K-State Research and Extension

IPM

INTEGRATED PEST MANAGEMENT
& PESTICIDE SAFETY EDUCATION

Interior Landscape Pest Management

K-STATE
Research and Extension

Kansas State University Agricultural Experiment Station
and Cooperative Extension Service

Category 3C

Table of Contents

Directions for Using this Manual

This is a self-teaching manual. At the end of each major section is a list of study questions to check your understanding of the subject matter.

These study questions are representative of the types that are on the certification exam. By studying this manual and answering the study questions, you should be able to gain sufficient knowledge to pass the Kansas Commercial Applicators Certification examination. Correct answers appear on page 35.

Introduction

In Kansas, subcategory 3C is titled, *Interior Landscape Pest Management*, and is defined as follows: "This subcategory shall include any commercial application of a pesticide to control pests in the production and maintenance of houseplants and other indoor ornamental plants maintained or located within structures occupied by humans, including houses, apartments, offices, shopping malls, and other places of business and dwellings."

Plants are used in interiorscapes primarily for aesthetic purposes. But growing indoors does not exempt plants from attack by a wide array of insect, mite, disease, weed, and nematode pests. Pest management associated with interiorscapes in public areas is a highly sensitive issue. Because of public access to these plants, pest management must be safe to humans and many different plant types. Pesticide selection and application method are important criteria to consider.

A complicating factor in interiorscape pest management is that plants may have originated from greenhouses where intensive pesticide use may have led to pesticide resistance. Consequently, some ornamental plants may be infested with pesticide-resistant pests when incorporated into malls, banks, and restaurants. Pest management may be more labor intensive because pesticide selection is limited to those labeled for interiorscape use.

The physiological condition of interiorscape plants is different from those grown in greenhouses. For example, interiorscape plants endure suboptimal light, water, and temperatures for sustained growth, and often are exposed to excessive soluble salts. Under most interiorscape conditions, plants experience maintenance, rather than normal growth. These less than ideal growing conditions expose plants to physiological stress. Plants experiencing stress tolerate fewer insects, mites, and diseases, and the effects of such pest attacks are much more damaging than they would be to healthy plants.

Cultural practices such as appropriate watering and sanitation should be the first line of defense in pest management of interiorscape plants. The next section on environmental management provides guidelines on maintaining overall plant health.

Pesticide-based pest management of ornamentals grown in restaurants and food-handling establishments must be conducted with extreme care to avoid contaminating food and eating utensils. Plants should be moved outdoors or to an isolated area for treatment if possible. If not, eating utensils and food handling surfaces should be covered. Areas that may have been contaminated during treatment must be thoroughly cleaned before replacing food or eating utensils.

Another consideration associated with interiorscape pest management is that various inert ingredients, including petroleum distillates used to dissolve pesticides, may permanently stain, blister, or damage fine-wood paneling or paints used in malls, atria, lobbies, restaurants, and offices. To obtain appropriate management, pesticides must be applied thoroughly to cover all plant parts. Consider using polyethylene film to protect paneling and furniture during treatment.

A key to managing pests and diseases in interiorscape environments is to avoid plant stress by using plants that tolerate indoor conditions, and provide proper care including water and fertilizer.

Environmental Management

Foliage Environment

Besides insects, mites, or plant pathogens, the main environmental factors affecting plant growth are light, temperature, and relative humidity.

Light: Generally, insect and mite pest problems are more likely to occur under high-light, long-day conditions of a greenhouse or outdoor plant production area. In most cases, indoor light is not conducive to pest development, but pests will survive, especially on stressed plants.

Direct sunlight is unsuitable for most plants because of excessive heat and leaf drying. Most indoor environments do not have sufficient light for vigorous plant growth, but there may be enough light for maintenance growth.

Plants adapt to varying amounts of light as long as it does not fluctuate widely. Proper acclimatization minimizes potential pest and disease problems and can be accomplished by moving plants from an area of high light intensity to an area of low light intensity gradually over three to four months. Another option is to purchase acclimatized plants ready for installation. Not all foliage plants exhibit effects of low-light acclimatization or need to be acclimated, but it is a sound general practice.

Symptoms of improper acclimatization resemble those caused by pests or diseases. For example, leaves of the weeping fig, *Ficus benjamina,* turn yellow and drop if moved abruptly from a high-light environment to a low-light environment. Spider mites, scales, and mealybugs also can cause leaf yellowing and leaf drop. Always acclimatize plant material before introducing it to the interiorscape.

Temperature: The effects of temperature on plants and pests are generally easier to deal with than the effects of light. Most interiorscape plants are tropical plants that are not usually found in areas with cool nights. Cool nights are desirable, but the temperature should never be less than 50°F.

Temperature fluctuations may damage foliage plants. In many commercial interiorscapes, heating and air conditioning units are turned off on weekends. This may result in problems during summer when temperatures tend to increase and in winter when temperatures decline. Infestations of the fungal disease, gray mold (*Botrytis cinerea*), can proliferate under these conditions.

Many problems occur when plants are placed near doorways, windows, or heating ducts and exposed to cold or hot drafts. Watering plants with cold tap water can shock plants, resulting in permanent root damage.

Relative Humidity: The dry atmosphere indoors during the winter may stress plants, so they require more time for maintenance. This is especially true for plants exposed to only a few hours of direct sunlight during the day. During the summer, air conditioning reduces relative humidity. Incoming sunlight increases leaf temperatures and the need for rapid transpiration to cool plant leaves. If the

growing medium is slightly dry, as is common in commercial interiorscapes, plant leaves desiccate or dry out. This can promote problems with spider mites.

Effective pest and disease management often involves raising the relative humidity of the environment. This can be done by placing potted plants on trays filled with pebbles and water, locating plants near interiorscape fountains, and installing humidifiers on furnace systems in homes or office buildings.

Temperature and relative humidity affect some pests directly. Spider mites, for example, survive best in warm, dry conditions. Drought-stressed plants are more favorable for development. Stabilizing environmental conditions to minimize plant stress will help avoid outbreaks of insects, mites, or diseases.

Root Environment

The root system, which facilitates uptake of water and nutrients, is important to a plant's health and growth. Most root-rotting fungi attack damaged roots. In fact, many root pathogens are called, "secondary" or "weakly pathogenic" because they are less likely to infect a healthy root system.

The root environment can be categorized into physical makeup and nutritional factors. Parameters that consitute a sound physical root environment can vary depending on plant type. For example, some plants require a growing medium pH of less than 7 or more sufficiently aerated growing medium than other plants. In general, the pH of the growing medium should be between 5.5 and 6.8 and contain amendments that provide adequate aeration (about 20 percent air-filled pore space). The growing medium should have a water-holding capacity of about 40 percent based on weight. These parameters can be measured easily, and most plant health care managers have adopted routine measurement procedures.

One consideration regarding preparation and use of growing medium is stability or time required for it to break down over an extended period. Plants remain in interiorscapes for a long time. If the growing medium does not have good stability and there is extensive compaction and breakdown, root damage can occur.

Interiorscape plants, especially those grown under low-light conditions, require minimal fertilization. For best results, apply fertilizers during the summer when light levels are higher. Use well-balanced fertilizers that contain both macronutrients and micronutrients.

Water thoroughly at every watering. Unless water percolates through the growing medium in the container or bed, soluble salts may build up to harmful levels. Salt-damaged roots are susceptible to infection by root-rot soilborne diseases, particularly when the growing medium is allowed to become too dry. In some cases, the growing medium may be difficult to rewet. Water may move through a portion of the growing medium, but fail to moisten the container evenly.

Environmental Management

Interiorscape technicians should know how to acclimatize plants so they can tolerate less frequent watering. This is similar to acclimating plants to higher light conditions. Many plants adapt to being kept dry. They are more likely to survive in interiorscapes. Allowing the growing medium to dry out may increase spider mite populations or create a buildup of soluble salts.

Overwatering is unusual in interiorscapes because most planters or containers have drainage holes, or excess water is removed via leaching. Some plants need consistently moist growing media, while others thrive when allowed to dry out between waterings. Check watering guidelines for the particular species. Apply water that is room temperature, not hot or cold.

Some growing media available in small packages for consumers, is poorly constituted and may lead to problems because it retains moisture too long. The fungal root rot pathogens, *Pythium* and *Phytophthora*, can cause severe problems when the growing medium is waterlogged or excessively wet.

Remove water that drains into saucers after watering. Use a siphon system to drain water from the bottom of containers and planters that do not have drainage holes. A growing medium that compacts and settles over time is more susceptible to overwatering problems. Remove plants from containers occasionally to determine if they are staying too wet for long periods of time. For large plants, use a soil probe or similar device to routinely check growing medium moisture and water penetration.

Diagnosing Problems

Plant problems should be diagnosed quickly to avoid plant death and insect or mite pest outbreaks.

Diagnosis involves three steps:

- identifying the problem,
- determining the cause or causes,
- developing a solution.

This process should be approached systematically. See *Table 1* for guidelines.

Interiorscape technicians monitor for the appearance of symptoms. A symptom is defined as a noticeable or abnormal condition. Technicians should anticipate and recognize symptoms early to avoid serious problems.

Many methods are available to determine the cause of plant symptoms. The most common is to use a 10X hand lens or magnifier to view plant tissue. Spider mites and other pests or powdery mildew can be quickly diagnosed in this manner.

The technician should examine both upper and lower leaf surfaces and try to determine how long a certain symptom or set of symptoms has been present.

Knowledge and experience can be helpful in diagnosing plant problems, which vary depending on time of year and plant type. Schefflera, for example, is particularly susceptible to spider mites, while grape leaf ivy is prone to powdery mildew.

Table 1. Guidelines for Diagnosing Plant Problems in Interiorscapes

Symptom	Possible Causes
Brown or scorched leaf tips	Poor root health or roots damaged due to overwatering, excessive drying of growing medium (especially between waterings), excessive fertility or build up of soluble salts in the growing medium
	Specific nutrient toxicities such as fluoride, copper, or boron
	Low relative humidity
	Pesticide or mechanical injury
Spots, blotches, blemishes, or blisters on plant leaves	Intense light (sunburn) associated with recent movement of plant or drying out of growing medium
	Chilling injury (below 50˚F)
	Chemical spray injury
	Overwatering
	Fungal or bacterial infections, usually rare unless plants come from a field or greenhouse.
Foliage yellow-green, older leaves	Insufficient fertility, especially nitrogen
	Poor root health due to being pot-bound, compacted growing medium, or insufficient drainage
	Insufficient light
Foliage yellow-green, newer leaves	Imbalanced growing medium pH (acidity)
	Imbalanced micronutrients
Foliage yellow-green, general	Too much light
	Insufficient fertility
	Exposure to high temperatures, especially when associated with low relative humidity
	Insect infestation or root rot disease
Leaf drop	Poor root health due to overwatering, growing medium drying out, excessive fertility or build up of soluble salts in the growing medium, compacted growing medium, or pot-bound plants (restricted root system)
	Sudden change in light, temperature, or relative humidity
	Root rot disease

Environmental Management

Symptom	Possible Causes
Wilting of foliage	Poor root health due to overwatering, growing medium drying out, excessive fertility or build-up of soluble salts in the growing medium, compacted growing medium, or a poorly drained container
	Alcoholic beverage or cleaning solution poured into growing medium
Roots brown in color; soft or rotted, roots with tissue that can easily be "sloughed off" leaving behind the string-like center tissues; roots massed at top or bottom of container	Poor root health due to overwatering, growing medium drying out, excessive fertility or build-up of soluble salts in the growing medium, compacted growing medium, or a poorly drained container
	Toxic chemical poured into growing medium
	Overwatering or underwatering
	Root rot disease
Yellowed leaves with tiny speckling; leaves later bronzed and dry; webbing near growing point.	Twospotted spider mites
Leaves covered with a sticky substance; mold growing on leaves; small brown or white objects on leaves or in crotches of branches; leaf drop or branch dieback; leaf or growing point distortion	Scales or mealybugs

Generally, plant problems do not arise from an isolated cause. A number of factors may contribute to a plant's susceptibility to insect and mite pests or diseases.

The technician should keep good records, and gather as much information from them as possible to diagnose symptoms. The most difficult problems to diagnose are those associated with non-specific symptoms (*Figure 1*). Leaf yellowing, leaf drop, or browning leaf tips (*Figure 2*) are examples of symptoms not associated with a specific cause.

Environmental and cultural factors can lead to problems in the root environment that are manifested as root damage and distinctive

symptoms. Some may be infectious diseases, while others may be noninfectious problems.

The technician should inspect roots carefully to assess the problem. A soil probe can be used to remove a core of growing medium to observe conditions at the bottom of containers or planting beds.

Methods that can be used to correctly diagnose root problems include the following: test growing medium nutrient and salt content, investigate growing medium components, determine growing medium aeration and drainage, analyze water quality, assess fertility program, conduct a site analysis, and request laboratory culturing of root tissue.

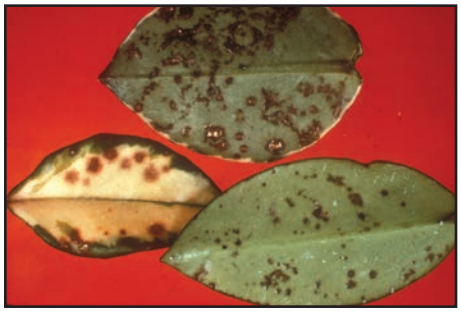

Figure 1. Pesticide spray injury

Figure 2. Brown or yellow leaf tips

Introduction and Environmental Management

Study Questions

These study questions are designed to help you learn the material on pages 3 through 9.

1. *In Kansas, subcategory 3C is titled:*
   a. Ornamental Pest Control
   b. Agricultural Pest Control
   c. Turf Pest Control
   d. Interior Landscape Pest Management
2. *Pest management of ornamentals in restaurants and food handling establishments may involve:*
   a. removal of plants before treatment
   b. covering surfaces and eating utensils before treating plants
   c. cleaning all surfaces and eating utensils after treatment
   d. all of the above
3. *Generally, pest problems are more severe under:*
   a. low-light, short-day conditions
   b. continuous light conditions
   c. high-light, long-day conditions
   d. dark conditions when plants are established
4. *Improper acclimatization may cause symptoms that are confused with:*
   a. insect (pest) problems
   b. disease problems
   c. a and b above
   d. none of the above
5. *Many problems occur when plants are placed:*
   a. near doorways
   b. near windows
   c. near heating/air conditioning ducts
   d. all of the above
6. *Combinations of temperature and relative humidity fluctuations affect pests such as:*
   a. spider mites
   b. powdery mildew
   c. a and b above
   d. none of the above
7. *Fertilization of interiorscape plants is best conducted in the:*
   a. spring
   b. summer
   c. fall
   d. winter
8. *An excessively dry growing medium may lead to:*
   a. extensive root growth
   b. spider mite population buildup
   c. soluble salt damage to roots
   d. b and c
9. *What may cause older leaves to turn yellow-green:*
   a. pesticide spray
   b. poor root health
   c. insufficient light
   d. b and c

10. To correctly diagnose a plant problem you need the following:

a. rubber gloves

b. a microscope

c. a camera

d. a large chemical kit

11. One of the most difficult problems to diagnose and determine the actual cause is:

a. nonspecific symptoms

b. excessive soluble salts

c. spider mites

d. fungal root rots

12. Methods that can be used to diagnose root problems include:

a. testing nutrient and salt content

b. visually assessing growing medium aeration and drainage

c. laboratory culturing of root tissue

d. all of the above

Common Diseases

Figure 3. Brown leaf spots on palms

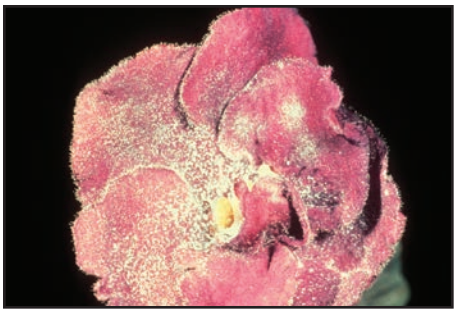

Figure 4. Powdery mildew on African violet

Figure 5. Fungal leaf spots

Infectious Diseases

The first line of defense against plant diseases is to avoid introducing pathogens into the interiorscape. If purchased plants are disease-free, infectious diseases will rarely become a problem. The many foliar leaf spots and blights that occur on plants growing outdoors or in production greenhouses usually will not be a problem in interiorscapes because of the lack of high relative humidity and water-splash. Most plant-pathogenic fungi and bacteria will not spread in dry conditions. If not extensive, affected leaves may be physically removed by the interiorscape technician.

Identifying infectious diseases on flowers, leaves, and stems usually is more difficult than identifying insect or mite pests because fungal or bacterial pathogens are too small to see with the naked eye (*Figure 3*).

There are four major categories of plant pathogens: fungi, bacteria, viruses, and nematodes. The sections below will describe each category.

Fungal Diseases

Fungi produce a variety of symptoms, including leaf spots, root rots, and stem rots. Fungi spread by producing spores which can be spread by splashing water or air currents. Most fungi thrive under wet conditions and do not grow well under dry conditions.

Fungal Leaf Spots and Blights

Fungi, generally associated with leaf spots and blights, are spread by splashing water onto plants. Common species include *Cercospora, Colletotrichum, Curvularia,* and *Alternaria. Botrytis* or gray mold, which has a wide host range, will produce spores, but only causes an infection under high relative humidity — greater than 80 percent. Many leaf-spotting fungi require moisture on leaf surfaces for 6 to 8 hours for an infection to occur.

On leaves, look for circular lesions on infected tissue. Sometimes circular lesions overlap with another lesion, giving leaves a blotchy appearance. Concentric rings in the lesion, which look like a bulls-eye, are another sign. Sometimes fungal spore production can be observed. Look for fluffy, moldy growth on the leaf surface, which is characteristic of a powdery mildew infection, as described below (*Figure 4*).

In addition, look for black, pinpoint-like pustules within the lesion. These pustules are fungal structures where many spores are produced. Many different fungal pathogens may be found on a variety of foliage plants grown in interiorscapes, producing lesions of different sizes, shapes, and colors (*Figure 5*).

Cultural practices should be used to prevent fungal leaf spots. Avoid splashing water and extended periods of leaf wetness. Remove and discard infected leaves. Fungicides are not recommended for interiorscapes, but some products may be labeled for such uses.

Powdery Mildew

Most powdery mildew fungi are plant specific. Kalanchoe is an example of a plant that tends to become infected with powdery mildew. The white growth present on leaves, flowers, or stems is the fungus proliferating or growing on the surface (*Figure 4*). Small structures, called haustoria, grow within plant cells to obtain food. Powdery mildew will usually not kill a plant, but the unsightly fungal colonies may greatly reduce plant quality or appearance.

In order to avoid problems with powdery mildew in interiorscapes, reduce relative humidity during the evening by not watering late in the day. Avoid drafts associated with cold windows, entryways or air conditioning.

Root and Stem Diseases

Infectious root rots caused by a fungus may be diagnosed, to some extent, by direct observation of the root system. Off-color or brown to black colored roots often indicate a problem associated with a root-rot pathogen. If removing the outer root tissue reveals a string-like cortex layer, this may indicate that a root-rot pathogen is involved. To determine the actual health of a root system, you need to know what a healthy root system looks like. In general, a healthy root system will have distinctive white roots that are distributed uniformly throughout the growing medium.

The fungus *Rhizoctonia* spp. lives in the growing medium and attacks a wide variety of plants used in interiorscapes. Species of *Fusarium* and *Thielaviopsis* also may attack certain plant species. All these fungi may persist in the growing medium for months via specially adapted resting structures (spores).

Managing these fungi involves growing medium pasteurization and implementing thorough sanitation programs. Avoid purchasing stressed plants or those with discolored roots or stems. Do not overwater plants, and make sure the growing medium drains well. In general, fungicide use should be avoided, and cultural practices and sanitation should be utilized instead.

Water Mold Root and Stem Diseases

Pythium and *Phytophthora* are called water molds because they have a spore stage that is adapted to swimming in water. These fungus-like pathogens attack a wide variety of plants, causing root rots and stem rots. Aboveground symptoms include plant yellowing or stunting. Root symptoms include poor root growth, dark coloration, and a soft texture.

Both *Pythium* and *Phytophthora* are usually not a serious problem in interiorscapes unless plants are overwatered or the growing medium does not drain well. Furthermore, old growing medium may retain too much moisture, leading to problems with *Pythium* and *Phytophthora*.

Avoiding problems with *Pythium* and *Phytophthora* involves using a growing medium that drains well and has plenty of air space, and not overwatering plants in interiorscapes. Also, avoid applying too much fertilizer, especially nitrogen-based fertilizers, as this may result in an accumulation

Figure 6. Bacterial soft rot on stem

Figure 7. Water-soaked bacterial spots

of soluble salts in the growing medium, which may damage roots and increase susceptibility to both pathogens. Plants exhibiting severe symptoms should be disposed of and replaced with new plants. In general, avoid fungicide use in favor of cultural practices and sanitation.

Bacterial Diseases

Bacterial diseases typically appear as oily, greasy, or water-soaked spots on leaves or other tissues. Some bacterial diseases are systemic and may cause wilting and a general yellowing of plants. With soft rots, rotting or cankering of the stem tissue may occasionally be observed. These cankers or rots will be soft. They appear mushy, and may have an unpleasant odor. Bacteria are primarily spread by splashing water and contaminated pruning tools.

To avoid problems associated with bacterial diseases, it is critical to practice good sanitation, keep relative humidity low through adequate airflow, avoid prolonged periods of leaf wetness and avoid splashing water, and discard diseased plant(s).

Leaf-Spotting Bacterial Diseases

Several species of bacteria, including *Pseudomonas* and *Xanthomonas* cause leaf spots or leaf blights on many plants grown in interiorscapes. Common hosts of both bacteria include dieffenbachia, heart-leaf philodendron, English ivy, pilea, pellionia, aglaonema, dracaena and pothos *(Figure 7*). Disease symptoms are characterized by dark green, water-soaked spots that may turn tan, dark brown or black in color with a yellow border. Spots may coalesce eventually covering the entire leaf. Sometimes these lesions spread to petioles and stems and may resemble systemic bacterial diseases described previously.

Management of these diseases generally involves prompt removal of infected plant parts. Wash hands thoroughly with soap and water and disinfect pruning tools in 70 percent alcohol. Pesticides for bacterial control are not recommended. Cultural practices and good sanitation should be used.

Soft Rots

Soft rot is a mushy, foul-smelling rot of cuttings, corms, and bulbs. Often the entire plant collapses. Soft rot is caused by several species in the genus *Dickeya* and *Pectobacterium* (formerly *Erwinia*). The pathogen enters the plant through wounds and can be spread on infested tools, through movement of infested plant debris or water-splash. Pesticide sprays are not effective. The best management is to remove affected plants and debris and practice good sanitation by cleaning and sterilizing pots and pruning tools.

Viral Diseases

Viruses are systemic plant disease-causing agents or organisms that live and multiply only within the living cells of a host plant. Some viruses are spread by insects with piercing-sucking mouthparts such as aphids or leafhoppers. Also, pruning tools may spread certain viruses. The symptoms produced are diverse, depending on the specific virus. Generally,

Table 2. Diseases that may Affect Plants Used in Interiorscapes*

Diseases

1. Systemic bacterial diseases**
2. Bacterial leaf spots
3. Nematode diseases
4. Viral diseases
5. Powdery mildew
6. Water mold root and crown rots
7. Root and stem rots
8. Fungal leaf spots and blights***

Hosts

Adiantum (see Ferns)
Aglaonema spp. – 1,2,6,7,8
Aloe spp. – 6,7,8
Aphelandra spp. – 1,2,7,8
Aralia – 2,6,7,8
Araucaria spp. – 7,8
Ardisia spp. – 6,7,8
Areca spp. – (see Palms)
Asparagus spp. – 7,8
Asidistra spp. – 1,8
Asplenium (see Ferns)
Begonia spp. -1,2,5,6,8
Brassaia spp. – 2,3,4,6,7,8
Caladium spp. – 3,4,7
Calathea spp. – 8
Cacti – 1,3,4,6,7,8
Chamaedorea (see Palms)
Chlorophytum spp. – 1,6,7
Chrysalidocarpus (see Palms)
Cissus spp. – 7,8
Codiaeum spp. – 6,7,8
Cordyline spp. – 1,6,7,8
Crassula spp. – 1,7,8
Dieffenbachia spp. – 1,2,4,6,7,8
Dizygotheca spp. 2,6,7,8
Dracaena spp. – 1,6,7,8
English Ivy – 2,6,7,8
Epiphyllum (see Cacti)
Fatshedera – 2,6,7,8
Fatsia – 2,6,7,8
Ferns – 2,3,7,8
Ficus spp. – 1,2,3,4,7,8
Fittonia spp. – 4,7
Howea (see Palms)
Hoya spp. – 6,7,8
Maranta spp. 1,3,4,6,7,8
Nephrolepis (see Ferns)
Palms – 3,7,8
Peperomia spp. – 4,6,7,8
Philodendron spp. – 1,2,3,4,6,7,8
Phoenix (see Palms)
Pilea spp. – 5,7,8
Pittosporum spp. – 7,8
Platycerium spp. (see Ferns)
Plectranthus spp. – 6,7,8
Pleomele spp. -7,8
Podocarpus spp. – 6,7,8
Polyscias – 2,6,7,8
Polystichum (see Ferns)
Pothos – 1,2,3,6,7,8
Rhapis (see Palms)
Sansevieria spp. – 1,3,6,7,8
Schefflera spp. – 2,8
Sedum spp. - 8
Senecio spp. – 4,7,8
Spathiphyllum spp. – 2,4,6,7,8
Tolmiea spp. – 6,7,8
Yucca spp. - 8
Zebrina spp. – 3,4,7
Zygocactus spp. – (see Cacti)

** Disease occurrences are noted from the articles "Nematode Pests of Tropical Foliage Plants and Leatherleaf Fern" by A.R. Chase, D.T. Koplan, and L.S. Osborne (Foliage Digest July 1983, pp. 3–6) and "Guide to Diseases of Foliage Plants – 1983" by A.R. Chase (Foliage Digest, June 1983, pp. 7–9), and as listed in **Index of Plant Diseases in Florida**, Bulletin 11, Div. of Plt. Ind., Fl. Dept. of Agr. and Consumer Services. Minor or relatively rare occurrences are not listed.*

*** Includes Erwinia Carotovora.*

**** Includes anthracnose diseases.*

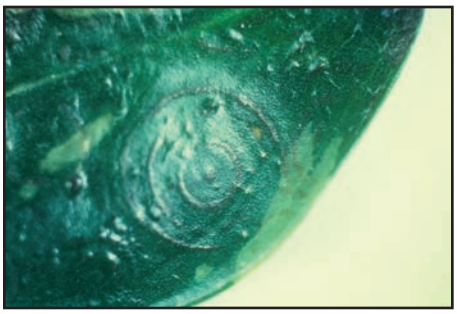

Figure 8. Viral disease

vein banding, mosaic (irregularly shaped dark and light green areas on leaves), flecking, ring-spotting or yellow-blotching will be present on leaves *(Figure 8*). Sometimes growth abnormalities will appear, which may resemble damage associated with a phenoxy-based herbicide (e.g. 2,4-D). Finally, viruses may cause plant stunting.

Viruses may be commonly seen on cacti (cactus virus X), maranta (cucumber mosaic virus), aglaonema, caladium, dieffenbachia, philodendron (dasheen mosaic virus), ficus (fig mosaic virus), rhoeo, columnea (tobacco mosaic virus), wandering jew (tradescantia mosaic virus), and schefflera.

Plants displaying symptoms of a viral infection should be disposed of immediately from the interiorscape.

Nematode Diseases

Nematodes are microscopic round-worms, 0.5-5.0 millimeters long, which usually live in soil. A typical nematode life cycle includes an egg, several juvenile stages, and an adult stage. Many nematode species are beneficial organisms that help cycle nutrients in field soils. However, plant-parasitic nematode species can be damaging by infecting either roots or leaves. They have a needle-like mouthpart called a stylet that is used to feed on plant tissue. Plant-parasitic nematodes are present in nearly all field soils, and they are spread via movement of soil on shoes, pots, equipment, or in contaminated plant material. Nematodes are rarely a problem in a soilless growing medium, and they should not be a problem in a soil-based growing medium that has been steam sterilized. Interiorscape technicians should purchase plants only from producers who implement proper sanitation practices, and plants should be examined closely before introduction into the interiorscape. Any plants infested with nematodes should be discarded. Nematicides tend to be very hazardous. There are no nematicides for interiorscapes.

Study Questions

These study questions are designed to help you learn the material on pages 12 through 16.

1. *The black, pinpoint-like pustules within a fungal lesion are:*
   a. spore-producing structures
   b. specks of growing medium
   c. physical damage
   d. leaf tissue breakdown
2. *Management tactics for systemic bacterial diseases depend on:*
   a. immediate use of pesticides
   b. altering fertilizer programs
   c. the technician knowing a plant is infected.
   d. altering watering schedules
3. *Nematodes can be managed by:*
   a. growing medium pasteurization
   b. inspecting all plant material closely before introducing into the interiorscape
   c. a and b above
   d. drying of the growing medium
4. *Symptoms of viral diseases may include:*
   a. vein banding and mosaic
   b. flecking and ring spotting
   c. abnormal plant growth
   d. all of the above
5. *Once powdery mildew is detected on a plant, it may be managed using:*
   a. high temperatures
   b. reducing the relative humidity
   c. natural enemies
   d. increased fertilization
6. *Infectious root rots usually do not cause serious problems unless plants are exposed to:*
   a. overfertilization
   b. overwatering
   c. high growing medium temperatures
   d. redwood planters
7. *Managing root and stem rots involves:*
   a. growing medium pasteurization and sanitation
   b. avoiding plant stress
   c. not purchasing plants with discolored roots or stems
   d. all of the above
8. *For an infection to occur, many leaf-spotting fungi require:*
   a. very dry growing medium conditions
   b. direct sunlight
   c. continuous leaf wetness
   d. high spider mite populations

Common Pests

Figure 9. Mealybugs on leaf

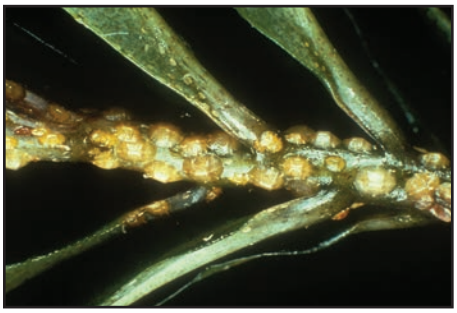

Figure 10. Brown soft scale on stem

Insects and Mites

Most insect and mite pest problems in interiorscapes do not originate from the interiorscape. They tend to originate where plants are initially grown, such as fields, lath or saran houses, or greenhouses. But once introduced into an interiorscape, many insect and mite pests will thrive and spread to other plants.

The key to avoiding insect and mite pest problems is to make sure plants are pest-free before installing them. It is much easier to deal with insect or mite pest populations in a greenhouse than in an interiorscape. Quarantine or place purchased plants in an isolated room and thoroughly inspect them for insect or mite pests. If present, apply an insecticide or miticide before placing them in the interiorscape. Early detection and diagnosis is critical to managing nearly all insect and mite pests before damage occurs. Insecticides, miticides, and natural enemies (e.g. parasitoids and predators) can be used to deal with most insect or mite pest problems in interiorscapes. There are management strategies for most insect and mite pest problems, but these strategies may not be simple or permanent.

A number of common insect and mite pests occur on plants grown in interiorscapes. Following are descriptions of the most important insect and mite pests.

Insects

Many insects cause damage to an assortment of plants in interiorscapes. Mealybugs (*Figure 9*) are the most common insect pest encountered and can be very difficult to manage. There are several species of mealybugs that may be found on plants used in interiorscapes including some that feed on plant roots. The most common species are the citrus mealybug, *Planococcus citri,* and the longtailed mealybug, *Pseudococcus longispinus.* All foliar-feeding mealybug species have piercing-sucking mouthparts, which are used to remove plant fluids. A sticky liquid called honeydew is excreted, which coats leaves below the infested area. Each female citrus mealybug may produce several hundred eggs, whereas longtailed mealybug females give birth to life young. The life cycle from egg to adult takes six to eight weeks to complete, depending on temperature. Placing infested plant material into an interiorscape is the way mealybug infestations become established in most interior plantscapes.

Several species of scale insects *(Figure 10*) infest plants, becoming established in the same manner as mealybugs on infested plant material. One of the most common species is the brown soft scale (*Coccus hesperidum*). Scales also have piercing-sucking mouthparts. As such, they excrete honeydew just like mealybugs. Females may produce up to 1,000 eggs underneath their protective shell or test. Eggs hatch into tiny crawlers, which spread on plants. After dispersing, crawlers settle and feed in one location for the remainder of their lives. The length of time required to complete development from egg to adult varies depending on the scale species, which may range from one to eight or more generations per year.

Table 3. Insect and Mite Pests of Plants in Interiorscapes

Pests

1. Aphids
2. Mealybugs
3. Brown Soft Scale
4. Thrips
5. Cyclamen and Broad Mites
6. Spider Mites

Hosts

Aphelandra spp. – 1,2
Aralia – 5,6
Ardisia spp. – 2
Asparagus spp. – 2,3,6
Brassaia spp. (see Schefflera)
Cacti – 2,3
Cissus spp. – 2
Codiaeum spp. (see Croton)
Cordyline spp. – 6
Crassula spp. – 2
Croton – 2,6
Diffenbachia spp. – 2,6
Dracaena spp. – 2,4,6
English Ivy – 2,3,5,6
Fatsia (see Aralia)
Ferns – 2,3
Ficus spp. – 2,3,4
Gynura spp. – 1,2
Hoya spp. – 2,3,6
Maranta spp. – 2,3,6
Palms – 2,3,6
Philodendron spp. – 2,3,4
Polyscias (see Aralia)
Pothos - 2
Sansevieria spp. – 2,4
Schefflera spp. – 1,2,3,4,6

This list adapted from information in Manaker, George H. 1981, Interior Plantscapes — Installation, maintenance, and management. Prentice–Hall, Inc., Englewood Cliffs, NJ. pp. 174–181.

Those pests most commonly found on different hosts are listed by number. It is not meant to be complete, and many other host–pest combinations can and do occur.

Table 4. Major Suppliers of Parasitoids and Predators.

Applied Bionomics
Victoria, BC– Canada
http://www.appliedbionomics.com
250-656-2123
315-497-2063

Beneficial Insectary
Redding, CA
http://www.insectary.com
1-800-447-3715

BioBest Biological Systems
www.biobest.be
519-322-2178

The Green Spot, Ltd
93 Priest Road
Nottingham, NH 03290-6204
603-942-8925

IPM Laboratories, Inc.
PO Box 300
Locke, NY 13092-0300
www.ipmlabs.com

Koppert Inc.,
Romulus, MI
www.koppert.com
734-641-3763

Sterling Insectary
Delano, CA
www.sterlinginsectary.com
661-792-6810

Syngenta Bioline
Oxnard, CA
www.syngenta-bioline.co.uk/america.htm
805-986-8255

Common Pests

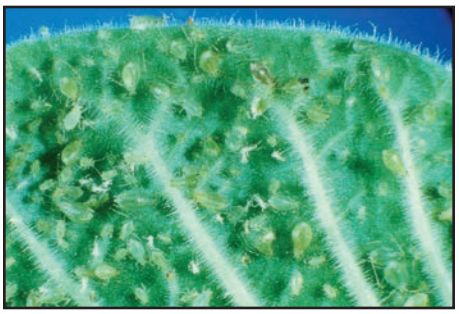

Figure 11. Aphids feeding on leaf

Figure 12. Whitefly

Figure 13. Adult thrips

Other insect pests with piercing-sucking mouthparts that produce honeydew are aphids (*Figure 11*) and whiteflies (*Figure 12)*. Aphids are soft-bodied insects that multiply rapidly. In interiorscapes, all aphids are females. Each mature female may give birth to up to 50 daughters that, in turn, begin reproducing in seven to 10 days. Aphid infestations are often evident by the presence of white cast skins that are shed during the molting process.

Whitefly species that may be encountered in interiorscapes are the greenhouse whitefly, *Trialeurodes vaporariorum,* and the sweet potato whitefly B-biotype, *Bemisia tabaci*. Whiteflies are mostly found on flowering plants brought in for color such as poinsettia, fuchsia, or chrysanthemum. All life stages develop on the undersides of leaves although adults may be usually present on the upperside of leaves. The development time from egg to adult takes between 21 to 36 days depending on temperature.

Thrips feed on both leaves and flowers. These are small, slender insects less than an ⅛-inch long *(Figure 13*). Thrips feed on plant tissues using their stylet-like mouthparts to consume plant fluids. Thrips feeding causes leaf scarring, distorted growth, sunken tissues on leaf undersides, and deformed flowers. Leaves and flowers may have a silvery appearance. Black fecal deposits may also be present on leaf undersides.

Eggs are laid in plant leaves. Development from egg to adult takes 18 to 21 days, depending on temperature. Most thrips species pupate in the growing medium. Thrips are difficult to manage on plants used in interiorscapes because there are few insecticides registered for use in interior plantscapes that are effective against thrips unless plants are moved to a greenhouse or outdoors before treatment.

Two fly types that may cause nuisance problems in interior plantscapes are fungus gnats (*Figure 14*) and shore flies. Fungus gnats are small (⅛ inch long), dark black flies that resemble midges or mosquitoes. Larvae (*Figure 15*) feed on decaying organic matter, and will feed on plant roots directly, damaging root systems and interfering with the plant's ability to take up water and nutrients. This may result in stunted growth. Fungus gnats have increased in importance because they may be present in bags of soilless growing medium. This is one way in which they may become established in an interiorscape.

Shore fly adults (*Figure 16*) resemble house flies, except they are black with five to six white spots on the wings. Larvae feed primarily on green algae, which often grows in moist areas. Shore fly larvae do not feed directly on plant roots.

Mites

Several mite species may attack and feed on many plant types causing severe damage. The most common mite species is the twospotted spider mite, *Tetranychus urticae* (*Figure 17*). The twospotted spider mite has a wide host range feeding on many different types of plants used in interiorscapes. Adult spider mites are about ⅓₀-inch long, and are found on leaf undersides. A 10X hand lens is helpful in identifying mites. Feeding by the spider mite causes light colored, stippled areas on leaves, and webbing may be present. Severe spider mite infestations may cause leaves to dry and fall from plants. At 75°F, it takes approximately two weeks for twospotted spider mites to complete development from egg to adult.

Other mites, including the broad mite, *Polyphagotarsonemus latus*, and cyclamen mite, *Phytonemus pallidus*, may also cause problems on certain plants used in interiorscapes. These mites are very small (⅟₁₀₀ inches long) and difficult to see even with a 10X hand lens. Typically, broad or cyclamen mites are detected when plant injury becomes noticeable, as the mites themselves are rarely detected. Most feeding occurs on young leaves. Feeding damage on new leaves is characterized by thickened and brittle leaves with margins curved downward. In addition, plants may be severely stunted. Most symptoms associated with broad or cyclamen mite feeding may resemble exposure to a phenoxy-based herbicide (e.g. 2,4-D), a virus, or nutritional imbalance.

Biological Management of Insect and Mite Pests

In general, interiorscapes offer opportunities for using alternative pest management strategies. Biological control involves using parasitoids, predators, or pathogens (e.g. beneficial nematodes and fungi) to suppress insect and mite pest populations. Biological control agents need to be introduced into an interiorscape and become established before insect and mite pest populations build up to damaging levels. In some situations, biological control agents (natural enemies) may need to be released periodically. There are a variety of predators and parasitoids that are commercially available from a number of sources. Among the most widely available include the predatory mite, *Phytoseiulus persimilis,* which is an effective predator against twospotted spider mites. This predatory mite develops twice as fast as spider mites, so they are able to rapidly reduce a population of twospotted spider mites.

Cryptolaemus montrouzieri, also called the mealybug destroyer, is a ladybird beetle predator of mealybugs, primarily the citrus mealybug. Both the adult and larvae are predators. *Encarsia formosa* is a small parasitiod that has been used for many years to suppress populations of the greenhouse whitefly. The use of this parasitoid will likely be limited in interiorscapes, but it may be more useful in conservatories.

A number of insectaries in the United States and Canada supply numerous natural enemies

Figure 14. Fungus gnat adult

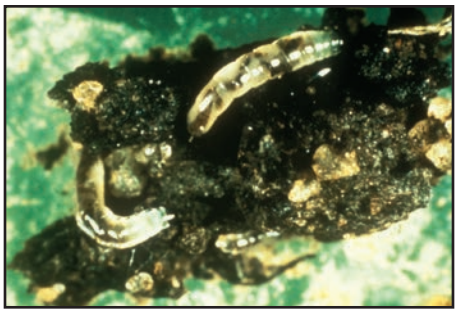

Figure 15. Fungus gnat larva

Figure 16. Shore fly adult

Figure 17. Twospotted spider mite

for introduction into interior plantscapes. *Table 4* on page 19 lists some suppliers.

Residents of the United States who wish to import natural enemies from Canada must obtain a PPQ 526 permit before requesting a shipment. This permit can be obtained through the on-line ePermits system which can be found on the web at: *http://www.aphis.usda.gov/permits/ppq_epermits.shtml.*

This form must be filled out and returned to the United States Department of Agriculture (USDA) before a permit may be issued. These permits are sent to the designated supplier who will attach the forms to the shipments.

Study Questions

These study questions are designed to help you learn the material on pages 18 through 22.

1. *The key to managing insect and mites pests in interiorscapes involves:*
   a. regular weekly spraying
   b. early detection and diagnosis
   c. fertilizing regularly
   d. regular plant rotation
2. *At _____ degrees (°F) spider mites can complete development from egg to adult in two weeks.*
   a. 65°F
   b. 67°F
   c. 75°F
   d. 80°F
3. *Mealybugs primarily become established in interiorscapes by:*
   a. technicians handling infested plants
   b. buying infested growing medium
   c. moving infested plants
   d. overwatering in the evening
4. *Scale insects hatch into tiny:*
   a. hummers
   b. fliers
   c. crawlers
   d. hoppers
5. *All life stages of whiteflies develop on:*
   a. leaf undersides
   b. plant stems
   c. the top of leaves
   d. just under the growing medium surface
6. *Fungus gnats are small flies that resemble:*
   a. midges
   b. mosquitoes
   c. a and b above
   d. shore flies
7. *Examples of predators are:*
   a. wasps
   b. ladybird beetles
   c. predatory mites
   d. b and c above
8. *U.S. residents who want to import natural enemies from Canada must:*
   a. first obtain a permit
   b. first send payment
   c. first seal the interiorscape
   d. first agree to not use pesticides

Pesticide Management

Timing and Coverage

The management of insect and mite pests in interior plantscapes using pesticides, in this case, insecticides and miticides, will be most effective if properly timed when susceptible life stages are present (e.g. larvae/nymphs and adults) and thorough coverage of all plant parts is obtained. For maximum performance, a pesticide must be applied at the proper rate and thoroughly cover the upper and lower surfaces of plant leaves. Additional applications may be required to sustain insect and mite pest or pathogen populations below damaging levels.

Pesticide Formulation and Compatibility

Pesticides are available in several formulations, which have advantages and disadvantages.

Granular formulations (G) may be applied to the surface of the growing medium, and then watered in. These formulations are generally used to manage belowground insect pests or have systemic activity against aboveground insect pests such as aphids, whiteflies, and mealybugs.

Wettable powders (WP) may leave uniform, long lasting residues, but may be unsightly on leaves. Wettable powders are less likely to cause plant injury (e.g., phytotoxicity) than emulsifiable concentrates.

Emulsifiable concentrate (EC) formulations are liquids composed of the active ingredient dissolved in organic solvents. Emulsifiable concentrates may cause plant injury due to the presence of these solvents. Do not use EC formulations on ferns.

Flowable (F) formulations are essentially suspensions of an insoluble pesticide. They usually result in better (e.g. uniform) coverage than WP formulations, and also cause less phytotoxicity than emulsifiable concentrates.

If you want to mix together two of more pesticides into a single spray solution, you must check to determine if the pesticides, when mixed together, are compatible. In general, only mix wettable powder formulations together. However, it is important to determine if the pesticides mixed together are compatible. Also, never mix emulsifiable concentrate pesticides together because this will increase the concentration of the inert ingredients (e.g., solvents or carriers). Always read pesticide labels to determine if there are restrictions or warnings.

Before applying any pesticide or combination of pesticides, it is recommended to treat a few select plants and wait seven to 10 days for any phytotoxic effects to appear.

Pesticide Shelf-Life

Most pesticide formulations are mixtures of a number of different compounds. The formulation consists of the active and inert ingredients. The inert ingredients are substances such as dispersing agents, wetting agents, solvents, and spreader-stickers. The stability of a pesticide formulation may impact shelf-life. Most pesticides are stable and as such there should

be no problems associated with shelf-life. Pesticide manufacturers have spent many years developing techniques and procedures to increase pesticide stability.

Pesticides, in general, will retain their effective properties for two years or longer if stored properly. Most wettable powder formulations stored at temperatures between 50 and 60°F and a low relative humidity may retain a shelf-life of up to seven years. All pesticide containers must be tightly sealed during storage. Liquid formulations will typically retain a shelf-life of three to four years if stored properly. It is critical to avoid exposing pesticides to extremes of hot (>90°F) and cold (<32°F) temperatures; as this will substantially reduce the shelf-life.

In general, avoid purchasing more pesticide than can be used within two years. Always keep pesticide containers off floors to avoid them getting wet. This will also prevent containers from rusting or decomposing. Make sure pesticides are retained in their original containers and the labels can be read easily. Avoid puncturing bags, which may release pesticides into an area. Always store pesticides in a separate metal cabinet that has sufficient air ventilation/ circulation.

Spray Adjuvants

An adjuvant is a compound added to a substance that usually has pesticidal properties, that increases the effectiveness of the second substance. Many adjuvants are used with pesticides or are a component of the pesticide formulation. Some adjuvants increase the adherence of the material to leaf surfaces. These are called stickers. Other adjuvants increase the systemic uptake of certain pesticides. These are called activators. Still, other adjuvants reduce spray drift, serve as anti-foaming agents, and decrease the surface tension of water thus allowing the pesticide to spread-out more over plant leaves. These are called spreader-stickers.

Spreader-stickers are the most commonly used adjuvants and have two functions. First, they moisten the leaf, creating a uniform barrier of pesticide over the leaf and other plant surfaces. Second, they allow the pesticide to adhere to leaf surfaces. A number of fungicides act as a preventative by forming a barrier on leaf surfaces. As such, spreader-stickers enhance the activity of contact fungicides.

The label may provide information on the function of adjuvants and how to best use them. A spreader-sticker may be anionic, ionic, cationic, or non-ionic. This refers to the charges on the molecules of the spreader-sticker. The charge may be important when using certain pesticides. It is important to select the appropriate adjuvant and make sure it is compatible with the designated pesticide.

Adjuvants may change the chemistry of a pesticide mixture such that the application results in plant damage. Furthermore, if an adjuvant is used at a high concentration this can result in phytotoxicity. There are a number of guidelines to be considered

when selecting and using adjuvants to help avoid problems with phytotoxicity. First, apply a new adjuvant on a small number of plants. Second, the adjuvant should be applied alone and with any pesticide mixtures intended for use. Third, make sure plants are not stressed before making applications. Be sure to water the day before. Also, avoid applications during hot, sunny weather.

In addition, determine, by reading the label, the appropriate rate of the adjuvant to use. However, this may be a problem in interior plantscapes because plants typically grown in indoors have softer growth (e.g. thinner leaf cuticles) that is more sensitive to adjuvants than plants grown outdoors in landscapes. In general, it is recommended to use the lowest label rate and be sure to thoroughly cover all plant parts to ensure uniformity of the spray application. If no problems occur, rates can be increased as long they are legal. For example, depending on the adjuvant, start at 1 or 2 ounces per 100 gallons and add 1 ounce at a time until the desired results are obtained. Keep records on the amount of adjuvant used, plants tested, and pesticides used in the mixture. Remember to trial all plant types because the response to each pesticide mixture will vary depending on plant species and cultivar.

Oftentimes plants may be sprayed several times within a one- to two-week period. For example, a miticide may be applied one day, followed by an insecticide several days later, and then a fungicide several days after that. In this case, using the same adjuvant in every spray solution may result in a buildup on plant leaves and injury. Once an adjuvant/pesticide spray mixture dries on the leaf, the adhering properties of the spreader-sticker will become evident. The use of a spreader-sticker enhances the effectiveness of a spray solution by allowing the material to uniformily cover all plant parts.

In some instances, the use of adjuvants may lead to allergic reactions associated with technicians and the public. For example, some rose growers have reported employees developing skin rashes after using a certain fungicide; however, this only occurred when a specific fungicide was used with certain adjuvants. It is important to determine if an adjuvant may cause allergic reactions before use.

Some commercially available pesticide formulations already contain adjuvants including spreader-stickers. Generally, these will be pesticides formulated as an emulsifiable concentrate or liquid. Thus, adjuvants may be more commonly used with wettable powder formulations of pesticides. It is recommended to read the pesticide label to assess whether an adjuvant may need to be added or not. Pesticide phytotoxicity problems often occur as a result of excessively using spray adjuvants.

Insecticides and Miticides

When using insecticides and miticides in interior plantscapes it is important to adhere to the following practices:

- Use the proper label rate.
- Thoroughly cover all plant parts with the spray solution.
- Apply insecticides or miticides frequently enough so that the most susceptible life stages (e.g., larvae/nymphs and adults) are exposed to the application.
- Use the appropriate product.
- The insecticides and miticides registered for use in interior plantscapes are listed in *Table 5*. Always read pesticide labels before use. It is important to determine that interior plantscapes and the target insect and mite pest are on the label.

Table 5. Insecticides and Miticides Registered for Use in Interior Plantscapes

Common name (active ingredient)	Trade name(s)	Type (insecticide and/or miticide)
Acequinocyl	**Shuttle**	Miticide
Azadirachtin	**Azatin XL/Molt-X/Ornazin**	Insecticide
Bacillus thuringiensis subsp. *israelsnsis*	**Gnatrol**	Insecticide
Beauveria bassiana	**BotaniGard**	Insecticide
Clarified hydrophobic extract of neem oil	**Triact**	Insecticide/miticide
Cyromazine	**Citation**	Insecticide
Dinotefuran	**Safari**	Insecticide
Fenpyroximate	**Akari**	Miticide
Fluvalinate	**Mavrik**	Insecticide
Imidacloprid	**Marathon**	Insecticide
Imidacloprid + cyfluthrin	**Discus**	Insecticide
Kinoprene	**Enstar AQ**	Insecticide
Paraffinic oil	**Ultra-Fine Oil**	Insecticide/miticide
Potassium salts of fatty acids	**M-Pede**	Insecticide/miticide
Pymetrozine	**Endeavor**	Insecticide
Spirotetramat	**Kontos**	Insecticide/miticide
Thiamethoxam	**Meridian**	Insecticide

Pesticide Management

Study Questions

These study questions are designed to help you learn the material on pages 24 through 27.

1. *An essential component of pesticide management involves:*
   a. proper timing of application
   b. proper use rate
   c. thorough coverage of all plant parts
   d. all of the above
2. *Flowable formulations are less likely to cause phytotoxicity than:*
   a. wettable powders
   b. granular formulations
   c. emulsifiable concentrates
   d. sprayable solutions
3. *Most pesticides have a shelf-life of:*
   a. six months
   b. one year
   c. eighteen months
   d. over two years
4. *Spreader-stickers may be:*
   a. anionic
   b. ionic
   c. cationic
   d. all of the above
5. *Adjuvants may change the chemistry of a pesticide mixture resulting in:*
   a. enhanced growth
   b. plant damage
   c. increased susceptibility to mite pests
   d. increased transpiration of plant leaves
6. *What are important points in ensuring the success of using an insecticide and/or miticide in an interior plantscape?*
   a. use correct product
   b. use proper label rate
   c. thoroughly cover all plant parts
   d. all of the above
7. *What is the function of a spreader-sticker?*
   a. enhance toxicity of pesticide
   b. improve penetration through insect cuticle
   c. decrease water tension thus allowing the solution to spread-out more
   d. none of the above
8. *What is the trade name for azadirachtin?*
   a. Ornazin
   b. Azatin XL
   c. Molt-X
   d. all of the above

Protecting Yourself and the Environment

Precautions

1. Pesticides are poisons and may be toxic if enough material is inhaled, swallowed, or absorbed through the skin. However, some pesticides are more toxic than others. As such, there are various ways of measuring toxicity, but the best way to determine the toxicity of a pesticide is by reading the label. Labels that display skull and crossbones with the words "DANGER-POISON" are highly toxic and must be handled with extreme care. These are usually restricted use materials and are not typically used in interiorscapes. Labels with the word "WARNING" are moderately toxic, and those with "CAUTION" are the least toxic pesticides. However, all labels must list precautions to take before, during, and after applying a given pesticide. Therefore, before applying any pesticide, be sure to read the label and follow all instructions. Labels are designed to protect personnel who are going to use/apply the pesticide. A notebook, which contains all pesticide labels and material safety data sheets (MSDS), must be accessible at the site for interiorscape technicians. This will allow technicians' to obtain complete background information associated with the pesticides they are using.
2. Always store pesticides in closed, original containers away from extremes of hot and cold. Never leave materials where children or customers may accidentally have access to them.
3. Store application equipment out of reach of children and adults. Be sure to label each sprayer in terms of what pesticide each sprayer is used for (e.g. insecticides/miticides, or fungicides). Always designate one sprayer for insecticides or miticides, and another sprayer for fungicides.
4. Do not save or reuse empty pesticide containers. Do not puncture pressurized containers or burn them because they may explode and cause injury or start a fire. For conventional containers, rinse thoroughly before disposing. Rinse each container three times, each time filling the containers about half full with water. The rinse water or rinsate should be poured into the sprayer and then applied in either the interiorscape or to plants moved outdoors. Afterwards, crush or puncture metal containers, and wrap in several layers of newspaper. Glass containers should be shattered after wrapping.
5. Do not apply more pesticide than recommended by the label as this may result in plant injury and/or jeopardize the safety of technicians. It is also a violation of both state and federal regulations.
6. When opening the container of a liquid pesticide, position your face away from and to one side of the cap or lid.
7. Always mix or prepare dusts or sprays outdoors or in a well-ventilated room away from wind.

Protecting Yourself and the Environment

8. When handling any pesticide, avoid contact with skin. Also, avoid getting any pesticide near your mouth, eyes, or nose.
9. If any pesticide gets in your eyes, flush your eyes with water for 15 minutes, and then immediately seek medical attention.
10. Never smoke, eat, or drink while handling pesticides. After completing an application, wash exposed skin with soap and water.
11. If you spill a pesticide on your clothing, immediately launder the clothing. Always launder pesticide contaminated clothing separate from non-contaminated clothing.
12. If you become ill during or shortly after applying a pesticide, call your poison control center immediately. Read the name of the active ingredient or active ingredients of the pesticide from the container label and follow instructions for first aid treatment.
13. It is essential that proper protective respiratory devices (e.g. respirators) be worn by workers handling pesticides. Read the label to obtain information on the required personal protective equipment (PPE) to wear when applying a pesticide. It is important to always follow all label instructions.

Calibration

Effective pest management and safety will only be ensured through proper application. One critical component associated with the success in managing insect and mite pests, and diseases is calibration of application equipment. Calibration is a procedure to determine the correct amount of pesticide that should be applied to the target pest. The type of equipment used will often determine the calibration procedure required. There are two methods that may be used to calibrate spray equipment used in interior plantscapes: concentration and volume methods.

Concentration Method

The concentration method is used when the amount of material to apply is based on label instructions. This is the typical application procedure utilized in interiorscapes. One important aspect of this procedure is determining the amount or volume of material needed to complete the application while minimizing the amount of residual left over. This procedure consists of the following:

1. Place a known amount or volume of water into the sprayer that will be used for the application.
2. Select a representative plant and apply the water similar to how you would apply a pesticide. Apply to run-off, that is, until leaf surfaces and other plant parts are thoroughly moistened.
3. Measure the amount or volume of water used after completing the application. Multiply the volume used by the total number of plants that need to be treated to obtain the total volume of spray solution required for the treatment.
4. Add the correct amount of pesticide to the volume of water determined in step three. Mix thoroughly and apply the spray solution to the designated number of plants as performed in step two.
5. Immediately following the application, add water to the sprayer container, agitate and apply rinsate lightly onto foliage of plants just treated. Repeat this procedure at least twice.

This procedure should ensure that the correct volume of spray solution is prepared for the treatment with minimum remaining for disposal.

Volume Method

The volume method may be utilized when a pesticide label designates the application of a specific amount or volume of formulated pesticide to each plant or area. As such, calibration requires determining the volume of material to be dispensed using the intended application technique and the area to be sprayed. Based on this technique, the procedure to use is as follows:

1. Measure and mark-off a known area on the ground, concrete, or asphalt. Practice spraying the area with water making sure to maintain uniform walking speed, constant height, and a uniform sweeping, overlapping motion. Be sure to avoid applying too much or too little spray volume.

Repeat this procedure as many times as it takes until you obtain uniform coverage.

2. Fill the sprayer to a known level with water, and then spray the area using the procedure outlined in step one. Afterward, measure the volume of water remaining in the sprayer. The difference between the remaining solution volume and the known (starting) volume may be used to determine the application rate by dividing the amount of the difference by the area sprayed.
3. Determine the proper amount of pesticide needed for the designated area and add sufficient water to the sprayer or tank. Mix thoroughly and apply to the area using the procedure outlined in step two.
4. After completing the application, add sufficient water to the sprayer, agitate thoroughly, and apply the rinsate to the treated area. Repeat this procedure twice.

Conversion Factors

The easiest way to measure small amounts or quantities of a pesticide is by weighing, using the same unit of measure in which the pesticide is sold. Liquid formulations (F, EC) are generally available in quarts or gallons. These volumes may be reduced by converting to smaller volume units such as fluid ounces, tablespoons, teaspoons, or milliliters. *Table 6* presents the common conversion factors for liquid volume units of measure. Remember, when using teaspoon or tablespoon measurements, be sure to utilize level measuring spoons not disposable plastic spoons or spoons associated with a silverware set. **Always wear non-porous gloves while measuring pesticides. Also, measure in a well-ventilated area. Never allow spoons, cups, or other measuring devices associated with pesticides to be used for food preparation or consumption.**

For example: If it is recommended to apply 1.5 ounces of a formulated product (e.g., pesticide) to 1000 ft^2 using a three gallon sprayer that has an application rate as determined in step two of 1.5 gallons per 1000 ft^2, then you should add:

$$\text{ounces/sprayer} = \frac{(\text{gal/sprayer})\,(\text{ounces of formulation}/1000\ ft^2)}{(\text{gallons}/1000\ ft^2)}$$

$$= \frac{(3\ \text{gal/sprayer})\,(1.5\ \text{oz}/1000\ ft^2)}{(1.5\ \text{gal}/1000\ ft^2)}$$

$$= 3\ \text{ounces of formulation/sprayer}$$

Table 6. Liquid Volume Measure Equivalents

Measuring Unit	Tsp.	Tbsp.	Fl. Oz.	Cup	Pint	Qt.	Gal.
Teaspoon	1	0.3	0.167	0.021	0.01	0.005	0.001
Tablespoon	3	1	0.5	0.063	0.031	0.016	0.004
Fluid Ounce	6	2	1	0.125	0.063	0.031	0.008
Cup	48	16	8	1	0.5	0.25	0.063
Pint	96	32	16	2	1	0.5	0.125
Quart	192	64	32	4	2	1	0.25
Gallon	768	256	128	16	8	4	1

** Decimal values of .0005 and over are rounded to the next highest three-place value, .004 or less rounded to the next lowest three-place value.*

Table 7. Liquid Volume Conversion to Metric Units

		Metric		
Liquid Volume		**Liters**		**Milliliters**
1 gallon	=	3.785	=	3,785.4
1 quart	=	.946	=	946.3
1 pint	=	.473	=	473.1
1 cup	=	.237	=	236.6
1 fluid ounce	=	.0295	=	29.57
1 tablespoon	=	.0148	=	14.8
1 teaspoon	=	.005	=	5.0

Protecting Yourself and the Environment and Calibration

Study Questions

These study questions are designed to help you learn the material on pages 29 through 33.

1. *All pesticides are toxic to humans if enough is:*
   a. inhaled
   b. swallowed
   c. absorbed through the skin
   d. all of the above
2. *Labels are designed to:*
   a. keep the container from getting scratched
   b. protect the pesticide user
   c. protect glass containers from breakage
   d. none of the above
3. *Applying more pesticide than is recommended on the label is:*
   a. wasteful
   b. dangerous
   c. illegal
   d. all of the above
4. *Always launder pesticide protective clothing:*
   a. before reuse
   b. separate from other clothing
   c. a and b above
   d. with family clothing
5. *The procedure to determine the correct amount of pesticide to apply is called:*
   a. calibration
   b. calculation
   c. application
   d. concentration
6. *The method of calibration associated with applying a pesticide spray solution to run-off is called:*
   a. run-off method
   b. concentration method
   c. calculation method
   d. volume method
7. *The method of calibration associated with applying a pesticide on a per plant or area basis is called:*
   a. concentration method
   b. run-off method
   c. volume method
   d. calculation method
8. *When measuring pesticides:*
   a. wear non-porous gloves
   b. work in a ventilated area
   c. do not use food measuring utensils
   d. all of the above

Answers to Study Questions

Pages 3–9
1. d 2. d 3. c 4. c 5. d 6. c 7. b 8. d 9. d 10 b 11. a 12. d

Pages 12–16
1. a 2. c 3. c 4. d 5. b 6. b 7. d 8. c

Pages 18–22
1. b 2. c 3. c 4. c 5. a 6. c 7. d 8. a

Pages 24–27
1. d 2. c 3. d 4. d 5. b 6. d 7. c 8. d

Pages 29–33
1. d 2. b 3. d 4. c 5. a 6. b 7. c 8. d

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Frannie L. Miller
Pesticide Coordinator

Authors
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