not cultivate if the weeds are perennials that will produce new plants from the cut parts of the original plant, as plants will regrow from root fragments.

**Biological Control:** Biocontrol of weeds is most successful in sites such as rangeland or pasture land, rather than nurseries and greenhouses. Numerous weed-feeding insect species have been introduced into the United States to control specific weed species. To be effective, there must be a large enough weed population to allow insects to feed, reproduce and spread. Recent work with plant pathogens has demonstrated some potential for weed control. For example, a newly discovered variety of the fungus *Verticillium dahliae* attacks seedlings of velvetleaf, a common Midwest weed.

**Chemical Control:** The effectiveness of herbicides is affected by environmental factors. Air and soil temperatures, humidity, rainfall or irrigation, and wind all influence the effectiveness of herbicides. Some herbicides are not absorbed or translocated (moved from one part of the plant to another) at low temperatures. High temperatures cause some herbicides to volatilize, reducing the chemicals' effectiveness and increasing the potential for herbicide vapors to damage nearby desirable plants. This is particularly true for herbicides applied in greenhouses. Wind greatly increases the risk of herbicide drift onto desirable plants.

The type of soil can affect soil-applied herbicides by decreasing their effectiveness or increasing it to damaging levels on otherwise tolerant plants. Some herbicides are absorbed and inactivated when applied over
organic mulches or on clay soils. Groundwater contamination has occurred when soil-applied herbicides are used on sandy soils.

The age or growth cycle of a plant can affect herbicide absorption and translocation within the plant. The older the plant, the less responsive it will be to herbicides. The depth and degree of establishment of a plant’s root system can affect its response to soil-applied herbicides.

It is very important to read all directions and precautionary statements on herbicide labels before applying or recommending application. The herbicide label is the law. Be sure to note weather and other factors that affect the use of a particular product. **Never use or recommend an herbicide for an application or site that is not included on the label.**

**Types of Herbicides**

Herbicides are classified into types based upon their use and mode of action.

**Preemergence herbicides** are often referred to as "weed preventers". They kill germinating weed seeds or seedling weeds. Most have little effect on established plants, but some can damage existing plants. They often do not kill established perennial weeds that emerge from underground roots or other storage organs, but reduce the establishment of new perennial weeds from seed. Preemergence weed killers are applied prior to the appearance of weeds or after established weeds are killed or removed.

Most preemergence herbicides are applied to the soil surface and then either watered in or mixed into the top inch of soil with a rake. Failure to water in or incorporate the herbicide often results in poor weed control. When the soil is disturbed by cultivation, the chemical barrier formed by a preemergence herbicide is also disturbed and weed seeds can germinate and grow. The length of control provided by different preemergence herbicide varies from a few weeks to several months or even years.

Preemergence weed killers are most often used to kill weeds around perennial woody plants with well-established root systems. Some are used to control weed germination in lawns.

"Garden weed preventers" are recommended for use around established vegetables and flowers. These are applied after seeds have germinated and the first crop of weeds has been removed. With some flowers and vegetables, weed preventers can be applied immediately after transplanting. Some species, however, are stunted or damaged unless you allow their root systems to become established for at least two weeks before applying the herbicide.
Preemergence "crabgrass preventers" are available for use on lawns. These products are applied in late winter or early spring to prevent the germination of crabgrass and other warm weather summer weeds. These products are often combined with fertilizers.

Longer-lasting preemergence herbicides are often called soil sterilants. These are herbicides that are applied to the soil to prevent any plants from growing in an area for a prolonged period of time (several months to several years). Soil sterilants should never be applied to areas where you plan to plant in the future. Because they last so long, there is greater risk that these products will contaminate water supplies. Although they are useful for weed control in driveways and along fencerows, take care to avoid contacting the roots of desirable plants. Large trees and shrubs have root systems that can extend far beyond their drip lines.

Post-emergence herbicides kill established weeds but may or may not prevent new weeds from developing from seeds or underground organs. These herbicides are divided into two types: contact and systemic. Contact herbicides kill only those plant parts with which they make contact. Systemic herbicides are absorbed by roots, stems or leaves and are moved throughout the plant. Contact weed killers are effective in controlling small weeds and annual weeds. Systemic herbicides provide control of perennial weeds because the chemical moves into and kills plant roots.

Selective herbicides are designed to kill only certain plants, leaving others undamaged. For example, some products may only be effective on broadleaf weeds, while others may only kill grasses. They damage desirable plants if applied incorrectly. Common mistakes include applying more than the recommended rate, applying the herbicide when temperatures are too high, applying it to sensitive desirable vegetation, or applying it before plant root systems have become established.

Non-selective herbicides are toxic to all susceptible plants. They are used where it is desirable to kill all vegetation or where application can be directed away from desirable plants. Non-selective herbicides are often used to kill weeds before planting or replanting. When applying them in an established landscape, special application methods or equipment, such as wipers, can be used. Desirable plants can also be covered to prevent the herbicide from contacting them. Diquat and glyphosate (Roundup®) are examples of non-selective herbicides.

Because it is very difficult to remove all herbicide residues from sprayers, even with repeated rinsing, use one sprayer only for applying herbicides and another, separate sprayer for all other pesticides.

Soil sterilants should never be applied to areas where you plan to plant in the future.

Contact herbicides kill only those plant parts with which they make contact.

Systemic herbicides are absorbed by roots, stems or leaves and are moved throughout the plant.

Selective herbicides are designed to kill only certain plants.

Non-selective herbicides are toxic to all susceptible plants.
Making Weed Control Decisions

- Identify the weeds or types of weeds present.
- Identify all plants in the treatment area.
- Select the method of control appropriate for the setting that will effectively kill the weeds without harm to desirable plants. Choose the safest control methods and chemicals available for the crop, applicator and the environment.
- If an herbicide is selected, READ THE ENTIRE LABEL and follow all label instructions and precautions.
- Follow all safety procedures when handling the pesticide. Apply on a calm, cool day to prevent drift and volatilization from injuring non-target plants.
- Make sure you have the necessary application equipment to apply the herbicide correctly and that the equipment is in good condition.

Vertebrate Pests

Vegetable pests can occasionally be a problem in the greenhouse or nursery setting. Refer to the General Knowledge: General Pest Problems chapter of this manual for information on controlling specific vertebrate pests.

Conclusion

Category 11, Nursery and Greenhouse Pest Control, involves both the management of pesticides and controlling pests in nurseries and greenhouses. The Worker Protection Standard (WPS) applies to nurseries and greenhouses. Pest control in nurseries and greenhouses is complicated by the density of plantings, the presence of work personnel and the possible presence of customers or other members of the public. Consider these additional factors when planning pest control programs in these areas.

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READ THE ENTIRE PESTICIDE LABEL and follow all label instructions and precautions.

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