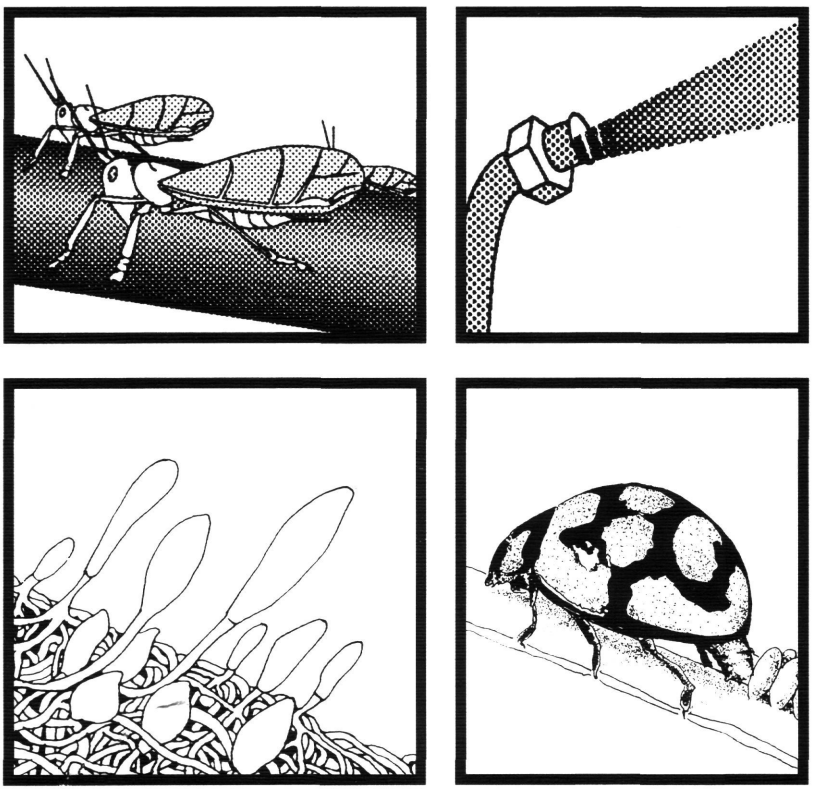
Interiorscape Pest Management

A Training Manual for Commercial Pesticide Applicators (Category 7E)



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This publication contains pesticide recommendations based on research and pesticide regulations. However, changes in pesticide regulations occur constantly. Some pesticides mentioned may no longer be available, and some uses may no longer be legal. If you have questions about the legality and/or registration status for using pesticides, contact your county Cooperative Extension Service office.

To protect yourself and others and the environment, always read the label before applying any pesticide.

Interiorscape Pest Management Training Manual for Commercial Pesticide Applicators

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Preface

This manual **along with** the Commercial and Private Pesticide Applicator Core Manual (E-2195), is intended to prepare pesticide applicators in Category 7E, interiorscape pest management for initial certification **and** recertification under the Michigan Pesticide Control Act of 1976, as amended. This category includes the management of pests of plants used in indoor landscape settings.

After studying both manuals, complete appropriate forms and contact the Michigan Department of Agriculture to schedule an examination for becoming a certified pesticide applicator in category 7E, interiorscape pest management.

Acknowledgments

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Portions of Cooperative Extension Service publications from Ohio State University, North Carolina State University, University of Maine, Rutgers University and Kansas State University were incorporated into this manual and have been invaluable resources. The Alberta Environmental Centre booklet, *Biological Pest Management for Interior Landscapes,* has also been an important resource in developing this manual.

Section 1

INTRODUCTION

The increased use of plants in shopping malls, offices, restaurants, public spaces and homes has created an important industry in North America; indoor plant maintenance. The plants which make up **interior landscapes** play an important role in defining an establishments' image. The aesthetics and health of these plants directly reflect on an establishments' presumed level of service, quality of food, professionalism, and cleanliness. Owners and managers of these establishments recognize that customers are drawn to places of business where they see living, healthy plants. Conversely, unhealthy plants can have an adverse effect upon a business enterprise.

Several factors can negatively influence the health and appearance of indoor plants. Stressed plants are more prone to pest invasions and may also show more severe damage symptoms than unstressed plants subjected to identical insects and diseases. The relationship between environmental conditions, cultural practices, and the potential for pest invasion needs to be understood to appropriately maintain plants.

The knowledge and services of interior plantscapers are indispensable to maintaining healthy plants. In a sense, interior plant technicians contribute directly to the well-being of the establishments whose plants they maintain and carry a significant amount of responsibility. The management of indoor plants incorporates public relations, horticultural knowledge, cultural and mechanical practices and potentially, pesticide applications. The purpose of the pesticide applicator certification program is to insure that pesticide applicators in the interior landscape are knowledgeable in all these areas.

Portions of this manual discuss growing conditions and cultural practices that may promote insect or disease development, how to avoid these problems, their diagnosis, corrective treatments and evaluation of management tactics used. Legal and social implications of applying pesticides in the interior landscape are also discussed.

In order to fully understand your legal obligations, obtain copies of those laws and regulations that influence your line of work, especially:
- Federal Insecticide, Fungicide and Rodenticide Act
- Michigan Pesticide Control Act including Regulation 636 and 637.

Suggestions For Studying This Manual

This manual is to assist prospective commercial pesticide applicators in meeting the certification requirements for Category 7E under state and federal guidelines. Interiorscape Pest Management, A Manual for Commercial Pesticide Applicators (Category 7E), number E-2308 should be used in conjunction with the Commercial and Private Pesticide Applicator Core Manual, bulletin number E-2195. If you have problems using this manual, please consult your county Extension office or a representative of the Michigan Department of Agriculture (MDA) for help.

Some suggestions for studying this manual are:

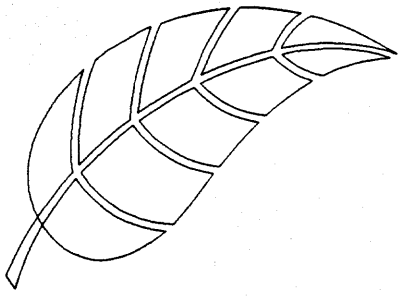
1. Find a place and time for study where you will not be disturbed.

2. Read the entire manual through once to understand the scope and the manner in which the material is presented.

3. Study one segment at a time. Consider underlining important points in the manual or take written notes as you study each segment.

4. Reread the entire manual once again when you have finished studying all of its sections. Review with care any sections that you do not fully understand. Seek additional help if necessary.

This manual is intended to help you use pesticides effectively and safely when they are needed. We hope you will use this as a resource in the future and review it occasionally to keep the material fresh in your mind.



Review Questions For Section 1 - Introduction

Write answers to the following questions and then compare your answers with those in the back of the manual.

1. How does the health of plants influence a person's perception of a business establishment?

2. Stressed plants can show more severe damage symptoms than a healthy plant subjected to the identical pest. (True or False)

3. What type of knowledge and skill does managing indoor plants require?

4. There are both legal and social responsibilities associated with maintaining indoor plants and being a certified pesticide applicator. (True or False)

5. Is this the only manual you need to study to become a certified pesticide applicator in category 7E? If no, which other manual should you obtain and study?

Section 2

LAWS AND REGULATIONS

In the United States, pesticide usage has increased from approximately 300 million lbs. of active ingredient in 1964 to approximately 800 million lbs. of active ingredient in 1989. New highly sensitive measuring devices are detecting pesticides in groundwater and other parts of our environment. To protect the environment and human health, federal and state laws regulate the proper, safe use of pesticides. It is imperative that each pesticide applicator have a working knowledge of the laws and regulations governing pesticide use for their own safety and the safety of the client. Knowledge of regulatory guidelines demonstrates an applicators proficiency and concern for safe procedures. In this chapter you will learn about the state and federal laws that regulate pesticide applicators.

Federal Law

Several federal laws regulate pesticide use. Both state and federal agencies enforce these laws. The basic federal law regulating pesticides is the **Federal Insecticide, Fungicide and Rodenticide Act (FIFRA)**, first enacted in 1947. This law was amended in 1972, 1978, and 1988. One of the major provisions of FIFRA is that states have the authority to certify applicators, register pesticides, and initiate programs designed to meet local needs. More detailed information about FIFRA provisions and who enforces them is located in the chapter, **Pesticide Laws and Regulations** of the *Commercial and Private Pesticide Applicator Core Manual, Initial Certification*, E-2195, available from Michigan State University, 10 Agriculture Hall, East Lansing, MI 48824.

State Law: Michigan Pesticide Control Act

The primary Act regulating pesticides and their use in the state of Michigan is the **Michigan Pesticide Control Act.** The Michigan Legislature passed this Act in 1976 and amended it in 1988. This legislation gives the Director of the Michigan Department of Agriculture (MDA) authority to register or certify private and commercial applicators and to prescribe standards for certification and registration.

A **private applicator** is a person using or supervising the use of restricted use pesticides (RUP) to produce an agricultural commodity on their own or their employer's land, or on lands rented by them.

A **commercial applicator** is any person applying pesticides other than private applicators. There are two subclasses of commercial applicators:

Subclass A - Any person (including homeowners) who uses or supervises the use of RUP's for a non-agricultural purpose.

Subclass B - Any person who applies pesticides in the course of his or her employment on the property of others.

Applicators included in subclass A must be *certified* as a commercial applicator. Those in subclass B have the option of becoming a certified commercial applicator or a registered technician. Because pesticides are used in a wide variety of operations, commercial applicators are certified or registered in special commodity or site specific categories. For example, a person applying pesticides to interior plants needs to be certified or registered in **category 7E, Interiorscape.**

Certified Commercial Pesticide Applicator

To become **a certified commercial pesticide applicator** a person must pass the Core examination, as well as, an examination specific to the commodity or site they will be working. A person can be certified in several categories if necessary.

When commercial applicators use a pesticide with a label that requires *direct supervision*, a certified applicator must make the actual application or must supervise the RUP application by being physically present at the time and place the pesticide is applied.

Once a person has satisfied the requirements for becoming a commercial certified applicator, they are qualified to make commercial pesticide applications for a three year

period. At the end of the three year period it is necessary to become **recertified** to continue applying pesticides commercially.

Recertification

There are two methods by which a pesticide applicator could become recertified. The first is to pass a recertification exam administered by the MDA, specific to the category(ies) the applicator was originally certified. Additionally, an applicator has the opportunity to become recertified by a process referred to as **"recertification by training meeting attendance."** During the three-year certification period, pesticide applicators can obtain credits toward recertification by attending pre-approved pesticide application seminars. At the end of the three-year certification period, if the applicator has earned the proper number of credits, he or she will be recertified without taking an exam. To be recertified in the interiorscape category an applicator must earn 18 credits during the three year certification period. **Note:** the seminars must pertain to the category in which the applicator is certified.

It is the pesticide applicator's responsibility to keep track of the number of credits earned over the course of the three-year period. MDA also maintains a record of credits earned for each pesticide applicator based on seminar sign-in sheets. At the end of the three years, when the pesticide applicator receives his or her recertification packet from the MDA, the applicator simply sends a check for the recertification fee and a record of the pesticide training meetings which they attended, to the MDA Lansing office. MDA will compare the number of credits in their records with those on the pesticide applicator's record. If there is a discrepancy, MDA will go back to the actual training meeting sign-in sheets to verify attendance.

For more information on the recertification process, contact a regional MDA office or the MDA office in Lansing.

Registered Technician

The 1988 amendments to the Michigan Pesticide Control Act established a new classification of applicators referred to as **registered technicians.** This classification includes people who are authorized to apply general-use pesticides for a commercial purpose or apply general-use pesticides as a scheduled and required work assignment while employed on the property of another person for any purpose. A registered technician may apply general use pesticides under supervision of a certified applicator and restricted use pesticides (RUPs) under **direct** supervision. If the label permits, registered technicians may apply RUPs only after applying the RUP under direct supervision for a specific number of hours. The intent of this portion of the Act is to establish minimum competency standards for all commercial applicators.

To become a registered technician a person must pass the Core examination which tests a person's knowledge on general pesticide information found in the *Commercial and Private Pesticide Applicator Core Manual, Initial Certification,* E-2195. Next, the person must undergo "category specific training." This training must be designed to deliver specific information to properly prepare them for their job tasks. The training must be approved by the MDA and administered by an MDA "Approved Trainer."

All employees of golf courses, hospitals, schools, municipalities, and licensed pesticide application businesses such as an interior plant maintenance company, who apply pesticides must be either certified applicators or registered technicians.

For more information about the pesticide certification process, registered technicians, registered technician training and "approved trainers" contact the Michigan Department of Agriculture, Pesticide and Plant Pest Management Division. P.O. Box 30017, Lansing, MI 48909, (517) 373-1087.

State Law: Regulation 636 - Pesticide Applicators

In 1991 Regulation 636 was passed as part of the Michigan Pesticide Control Act amendments of 1988. This regulation directly impacts those persons and businesses who apply pesticides to interior landscape plants. The following are excerpts of the primary components of Regulation 636 of the Michigan Pesticide Control Act and are **not** intended to represent the regulation in its entirety. Check the actual regulation for details.

Regulation 636 expanded the pesticide **record keeping** requirements. All commercial applicators shall maintain records of pesticide use for a time period not less than the following:

- **General Use Pesticides.** One year following application.

- **Restricted Use Pesticides.** Three years following the application.

The records shall contain the following:

A) The name and concentration of the pesticide applied;
B) The amount of pesticide applied;
C) The target pest or purpose;

D) The date the pesticide was applied;
E) The address or location of pesticide application;
F) Where applicable, the method of application.

Regulation 636 also enacted the "**registered technician**" classification for pesticide applicators as a minimum competency standard. Registered technician information is explained above. Part of Regulation 636 and the registered technician program involves "**approved trainers.**"

"Approved trainers" are certified applicators who have two years of experience in the category they intend to train and who have participated in a designated seminar to earn credentials, making them eligible for training registered technicians.

Regulation 636 also provides an exemption from some provisions of the Act for **incidental uses.** An individual or firm may make written request to the MDA for an exemption to the registered technician or certified applicator requirement if they meet the following conditions:
- A general use pesticide is used;
- The person is not regularly engaged in the application of pesticides for hire; and
- The pesticide application is an integral part of another operation.

State Law: Regulation 637

Regulation 637 of the Michigan Pesticide Control Act will impact commercial pesticide applicators and their pest management operations in several ways. The rules of Regulation 637 will include, but are not limited to:

1) Standards for pesticide use.
2) Registry of persons requiring notification prior to the application of pesticides.
3) Mixing and Loading operations.
4) Washing and rinsing operations of equipment.
5) Management of excess pesticide and pesticide containing materials.
6) Protective equipment.
7) Off-target pesticide drift management.
8) Notification and posting requirements.
9) Applicator service agreements (contracts).
10) Advertising.
11) Integrated Pest Management.
12) Pesticide use in and around schools.

It is vital that you obtain a copy of Regulation 637 in order to understand the components of each rule and how your pest management practices must comply. MDA anticipates that Regulation 637 will become effective in 1992.

Commercial Pesticide Application Business License

Any *business* established to apply pesticides for hire must obtain a **commercial pesticide applicator license** by sending an application and fee to MDA. Such businesses must also employ at least one certified commercial applicator who has two years of experience or one year of experience and a related four-year college degree, before the license can be issued. The certified applicator supervises the use of any general use or restricted use pesticides by registered technicians. (Note that the *business* is licensed, not the applicator.) The business must also provide proof of insurance as required by Regulation 636.

The MDA is responsible for investigating pesticide misuse and failures of pesticides to perform when used in accordance with label instructions. **If you have a complaint involving a pesticide,** notify the nearest MDA office. Delays in making a complaint greatly reduce the chances of a satisfactory investigation. The MDA needs to receive the complaint within 60 days of the action. Make the complaint as soon as possible if you have reason to suspect pesticide misuse or failure.

Review Questions For Section 2 - Laws and Regulations

Write answers to the following questions and then compare your answers with those in the back of this manual.

1. Which of the following is true about FIFRA, the federal law regulating pesticides?

   a. The authority to select and register pesticides in the various states is the authority of the federal government.

   b. FIFRA means Federal Insecticide, Fungicide and Rodenticide Act.

   c. It gives the states the authority to certify pesticide applicators.

   d. b and c

2. Which of the following describes a commercial pesticide applicator?

   a. A homeowner certified to apply restricted-use pesticides on their own property.

   b. A person certified to apply pesticides as part of their job responsibilities on the property of others.

   c. A person applying general use pesticides for hire.

   d. all of the above.

3. If a person is employed by Miss Maple in her privately-owned tree nursery and is legally eligible to apply restricted-use pesticides he or she could be...

   a. a private pesticide applicator

   b. a commercial applicator

   c. either a or b

   d. none of the above

4. A registered technician is ....

   a. a person who is not certified but is authorized to apply general use pesticides for a commercial purpose.

   b. someone who has had to pass the Core examination

   c. someone who has had approved training from a MDA approved trainer.

   d. All of the above.

   e. None of the above.

5. If you are a certified pesticide applicator...

   a. your certification is valid for 5 years.

   b. the only way to become recertified is by taking an examination pertinent to the line of work and category you are currently certified.

   c. you can earn recertification credits by attending training meetings that are applicable to your line of work. When enough credits are earned they may be applied toward recertification instead of taking another examination.

   d. None of the above.

6. Anyone who applies pesticides as part of their routine job responsibilities must be a certified pesticide applicator or a registered technician. (True or False)

7. According to Regulation 636, how many years must a business retain records of a general use pesticide application?

8. Which of the following are or will be components of Michigan state laws?

   a. Notification and posting requirements

   b. Establishment of Category 7E, Interiorscape Pest Management

   c. Applicator service agreement requirements

   d. All of the above

   e. A and C

9. If you have a complaint or concern about a misuse of a pesticide, who should you report the incident to?

   a. MDA (Michigan Department of Agriculture)

   b. EPA (Environmental Protection Agency)

   c. MDNR (Michigan Department of Natural Resources)

   d. CES (Cooperative Extension Service)

10. When you make a commercial pesticide application in an interiorscape setting, you must either be certified or a registered technician and the business that you are employed by must have a commercial pesticide applicator license. (True or False)

Section 3

Care of Indoor Plants

To successfully manage pests and diseases of interior landscape plants you must understand how to properly maintain plant health and manage plant stress. Plant stress usually results from either improper cultural care, placing the plant in an improper environment, or a combination of both. Pesticide use can be greatly reduced if plant management techniques are correctly executed for specific plants and their specific sites.

Plants imported from tropical and subtropical regions provide many of the species currently used in interior landscapes. Some of these plants are adapted to growing in full sun. Other foliage species are from the understory of tropical forests and are naturally adapted to low light levels. The species selected for use in interior landscapes must be those able to survive under the interior environment of low light and humidity and fairly consistent warm temperatures. If plants are not naturally adapted to, or grown under, these conditions they can be **acclimatized** (environmentally conditioned) to withstand the change in their surroundings.

The 7E Interiorscape certification exam will have questions from the following information to test your general knowledge of these concepts.

Table 1. Average Light Intensities of Familiar Locations

Location	Footcandles* of Light
Michigan Outdoors	
Sunny summer day	To 10,000
Cloudy winter day	500-2,000
Florida	
Full summer sun	To 15,000
Production of acclimatized plants	2,000 to 5,000
Interior	
Very "high" light maintenance	300 plus
Medium light maintenance	150 - 300
Low light maintenance	25 - 75
Offices	10-200
Stores	20-300
Homes (Living Room) Day	10-1000
Night	5-10
Churches	2-15

Footcandle: the standard measure used to determine light levels for plants in interior settings. A footcandle is the amount of light from a standard candle falling on one square foot.

Acclimatization

Understanding the process a plant goes through as it is moved from a production setting with high light levels, warm temperatures, adequate humidity and frequent irrigation and fertilization to interior conditions with low light levels, lower temperatures and humidity and irregular irrigation and fertilization is one of many important aspects of successfully maintaining interior landscape plants. When plants adapt to their surroundings the process is called **acclimatization,** and is defined as the *process required to cause physiological changes within a plant system that will enable the plant to withstand a radical change in environment without experiencing severe damage or even death.*

In the past it was not a common practice for plant growers to produce plant material that was acclimatized before leaving the nursery. However, even though the production of an acclimatized plant intended for use in an interior landscape requires more time, growers are choosing to provide their customers with such plants because they are a better product and more likely to survive in an interior setting.

A variety of factors influence acclimatization including light, water and fertilization with light being the most important. Considering light, let's look at outdoor light intensities compared to common interior settings. Based on values presented in Table 1, there is a large difference between outdoor intensities and indoor light levels.

Plant responses to light are varied, but in high light conditions, plants usually produce many small, thick leaves close together. Under low light conditions plants usually produce large, thin leaves, widely spaced. The leaves' orientation along stems, as well as the orientation of their internal elements, allow the plant to maximize the use of available light.

Some species can be successfully grown under partial shade conditions during the entire production period. Others require full sun to develop desirable traits such as thick

Table 2. Major Groups of Foliage Plants

	Shade Tolerant Low Light Intensity	Sun/Shade Plants Medium Light Intensity	High Light Plants
Description	Tolerant of low light levels, can not adjust to higher levels, easily scorch in bright light.	Widely used because they adapt to various interior conditions.	Rarely used in interiors, high light needed for best appearance.
Light Levels			
Preferred Level	50-500 footcandles	1,000-3,000 footcandles	4,000-8,000 foot-candles
Tolerance Level	>25-75 footcandles	100-1,000 footcandles	500-2,000 footcandles
Examples	Chinese Evergreens (*Aglaonema* species) Prayer Plant (*Maranta*) Bambo Palm (*Chamaedorea erumpens*)	Grape Ivy (*Cissus rhombifolia*) Figs (*Ficus* species) *Dracaena* and *Sansevieria* species	Pines (*Araucaria* spp.) *Begonia rex, Phoenix roebelenii*
Plant Placement	Shaded areas, up to 6 ft. from north window, 8 ft. from east or west window, 10 ft. from south window.	Indirect light, up to 4 ft. from north window, 6 ft. from east or west window, 8 ft. from south window.	Sunny spots, full sun for 5 hours in winter. Up to 2 ft. from east or west window, 5 ft. from south window.

trunks and full crowns. Plants grown in full sun must be converted to a lower light regime at some point during production to become acclimatized to the conditions they will face in an interior landscape setting. Most plants, depending on size and species, require six weeks to three months or more to convert and be adapted to a different light level than that under which they were produced. During the conversion plants will begin producing foliage that is typical of those grown in lower light; larger, thinner leaves, longer internodes (distance between leaves), medium to dark green color and rearrangement of internal leaf elements such as chloroplast (site of photosynthesis and starch formation). Table 2 describes plant categories based on light requirements and adaptability.

Nutrition level is another factor manipulated prior to and during the acclimatization process. Many growers recognize that excessive or insufficient nutrition prior to the acclimatization process directly affects the ability of a plant to acclimatize. During the acclimatization process, the amount of fertilization decreases as the level of light decreases.

Irrigation practices affect plant acclimatization. Improvement in the acclimatization process has been observed when plants have been watered as needed with some drying occurring between applications, rather than maintained at a constant moisture level, as is done during the growth phase of production.

Purchasers of foliage plants should request plants that have been acclimatized since they perform better under interior conditions. To determine if a plant has been acclimatized, first consider the grower and their reputation. Secondly, examine the plants and take note of the leaf color, size, spacing on the branches or vines, check to be sure no pests or diseases are present, confirm that the potting media is well drained, and look for a heavy root system, but not pot bound. Recognize that those growers and interior landscapers who have adopted acclimatization as part of their production and management plans have had a major impact on reducing stress, and increasing the longevity and aesthetic quality of plants utilized indoors.

The Root Environment

When purchasing plants, the interior plant manager must make sure the producer has used a quality root media that will hold up over several years. The growing media must provide support, moisture, aeration and a dark, disease-free environment. While light weight mixtures make containers easier to handle, they may not provide the support necessary for large plants. The volume of the potting material should be the same both wet and dry, with minimum shrinkage after repeated watering. If a potting media is not resistant to compaction and breakdown, it will soon lead to root stress and water-related problems.

While natural soil mixes dominated the type of media used in the past, growers and interior landscapers are now using soilless mixes. These mixes are well-drained, adequately aerated and uniform in quality; however they are low in nutrients. Information about soilless growing medias can be obtained from suppliers and in trade magazines.

The Shoot Environment

Light

All plants require light for survival. Interior landscape lighting is typically a combination of natural and artificial light sources. Either light source can support green plant growth as long as the proper light quantity and quality is supplied for sufficient duration.

When utilizing natural light supplied by a window or skylight, determine the distance light will penetrate into the room taking into consideration seasonal changes and the sun's orientation. Intensity of light close to windows is much greater than at a point just 4 feet away, with decreases of 75 to 90 percent possible in this short distance. Understanding light intensity is only half of the equation for maintaining plant quality.

An interaction exists between light intensity and "light duration" (the total number of hours of light received by a plant in a given day). A plant exposed to high light intensity for a short duration may be just as effective as exposure to lower light intensity for longer duration. Therefore, if an interior setting has variable lighting, adjusting the length of time that the different light sources remain illuminated can compensate for varying intensities and still provide a satisfactory growing environment.

Plant responses to lower than desirable light intensity may include elongation of newly formed internodes (etiolation), elongation and narrowing of leaves or small leaves, reduced production of leaves, loss of older leaves, and generally a sparse appearance. When plants are exposed to higher than desirable light intensities they will have shorter internodes, smaller leaves, reduced levels of chlorophyll, hence a lighter green color and, increased variegation in variegated plants. Excessive lighting may cause leaf yellowing, "burning" and sometimes browning of leaf margins.

When relying on artificial lights, fluorescent lamps, especially cool-white or warm-white, are more efficient than incandescent bulbs. Also, fluorescent lamps do not give off heat that can be damaging to plants.

No matter how well you understand the building's light intensities and duration, the most important factor to understand is the requirements of the various plant species within the interior landscape setting.

Humidity

Relative humidity (RH) is defined as the amount of moisture held by air at specific temperatures. Most foliage plants perform best if RH is above 50 percent, yet, can tolerate RH as low as 25 percent. Prolonged exposure to excessively low humidity levels will prevent indoor plants from producing food necessary for growth and reduce their aesthetic quality. Low humidity combined with low light levels and poor watering practices is lethal for many indoor plants. In some instances, adequate soil moisture will partially compensate for low humidity. When plants are low growing, evaporation of water from soil surfaces may contribute to the RH of the surrounding leaves.

Manipulating humidity in an interior setting is best accomplished by having the heating and cooling system for the area engineered for human comfort. In commercial buildings a range of 30 to 50 percent humidity is possible with the low end of the range being more common during seasons when continuous heating is necessary.

Pebble trays are effective ways of increasing RH around individual or small groups of plants. Pebbles, perlite or similar material can be placed in trays or saucers. Place the plant container on top of these pebbles and maintain a water level in the pebble-filled tray just below the bottom of the plant's container. Water above the pebble surface will be absorbed into the potting media, possibly keeping it too wet and promote root rot.

Grouping plants is not particularly effective and misting plants is definitely not recommended. Misting of plants does not provide any significant change in humidity. Misting can actually be detrimental to plant health since wetting the foliage allows infection by plant pathogens.

Temperature

Maintaining adequate temperatures during Michigan's winter months is of special concern. Indoor ornamental plants, especially tropical species, can suffer chilling injury when temperatures drop below 55 degrees F. The amount of damage depends on how long plants are subjected to cold temperatures. A brief exposure at 35 to 40 degrees F will cause as much damage as longer exposures at 45 degrees F.

If seasonal temperatures are extremely low when plant material is being transported and installed at a job site, the risk of exposure is great. It is difficult to provide adequate plant protection even for a short duration or during the transfer from a heated truck to a heated building when the temperatures dip below 15 degrees F. Consider rescheduling the job until conditions are more favorable and less risky for the plant material.

Be aware of prolonged furnace failures and temperature changes in buildings on weekends. Many businesses will lower the thermostat setting when the building is unoccupied by employees.

Several days may pass before chilling or freezing injury becomes obvious. Symptoms associated with injury from cold temperatures include:

* discoloration
* poor growth or wilting
* plant death
* collapse of flower clusters
* loss of foliage
* brown, water-soaked areas
* plant bending and leaf curl

Be aware of the plants proximity to ventilation devices. Cool drafts from air conditioning units, doorways and windows are a common cause of chilling injury to susceptible plants.

Air streams from heat registers will also cause problems. Hot drafts can dry out growing media and foliage quickly, and may increase the risk of mite infestations. Be aware of the conditions the plants you purchase were subjected to before you install them directly into an interior landscape setting.

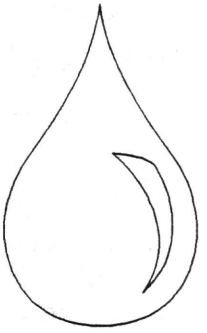
Water Requirements: No Simple Issue

Water management is the most problematic cultural practice in maintaining interior plants. Several factors influence a plant's water use in an interior landscape setting.

Environmental factors affecting water loss:
- **Light**
- temperature
- humidity
- air movement

Plant factors affecting water usage:
- **type of plant**
- size of plant and leaf number
- how long the plant has been in the interior environment

Container and media factors affecting water availability:
- **type of media**
- size and material of container
- drainage
- presence of mulch



While all these variables influence how and when water should be applied to plants, light level and plant type are the most important factors to consider. The higher the light level, the more water used. However, water requirements can vary dramatically for different plant species.

When determining if water is needed, observe the physical condition of the plant. Is the plant displaying true leaf color? Are the leaves dull or shiny? Is the plant losing its turgor (is it limp)? Crisp, rigid leaves indicate adequate moisture is still available.

It is also important to look at the root media. The color of the potting mixture will be lighter when it is dry. Water is a relatively heavy element and its presence in containers changes their weight considerably. For smaller plants, picking up the container will allow you to roughly estimate the moisture level. For larger plants taking a sample of media from the root ball using a soil probe is an accurate way to determine soil dryness or moisture availability and if the moisture is consistent throughout the soil profile. Also, check for water in the bottom of decorative containers.

Allowing the plant media to dry out between irrigations and watering only when the plant needs it is an ideal program. Yet, when dealing with professional plant maintenance, when to water is often dictated by the maintenance schedule rather than waiting until water is needed. So, while understanding what factors influence water loss and how to measure the amount of root media moisture are important, the timing of the applications may be predetermined. If this is the case, the technician is confronted with determining whether a watering can be disregarded during a particular visit or how much water to apply to sustain adequate moisture in the media.

Knowing the plant type and the environmental conditions will help determine the practicality of skipping a watering until the next scheduled visit. Conditions within one plantscape can vary greatly. A plant exposed to full sunlight requires more frequent attention than a similar plant in partial shade. Recognize that plants recently moved from production settings to an interior environment use more water during the first few weeks than they do after they have become acclimated to the interior environment. Otherwise, the type of container or planting bed, the planting method and availability of drainage can influence the amount of water to apply. The goal is to apply enough water to thoroughly and uniformly moisten the entire root zone.

Avoid watering with a strong stream of water that washes soil away from the roots leaving them exposed. Avoid watering to the point when excess water drains out the bottom of the container unless you are intentionally trying to leach (flush out) soil impurities such as soluble salts from excessive fertilization or hard water. If you water so that a percent of the water flows out the bottom of the container, you are faced with protecting your clients floors and table tops and discarding the water. When a growing container is placed inside of a decorative container using foam collars to keep it in place (double planting), excessive watering can lead to odor problems when water is trapped and stagnant

at the bottom of the outer container. If leach water is captured by the outer container, it will need to be pumped out or drained. Do not allow the growing container to sit in water for long periods of time (not more than a day or two). This creates a saturated root zone and promotes root rot problems.

The high rate of respiration and growth of roots requires a constant supply of oxygen in the growing media. Poorly drained soils retain water in all pore spaces, directly blocking out air. When too much water is applied, roots can suffocate because the supply of oxygen is depleted. If the roots are not killed directly as a result of poor watering practices, they will become stressed. When roots are stressed they are more susceptible to pathogenic diseases.

An alternative to conventional hand-watering is the use of subirrigation systems. With subirrigation, water enters the bottom of the pot and is distributed into the root media by capillary action. Capillary action is the upward and lateral movement of water as a continuous column into the micropores of a medium. There are currently four basic subirrigation design systems:

1) rope or fabric wick systems
2) root media wick systems
3) vacuum sensor systems, and
4) hydroculture or hydroponic systems.

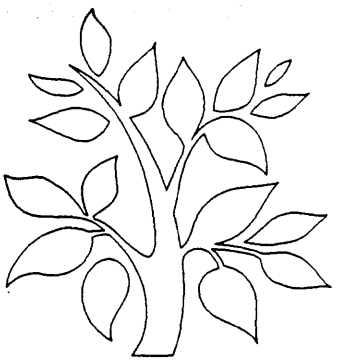
There are three keys to success with interior landscape irrigation systems: 1) understand the principles of how they work, 2) select the right system for the job and 3) train the people responsible for the plants and the irrigation system about the fine points of how it operates.

Fertilization

The most likely problem with fertilizing plants in professionally-maintained interior landscapes is over fertilization. A plant living in an interior landscape requires a fraction of the fertilizer that it received while it was growing in a nursery. The amount of fertilizer applied is a function of light, water applied and the plant species.

When considering an application of fertilizer it should be timed with the growth cycles of plants. Growth typically coincides with the time of year that provides the most amount of sunlight and warmer temperatures. For example, in the northern United States, spring and summer are the seasons of highest light intensity and potential growth.

The amount of leaching that occurs with routine watering practices can influence fertilizer requirements. Fertilizer nutrients are very soluble and can be washed away. With



regular leaching, fertilizer may need to be applied more often.

When a fertilizer is necessary the best option is usually a water soluble fertilizer applied with the irrigation water. Once the amount of fertilizer per year is determined, some fraction of the amount can be applied at regular intervals. A measured volume of a known concentration is applied to saturate the root media. This method is best when minimal leaching is occurring.

A complete fertilizer containing trace elements and a nitrogen (N), phosphorus (P) and potassium (K) ratio of 3:1:2 has been recommended for foliage plants. In general, boron should be avoided to prevent an elemental toxicity that can result in marginal leaf necrosis.

Excessive fertilization is harmful to plants. Fertilizers can "burn" plants causing leaves, especially the margins and tips, to lose color and turn brown. Fertilizers are nutrients in the form of soluble chemical salts. When dissolved in the soil water, they compete with root hairs for moisture. When high levels of salts are present in the growing media, water fails to move into the roots as easily and wilting may occur.

Remember, fertilizing is not a solution for inadequate light or moisture. Fertilizers will only aggravate these conditions.

If fertilizer has been applied but leaf color is still chlorotic (yellow or lighter in color) or no growth is occurring when expected, check the pH of the root media. Root media pH, or the relative acidic (low pH) or basic (high pH) condition of the media will influence nutrient availability. Both low and high pH conditions can be encountered in interior landscape settings depending on the root media, quality of the irrigation water and fertilization method.

High pH (greater than 6.8) is perhaps the most common problem. The root media pH of interior plants can be lowered by using acidic fertilizers, a soil drench of iron sulfate, a top dressing of finely ground sulphur powder, or by adding phosphoric, sulfonic or nitric acid to the irrigation water. If low pH (less than 5.5) is a problem, finely ground lime can be added and washed into the root media. Consult a greenhouse management text or local Cooperative Extension agent for specific recommendations for your area.

Summary

Successful management of plants in interior environments depends on understanding how the shoot environment and the root environment influence plant survival. The light and temperature levels in the shoot environment must be considered during design and installation since they can be influenced little during routine maintenance. The water and fertilizer levels of the root environment must be managed carefully if interior plants are to survive.

Review Questions For Section 3 - Care of Indoor Plants

Write answers to the following questions and then compare your answers with those in the back of the manual.

1. Plants become stressed due to poor cultural care, environmental conditions, or a combination of both. (True or False)

2. Why is it important to acclimatize plants?

3. A plant adapted to medium light levels prefers _____ footcandles but will tolerate _____.

4. What important qualities should a potting mix have?

5. Of all the factors that influence the amount of water a plant requires which two variables are most important to consider?

6. When irrigating plants your goal is to apply enough water to thoroughly and uniformly moisten the entire root zone. (True or False)

7. What are some of the problems caused by over-watering plants?

8. Plants growing in low light conditions require extra fertilizer to keep them healthy. (True or False)

9. Fertilizers are soluble salt compounds. (True or False)

10. Plants should be watered:

    a. so that 10% of the water leaches out each application.

    b. a small amount during every visit scheduled to the site.

    c. so that the potting soil is always wet and never dry.

    d. when a soil core shows lack of moisture.

Section 4

INTEGRATED PEST MANAGEMENT

To maintain healthy plants an interior plant technician must understand the optimal growing conditions for the species of plants he or she is working with including proper light, temperature, humidity, soil moisture and pH. Providing these conditions becomes challenging when an interior landscape can contain 20 or more species of plants in a variety of environments. Appropriate planning, placement, monitoring and maintenance will help to limit plant stress. Using all available tactics or strategies to manage pests so that an acceptable appearance and quality can be achieved economically and with the least disruption to the environment is called **integrated pest management (IPM.)**

The goal of IPM is to reduce the occurrence of plant problems and maintain pest (insect, disease, and weed) populations at levels where aesthetic and economic losses are tolerable. Any practice which helps prevent or reduce plant injury are used. Integrated pest management is not "anti-pesticide," but rather incorporates a wide range of pest controls such as resistant plant varieties, cultural practices, mechanical control, biological controls and pesticides.

The basic components of an IPM program will include:

1. Regular Monitoring and Early Detection of Disorders
2. Proper Diagnosis and Identification of Plant Disorders
3. Determination of Economic Significance
4. Selection of Management Methods
5. Evaluation of Management Methods

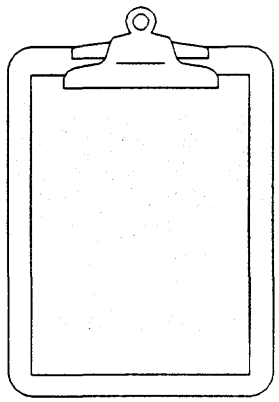
Monitoring and Detection

Typically a plant manager visits an interior landscape on a regularly scheduled basis. The task of monitoring should be an integral part of each visit. During routine tasks of watering, rotating and cleaning, be alert to health conditions of the plants and presence of potential pests. Detection of low-level pest populations is doubly beneficial. Early detection allows you to manage pests or alter conditions before host plants suffer serious injury. In addition, low-level pest infestations are typically easier to manage and the use of less toxic management strategies are still an option. Washing the foliage with a 2% soap solution, pruning the problem out or correcting a poor site condition may eliminate the problem without the use of a pesticide.

Some insect species can be detected with the use of yellow or blue sticky cards. These cards are approximately 3" x 3" and have a sticky substance on the surface. The cards are either hung in the canopy of the plant or attached to a stick inserted in the soil. Yellow cards are highly attractive to whiteflies and thrips, while blue cards are more specific for attracting only thrips. Both colors will also attract fungus gnat adults. Fungus gnats are seldom a problem for interiorscape plants, but may become a nuisance. Insects that come in contact with the cards' sticky surface cannot escape. Your observation of these cards will help determine what insects are present and changes in population density. It is important to write down the numbers of insects per card, each visit. Change the cards on a regular basis or when they become so heavily covered with insects that it is too difficult to count them, and after pesticide treatments.

To keep monitoring and detection information uniform, develop a system to rank plant condition. If time allows, documenting healthy plant conditions provides a written record of your inspection. If a problem does occur, you will have background information to help diagnose the situation at hand. Record information useful for planning management strategies:

- level of light (footcandles)
- plant species
- plant age and size
- date of installation
- size of container
- type of soil media
- life stage of the pest
- type and level of damage
- date of detection, etc.



Diagnosis and Identification

When damage or poor plant health is detected, the interior plant manager is faced with determining which organism or

Table 1: A General Diagnostic Guide for Indoor Plants

Symptom	Possible Causes
1. Brown or scorched leaf tips	A) Poor root health from overwatering, excessive soil dryness (especially between waterings), excessive fertilizer or other soluble salts in the soil or root rot disease. B) Specific nutrient toxicities (such as fluoride, copper or boron). C) Low humidity. D) Pesticide or mechanical injury.
2. Leaf spots, blotches, blemishes, blisters or scabby spots	A) Intense light (sunburn) associated with a recent move of the plant or excessive soil dryness and wilting. B) Chilling injury (below 50°F). C) Chemical spray injury. D) Overwatering. E) Fungal or bacterial infections (not common unless plants have recently come from a field or greenhouse).
3. a. Foliage yellow-green; older leaves	A) Insufficient fertilizer, especially nitrogen. B) Poor root health due to pot-bound growth, compacted soil, or poor drainage. C) Insufficient light. D) Senescence (natural aging process, individual leaves)
b. Foliage yellow-green; newer leaves	A) Soil pH (acidity) imbalance. B) Trace element imbalance.
c. Foliage yellow-green; general	A) Too much light. B) Insufficient fertilization. C) High temperatures, especially when associated with dryness. D) Insect infestation or root rot disease.
4. Leaf drop	A) Poor root health from overwatering, excessive dryness, excessive fertilizer or other soluble salts in the soil, compacted soil or pot-bound roots. B) Sudden change in light, temperature, or relative humidity. C) Root rot disease.
5. Wilting or drooping of foliage	A) Poor root health from overwatering, excessive dryness, excessive fertilizer or other soluble salts in the soil, compacted soil, or a poorly drained container or root rot disease. B) A toxic chemical poured into soil.
6. Roots brown in color, soft or rotted; roots with tissue that can easily be "slipped off" leaving behind the string-like center tissues; roots massed at top or bottom of pot. Associated with one or more of the symptoms noted above.	A) Poor root health from overwatering, excessive dryness, excessive fertilizer or other soluble salts in the soil, compacted soil, or a poorly drained container. B) A toxic chemical poured into soil. C) Over- or under- watering. D) Root rot disease.
7. Yellowed leaves with tiny speckling; leaves later bronzed and drying; webbing noted near growing points.	A) Spider-mite infestation.
8. Leaves or stems covered with a sticky substance; mold growing on leaves; tiny brown or white objects seen on leaves or in crotches of branches; leaf drop or branch dieback; leaf or growing point distortion.	A) Scale or mealybug infestation.

condition is responsible: cultural or environmental conditions, diseases, insects, mites, or human activity. Remember, there is often more than one damaging influence. Identify **all** conditions that may have stressed the plant, causing it to be more susceptible to the problem or pest you observe now.

Diagnosing Plant Disorders

Accurately diagnosing plant problems comes with experience. Adopt the following diagnostic techniques:

- Identify the plant. Certain problems are more common with certain plants. (See Table 1 in the "Common Insects of Foliage Plants" section and Table 5 in the "Diseases of Interior Plants" section.)

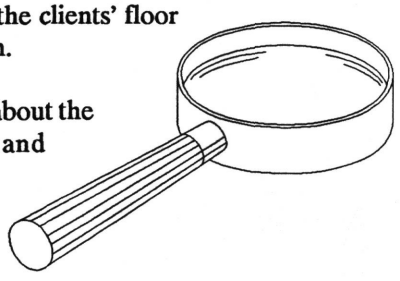
- Inspect the **whole** plant; leaf surfaces, especially the underside, stems and twigs. If possible, carefully remove the plant from its container to examine root and soil conditions. Inspecting the root environment is often difficult but necessary.

- Clearly define the symptoms. Where are the symptoms on the plant; random locations, localized or in a pattern? Are the symptoms that you identify the same as the symptoms your client is concerned about? (See Table 1 on the previous page.)

- Categorize the cause of the problem as contagious or non-contagious.

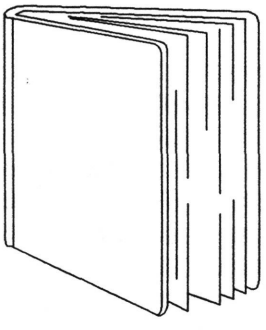
- Although fungal, bacterial and viral infections can be common in production environments, the interior landscape environment is generally **not** favorable for disease organisms when appropriate, cultural and environmental conditions provide for stress-free plants. Keeping foliage dry and relative humidity low, common conditions in indoor landscapes, are perhaps the best control for foliar diseases. Root rots can be a problem but generally only when the roots are first damaged by over- or under-watering or high levels of soluble salts in the media. Therefore, if a root problem occurs, evaluate your watering and fertilizing practices and the drainage of the soil and container.

- Tools are necessary for doing thorough investigations and sampling the roots, soil and foliage for pests. Bring with you: hand and pole pruners, a trowel, a soil probe, a sharp knife, a hand lens, specimen bags or containers and a drop cloth to protect the clients' floor during your inspection.



- Make observations about the surrounding micro and macro climate (conditions in close proximity to the plant and those in the larger, surrounding area). Make observations of the microclimate with the assistance of a magnifying lens. Signs of disease, mites and insects such as thrips are more easily diagnosed with this simple tool. Examine soil conditions, drainage, pH and fertility levels.

Consider these factors of the macroclimate: Where are the heat or air conditioning vents? Are there drafts from doorways? Are light levels adequate? Note temperature and humidity levels and the plant's proximity to windows.



- Ask the client about activities that may disturb the plant. Is the container being used as a receptacle for coffee, cigarette butts, cleaning compounds?

- Have ready access to plant diagnostic references such as Extension bulletins and agents, books, your records, and fellow diagnosticians.

- A checklist can help ensure that you are collecting and considering all pertinent information. Table 1 outlines common symptoms associated with indoor plants and their possible causes.

Contagious Disorders:			
A. Insect or Mite infestation	**B.** Disease or virus infection		
Non-contagious Disorders:			
A. Environmental:		**B. Chemical:**	**C. Human Activity:**
<u>Aerial</u>	<u>Root</u>		
Light	Water	Cleaning Compounds	Breakage, relocating,
Temperature	Media	Volatile Gasses	watering with excessively
Humidity	pH	Food Wastes	cold water, etc.
	soluble salts		

- An organism should not be classified and treated as a pest until it is proven to be one. Insects may pass through several life stages, changing in appearance and activity during their development. Most insects and related pests are affected by pesticides only during one or two phases of their life cycles, i.e. scale and whiteflies are most successfully treated while they are "crawlers." Regular moni-

toring of the interior landscape detects early infestations, when populations are low, and indicates the life stages present. Control measures made to small numbers of pests during their susceptible life stage are likely to accomplish your pest management goals. Missing this period of the pest's vulnerability can lead to more severe infestations. When considering pest management treatments, you must be able to:

* Identify the pest
* Know which of the pest's life stage is susceptible to your management tactics
* Identify the pest's susceptible life stage (many pests change dramatically in physical appearance as they mature)

The interiorscape environment has unique qualities compared to other horticultural settings. In an interior landscape the variety of organisms observed is significantly less than what can be found outdoors. Yet, like an outdoor setting certain plants tend to be vulnerable to specific pests; Ficus are susceptible to scales, schefflera are susceptible to mealybugs and palms are susceptible to spider mites as ferns are prone to bacterial leaf spots, and dracenas are prone to root and stem rots. It is vital that you recognize the correlation between host plants and the pests they are susceptible to.

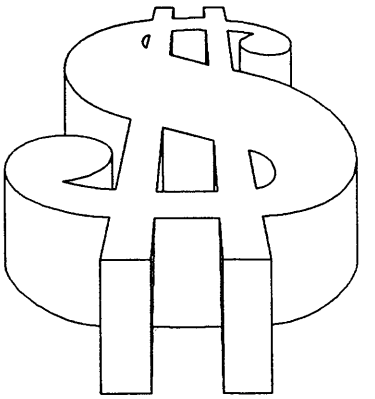
Listed in Table 1 in the "Common Insect Pests of Foliage Plants" section, English ivy and Schefflera spp. are noted to be susceptible to several insect pests. Thus, you may want to avoid their use, particularly in areas with chronic pest problems or access to the out-of-doors and open windows. Pests from the exterior landscape may come into the interior landscape through doorways and open, unscreened windows to infest your plants. If selection of pest-prone plants is unavoidable, use them on a limited basis and be cautious of where they are placed. As you gain experience the symptoms of plant disorders and pest identification become more obvious. Table 1 in Section 6 and Table 5 in the disease section identify common insect and mite, and disease pests commonly associated with plants used indoors.

Also unique to the interior landscape is climate control. The climatic conditions within a building are manipulated for the comfort of people and their activities with little consideration for the plants and pest populations in the same surroundings. Low relative humidity and high temperatures speed up the development of spider mite populations. Recognize that plants will not live forever in some environments and some decline is expected.

Overall, once an abnormal plant health condition is detected, it is extremely important that you devote ample time and research to your diagnostic process. Identify and assess all factors that have contributed to the abnormal condition. A thorough and systematic diagnostic approach to problem solving will help you evaluate, select and accurately time the most appropriate management practice(s) for the host plant, pest(s) and site. This process is also the key to avoiding unnecessary applications of pesticides.

Economic and Aesthetic Significance

All pest management activities have costs in terms of materials, time, or environmental impact. The routine plant management activities, which also serve as preventative pest management practices, are typically defined in a service contract between the client and plant maintenance company. Account for the costs of plant maintenance activities and predicted pest management procedures before you sign the contract. There are legal requirements for pesticide applicator service agreements in Regulation 637 of the Michigan Pesticide Control Act. Be familiar with the contents of this regulation and be sure your contracts and service agreements satisfy these requirements. It is important that the client and contractor justify the cost and related benefits of pest management tactics.



Replacement plants and their value are often accounted for in the service contract with the understanding that some indoor conditions are harsh and sustaining long term plant health is extremely difficult. Therefore, cost of replacing or rotating plants is accounted for in the original work agreement. Any activity that reduces the frequency of plant replacement will increase the profitability of the account.

Special cases requiring additional pest management strategies are likely to arise over the long term. Cost-benefit analyses are determined when these unique situations occur. The decision to treat for a pest or to replace a plant(s) may be the responsibility of the account manager. As a plant technician, consult with the appropriate persons before action is taken. For example, a large specimen palm in a shopping mall infested with spider mites presents a problem. Several special circumstances arise when spraying in a public area, yet, taking no action will result in a costly, labor-intensive replacement. Early pest detection may allow time for treatment with predatory mites and avoid the need for chemical use.

Cost-benefit analysis requires educating the customer on basic plant growth habits and requirements, pest manage-

ment alternatives and techniques. Be informed and prepared to explain the decision and need for pest treatments. Educate the client when negotiating a contract and when unique pest outbreaks occur. The clients' input is vital in this process, since it is their interpretation of the cost-benefit analysis that dictates whether a pest management tactic will or will not be implemented.

Selection of Management Methods

Many factors limit pest populations including natural enemies of pests, i.e. predator insects, plant defenses, and a host of controls implemented by people. The pest management methods most appropriate for a specific circumstance will depend upon the biology of the pest and host plant, and the interior landscape situation. You must consider all available management tactics and evaluate the benefits and risks of each, for every pest problem.

Choose methods that:

- are practical in an indoor setting.
- are the least toxic to nontarget organisms.
- enhance natural controls and plant defenses.
- will most likely limit the pest permanently.
- are the least hazardous for the applicator to handle.

Your options will include selecting appropriate plant species for a given site, correct water and fertilizer applications, pruning, washing, rotating, replacing, altering environmental conditions such as temperature, humidity, exposure to direct light or drafts, sanitation, providing adequate drainage, soil pH and soluble salt levels and pesticide applications when necessary.

Most likely, a combination of methods will make up your pest management program. No matter how environmentally-sound or effective the options are, a pest management program is only successful if it can be economically and practically implemented. Keep in mind the factors which limit the number of appropriate management options:

1. Budget
2. Availability of equipment
3. Availability of personnel
4. Time frame allowed for management procedures -- your procedure must be implemented during the pest's vulnerable stage of life, when no one occupies the interior landscape and the area can remain vacant until the re-entry period has been observed.
5. Public/client acceptance of management methods
6. Availability of products labeled for interior use.

Also, as a plant manager, consider the option of removing the plants to be treated from an interior landscape and temporarily relocating them to outside or to a greenhouse. By relocating plants, you will have a larger selection of products registered for use in those areas including some that may have been cancelled for use in the interior landscape setting. Furthermore, the conditions in a greenhouse (light, temperature, and water) may be more conducive to the plant's recovery. Once the plant has been treated and the problem corrected, it can be replaced to its original interior landscape location.

IPM - Evaluation

It is extremely important to evaluate the results of your pest management strategies. This can be done in several ways such as counts of pests or level of infection before and after treatment, comparative damage ratings, length of recovery time, etc. Sticky cards, as discussed under monitoring in this section, are helpful in evaluating the results of an insect management treatment. Keep written records of successes and failures, timing of treatment, special conditions.

IPM as a Component of Regulation 637

When pesticide applications are made in public buildings there are Integrated Pest Management requirements that the pesticide applicator or account supervisor must fulfill as outlined in **Regulation 637** of the Michigan Pesticide Control Act.

This regulation requires that the pesticide applicator or responsible contractor has had verifiable training which included IPM principles, and a verifiable IPM program must be in place for the building. The building IPM program includes keeping records of various facts associated with the site such as your monitoring practices, the pests, and your pest management treatments.

It is your responsibility to become familiar with and fulfill all the requirements of Regulation 637 in order to operate a legal business. For questions concerning the interpretation of Regulation 637, contact the Michigan Department of Agriculture.

Review Questions For Section 4 - Integrated Pest Management

Write answers to the following questions and then compare your answers with those in the back of the manual.

1. The goal of an IPM program is to:

   a. never use pesticides.

   b. manage pests using cultural and biological controls no matter what the cost.

   c. maintain pest populations where economic and aesthetic losses are tolerable.

   d. eradicate all pests at first sight to prevent additional damage.

2. Yellow and blue sticky cards:

   a. are an effective, non-toxic method used for eliminating insect pests.

   b. are useful tools for monitoring pest presence and population densities.

   c. will not attract thrips.

   d. should be changed only twice per year.

3. Which of the following is a non-contagious disorder?

   a. relative humidity

   b. powdery mildew

   c. high level of salts in root media

   d. a and c

4. Keeping foliage dry and relative humidity low are two of the best methods for managing foliar diseases. (True or False)

5. Pests from exterior landscapes may enter through windows and doorways to infest interior landscape plants. (True or False)

6. Low relative humidity and low temperatures speed up the development of spider mite populations. (True or False)

7. Which of the following are preventative pest management techniques?

   a. irrigating with enough water to leach salts out of plant containers.

   b. irrigating with the coldest tap water available to discourage root feeding insects.

   c. wetting the foliage when watering to raise relative humidity around the plant.

   d. a and c

   e. all of the above

8. Which of the following should you consider when selecting a pest management method?

   a. the biology of the pest

   b. where the plant and associated pest problem are located

   c. the type of host plant

   d. all of the above.

9. Regulation 637 of the Michigan Pesticide Control Act has requirements that pertain to which of the following?

   a. Registered technicians

   b. IPM programs for the sites you manage

   c. service contracts between pesticide applicator and client

   d. all of the above

   e. b and c

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HOUSEPLANTS:

Common Insects & Diseases

C.T. Stephens and D. Smitley
Department of Botany and Plant Pathology
and Department of Entomology

Section 5 of *Interiorscape Pest Management Training Manual for Commercial Pesticide Applicators* (Category 7E), E-2308

Many people who care for houseplants do not recognize problems until one or more plants have been severely damaged. Most of the common insects and diseases of houseplants are inconspicuous at first and easy to overlook until the infestation or infection is severe. Learning to recognize early damage symptoms is the easiest way to tell if you have a problem so you can prevent serious damage and restore the plant to good health.

Often a 10X hand lens will be necessary to identify a suspected pest problem. Of course, you need to know what symptoms to look for and where they are likely to be on the plant. Keep in mind that most houseplant problems caused by insects and diseases occur because the plants have been stressed by improper care: too much or too little water, light, heat or fertilizer, or improper soil type and pH. Check these routinely when caring for and examining your houseplants (see Extension Bulletin E-1077, *Houseplant Problems,* free).

INSECT PESTS

Two general types of insects occur on houseplants: soil-related pests and leaf- and stem-related pests. The first group contains the springtails and fungus gnats. These pests are easily controlled and are usually not a serious problem. The second group consists of several species of insects that feed on leaves and stems. Spider mites are one type. A second group, the sucking insects, contains four members of the insect group called the Homoptera: aphids, mealybugs, scales and whiteflies. A third type of sap feeder is the thrips. These tiny insects rasp the plant tissue and suck up the sap that seeps from the damaged plant cells.

DISEASES

Disease problems associated with houseplants can also be divided into two groups: leaf and stem diseases and root disorders. A number of fungi and bacteria can cause disease in either category. Disease-causing fungi include species of *Alternaria, Botrytis, Erysiphe, Sphaerotheca* and *Septoria.* Disease-causing bacteria include *Erwinia, Pseudomonas* and *Xanthomonas.* Disease agents considered to cause root disorders include *Phytophthora, Pythium* and *Rhizoctonia.*

Several conspicuous fungi, algae and mosses also grow on the soil surface in pots when moisture is adequate. These organisms do not pose a problem to plants unless their growth becomes so dense that it keeps water from penetrating the soil.

INSECT AND DISEASE MANAGEMENT

Plants subjected to environmental stress are usually more susceptible to invasion by insects and disease organisms. Stressed plants may also show more severe damage symptoms than unstressed plants subjected to identical insects and diseases. Therefore, it is important for the interior plantscaper to provide optimum growing conditions for plants, including proper light, temperature, humidity, soil moisture and pH.

Sometimes, however, even plants growing under ideal environmental conditions will develop serious insect and/or disease problems. These plants may need to be treated with an appropriate pesticide to reduce the pest population. After applying pesticide, you will need to make every effort to optimize the environmental conditions so the treated plant can recover.

Use a pesticide to control an insect or disease problem only after you have properly identified the infesting organism. Correct identification of the organism and an understanding of its life cycle

will help you choose the proper pesticide and apply it properly and at the best time to achieve the most effective control.

You also need knowledge of the horticultural characteristics of the plant, especially its sensitivity to environmental stress and pesticides to choose and use the right pesticide. Some pesticides are harmful (phytotoxic) to houseplants because of the plants' sensitivity to environmental stresses or because of improper pesticide application. Some chemicals recommended in this bulletin—malathion, for example—are known to be phytotoxic to some species of houseplants.

The following chart describes common plant pests and problems and suggests various control measures. Remember: before you purchase any pesticide, know exactly what **pest** you are trying to control on what **species of ornamental plant.** Use the selected pesticide only on the plants listed on the label of the product and on the pamphlet (labeling) that usually accompanies the pesticide container. Do not treat any plants that the label lists as sensitive to the pesticide.

SAFE USE OF PESTICIDES

For all pesticides, follow ALL the instructions and limitations that appear on the product label and in any pamphlets that accompany the product. Pay close attention to the precautions and emergency procedures in case an accident occurs. Wear protective clothing when using any pesticide: long-sleeved shirt, long pants, rubber boots, gloves (no leather items) and goggles. Always apply the exact amount of diluted pesticide material specified by the label. Do not misuse or mishandle any pesticide.

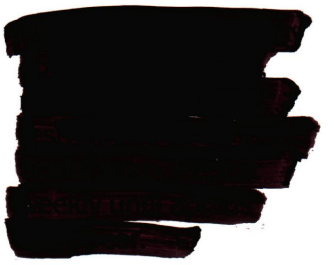
Some pesticides that can be used on ornamental plants are formulated for use in a home or office—an example is ORTHO House Plant Insect Control. But the majority of pesticides labeled for ornamentals may not be used indoors. Always move an infested plant outside to a shady spot to treat it with a pesticide. If the weather is cold, treat the infested plant in a garage, remembering to avoid using the pesticide near any air intakes for heating units or near any open flame, including pilot lights on gas hot water heaters and furnaces.

After applying any pesticide to an infected plant, allow the surface of a plant treated with a spray to dry before taking it back into any living areas, or move a plant treated with a dust to an area inaccessible to children and animals. Allow 24 hours for the pesticide dust to work, and then wash it off with large amounts of water before taking the treated plant back into the living quarters.

Pesticides must be registered with the U.S. Environmental Protection Agency and the Michigan Department of Agriculture before they can legally be sold and used in Michigan. Purchase only pesticide products that are labeled for the ornamental plant you wish to treat and the pest you wish to control on that plant. Remember that the pesticide label is the legal document on pesticide use. Read the label carefully and follow all instructions and limitations. Using a pesticide in a manner not consistent with the label can lead to the injury of plants, humans, animals and the environment. Pesticides are useful management tools for the control of pests only when they are used in an effective, economical and environmentally sound manner.

INSECT	DESCRIPTION AND DAMAGE	CONTROL MEASURES
APHIDS		

Aphids are soft-bodied insects about 3 mm (1/8 inch) long that cluster on undersides of leaves, buds and other tender plant parts. They feed by sucking plant juices and cause poor growth and distorted leaves. Aphids excrete honeydew, which can build up on leaves and promote growth of sooty mold.



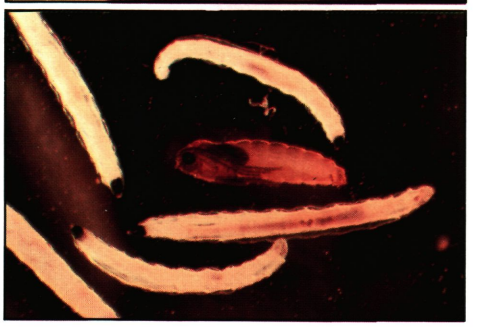
INSECT	DESCRIPTION AND DAMAGE	CONTROL MEASURES

SCALES

Scales are soft and oval with a flat upper surface, yellowish brown and about 3 mm (1/8 inch long). Other species have different shapes. All have immobile feeding stages and mobile (crawler) stages. Crawlers are the life stage easiest to control. Heavy scale infestations weaken and stunt plants.

[redacted]

FUNGUS GNATS



Larvae are thin, whitish, wormlike maggots about 6 mm (1/4 inch) long. They are most likely to occur in soils high in organic matter. Larvae feed on roots and crowns of plants, stunting growth and ultimately causing leaf drop. Adults are dark, flylike insects about 3 mm (1/8 inch) long. They are attracted to light. They cause no damage but are a nuisance.

[redacted]

MEALYBUGS

Mealybugs are soft-bodied, wingless insects. Most types have waxy filaments extending from the edges of the body. Young and adults look similar, with adults about 5 mm (3/16 inch) long. Eggs are laid in a cottony mass on the plant. Adults can be found at rest or slowly crawling on stems and on the undersides of leaves. They damage plants by sucking plant sap, which causes stunted growth or kills the plant. These insects secrete honeydew, and sooty mold may develop. One kind of mealybug feeds on the underground parts of plants. If no other cause of plant decline is found, examine the roots for mealybugs.

[redacted]

INSECT	DESCRIPTION AND DAMAGE	CONTROL MEASURES

SPIDER MITES

Minute spiderlike mites may be greenish, yellowish or reddish. They are found most often within fine, silky webbing on the undersides of leaves. If the infestation is heavy, they may be found over the entire plant. Damage is caused by mite feeding on epidermal plant cells. Injury shows up first as yellowish blotching on leaves. Progressive feeding results in bronzed leaves, leaf drop and possible plant death.

[redacted] Repeat applications weekly until spider mites disappear. Syringing foliage with a mild soap solution (1 tsp dish soap per gallon of water) will also help reduce mite populations. (Some plants may be injured by soap solutions.)

CYCLAMEN MITES

Cyclamen mites are so small ($^1/_{100}$ inch) that they cannot be seen without a microscope. They must be diagnosed by the damage they cause. Examine the new growth of cyclamens, African violets and other susceptible plants. If the new growth is distorted or brown, the plant may be infested with cyclamen mites.

[redacted] Use caution because [redacted] sprays may injure delicate plants such as African violets.

THRIPS

Thrips are very small (1 mm), cream to dark brown, cigar-shaped insects. Adults have two pair of feathery wings; immature forms are wingless. They are active if disturbed, and adults fly readily. Leaf surfaces become whitened and may appear flecked. Leaf tips wither, curl up and die. Buds fail to open normally.

A [redacted]. Treat one plant first to test for possible phytotoxicity problems. Repeat application every 2 weeks until thrips are no longer found.

INSECT | DESCRIPTION AND DAMAGE | CONTROL MEASURES

WHITEFLIES

Adults are white, with wedge-shaped wings, and are about 2 mm (1/16 inch) long. When infested plants are moved, whitefly adults take flight and look like pieces of ash floating in the air. Larvae are scalelike, oval and flat on top. They are immobile and attach themselves to leaves. Both adults and larvae suck plant juices. Infested leaves turn yellow and may drop off. Whiteflies secrete honeydew, and sooty mold may develop.

DISEASES | DESCRIPTION AND DAMAGE | CONTROL MEASURES

SAPROPHYTIC FUNGI, ALGAE & MOSSES *on soil surface*

If a pink, white, light orange or tan growth appears on the soil surface, suspect saprophytic (non-pathogenic) fungi. If a green to near-black, sometimes slimy growth appears, suspect algae; and if a green, velvetlike mat develops, suspect a moss to be the cause of your problem. These organisms may form such a dense mat over the soil that it excludes water and/or water penetration is very slow. Plant symptoms include poor growth or wilting even when adequate water has been provided.

Excessive growth of algae and mosses indicates high air and soil moisture conditions. Let the soil surface dry between waterings. Also cultivate the soil surface to break up the matted growth. Incorporate fresh peat or vermiculite with the soil to improve drainage.

BACTERIAL LEAF AND STEM ROTS (Xanthomonas *or* Erwinia spp.)

Irregular to circular, brownish spots surrounded by water-soaked margins and/or yellow halos occur on leaves or stems. As the spots enlarge, centers dry out, crack and become brown to near black. Under high humidity, small droplets of milky or amber-colored ooze can be found in the spots.

Remove and destroy affected plant tissues. Disinfect tools between cuts and remove tissues only when plants are dry. Do not mist or spray leaves with water, as this tends to spread the bacteria. Avoid handling plants.

DISEASES	DESCRIPTION AND DAMAGE	CONTROL MEASURES

POWDERY MILDEWS (Erysiphe *and* Sphaerotheca spp.)

White to grayish, fuzzy or powdery, circular spots appear on leaves, petioles, stems or flowers. The tissue in spots may become crusty or scablike.

Wash leaves with mild detergent water to help reduce disease. [redacted]

FUNGAL LEAF SPOTS (Alternaria *or* Septoria spp.)

Small, circular, brown spots develop on leaves. With some pathogens (e.g., anthracnose), spots enlarge and a concentric ring pattern develops as the fungus grows in the tissues.

Remove and destroy affected leaves or portions of leaves. [redacted]

OEDEMA *(Physiological)*

Small, blisterlike eruptions appear on the undersides of leaves. Affected tissues appear water-soaked and soon develop tan to brown, corky centers. As spots become numerous, the leaf yellows and falls. Once affected, leaves do not recover. Oedema usually develops when the soil is moist and warm, the air is moist and cool, and available light is much reduced. (For more detailed information, consult Extension bulletin E-1581, "How to Recognize and Control Oedema in Ornamental Plants."

Reduce watering. Improve soil drainage, increase light and increase air circulation. Increased humidity and low light conditions occur frequently during the cloudy winter months.

DISEASES	DESCRIPTION AND DAMAGE	CONTROL MEASURES

DAMPING-OFF (Pythium *and* Rhizoctonia spp.)

In pre-emergence damping-off, the seed rots either before germination or before the seedling has emerged from the soil. It is attacked at the soil line by the pathogens. A constriction develops at the point of fungal contact and the resulting stem rot causes the seedling to topple over.

Pot plants in porous, well drained soil, and do not overwater. [redacted]

ROOT ROTS (Rhizoctonia, Pythium *and* Phytophthora spp.)

Plants grow poorly and leaves may yellow and drop prematurely. The basal stem and roots show brown to black lesions, and sections of root may be collapsed. In advanced stages, severe wilt accompanies other symptoms. Poorly drained soil, high soil moisture and poor aeration favor development of root rot fungi.

See above.

RUST (Puccinia spp.)

Leaves develop small, blisterlike eruptions, usually on the undersides. The pustules burst to expose a yellowish or brownish orange mass of powdery spores.

Remove and destroy infected leaves. [redacted]

DISEASES	DESCRIPTION AND DAMAGE	CONTROL MEASURES

BOTRYTIS BLIGHT (Botrytis spp.)

Flowers or leaves develop brown, mushy spots, usually where healthy tissues are in contact with dead petals or leaves. Under humid, moist conditions, a gray to brownish gray, fuzzy growth develops on the dead plant tissues.

Reduce humidity, keep foliage dry. Remove dead foliage and flowers.

New-5M-12:87-KMF-HP, Price $1.25 for sale only (Horticulture)

Review Questions For Section 5 - E-2018, *Houseplants: Common Insect and Diseases*

Write answers to the following questions and then compare your answers with those in the back of the manual.

1. Generally houseplant problems caused by insect and diseases occur because the plants have been stressed by improper care. (True or False)

2. Which insects belong to the homoptera family and what common characteristic do they have?

3. In what ways do moss and algae create problems?

4. Pesticides can be labelled for use on a particular foliage plant but not necessarily in an indoor setting. (True or False)

5. What is the substance that promotes the growth of sooty mold?

6. Which insect is associated with bronzed leaves, leaf drop and possible plant death?

   a. Aphids

   b. Scales

   c. Spider mites

   d. Fungus gnats

7. A physiological problem can be caused by environmental conditions and an example is:

   a. Rust (*Puccinia* sp.)

   b. Powdery mildew

   c. Oedema

   d. All of the above.

Section 6

MANAGING INSECTS AND MITES

Due to your monitoring practices you will observe conditions and organisms that the casual passer-by may never notice. If your observation reveals plant damage and a suspected insect pest, the next step is to identify the insect. It is important to identify the insect for several reasons. Some insects are beneficial and may be suppressing the population of a pest insect. Among pest insects some are more damaging than others. Once you know what kind of insect is present, you can better judge whether the potential damage justifies control measures and how quickly these management practices should be executed. Knowing the identity of a pest also enables you to learn about the insect's biology and use other IPM tools to control the insect. Insects may have several different life cycles and different body structures. Becoming familiar with the various stages of the pests you will most likely encounter will allow you to make sound management decisions in a timely manner. **Knowing which of the insect's life stages causes the plant damage and which life stage is vulnerable to your control strategy is vital information for implementing an effective management program.**

Certain plants are more vulnerable to specific pests. Knowing which plants an insect typically infests is useful in identifying a pest more accurately. Table 1 (at the end of this section) is a summary of some of the more common insect and indoor plant relationships.

The following insects are commonly found on foliage plants. Familiarize yourself with their desired host plants, life cycles and type of damage they cause.

Fungus Gnats

Lycoriella spp. and *Bradysia* spp.

Description

Adult - The flies are rather slender with comparatively long legs and antennae. They are grayish black and about 2.5 mm long.

Egg - The tiny, yellowish white eggs are 0.2 mm long and 0.1 mm wide.

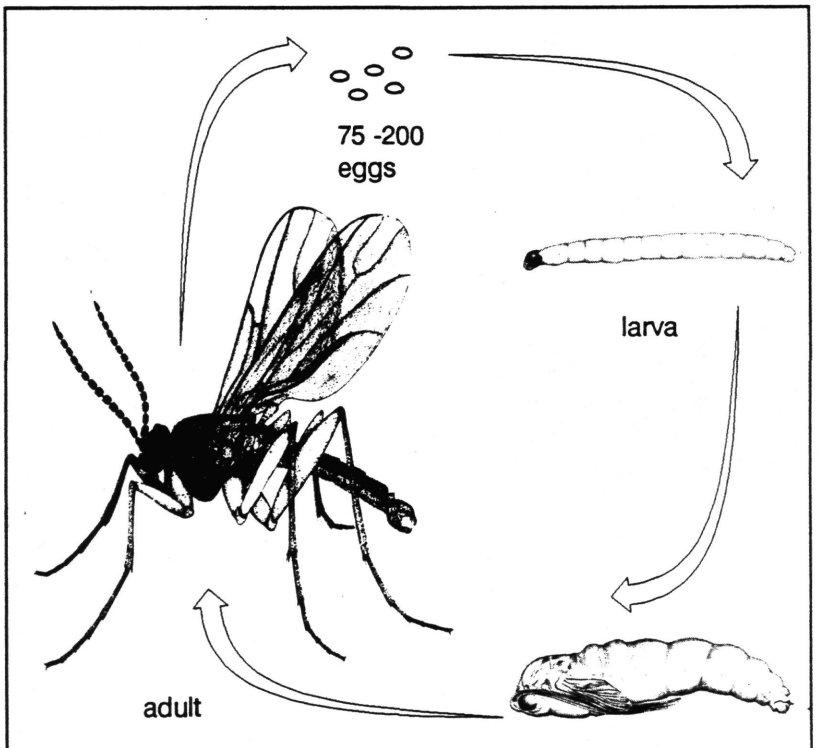
Larva - Fungus gnat maggots have black head capsules and white bodies. The last body segment is lobed, serving as a foot. Mature larvae are about 5.5 mm long.

Pupa - Initially white, the pupae become dark shortly before the adults emerge. The pupae are 2.0 to 2.4 mm long.

Biology

Host Plants - Fungus gnats feed on carnations, clover, Easter lilies, geraniums, ivy, nasturtium, poinsettias, and organic matter.

Damage - Damage first becomes apparent when plants lose their healthy appearance and wilt. The fungus gnats



Fungus Gnats (22-40 day life cycle)

themselves are usually noticed before injury is apparent. When abundant, fungus gnats will injure roots and the base of young plants.

Life History - Fungus gnat maggots have only recently been recognized as important pests in greenhouses and mushroom cellars. They are also pests of house plants. Several of these flies are of economic concern. Fungus gnats have increased in importance due to the prevalent use of soilless potting mixes in the plant industry. Apparently some of these growing medias are excellent for the survival of these gnats.

Generally, fungus gnats are most abundant in the winter and spring. Adults and larvae inhabit moist, shady areas. Adults live about 1 week, during which time each female will deposit 100 to 150 eggs. They are laid in strings of 3 to 40 in the top of the soil, usually near stems of plants. They hatch within 4 days in the greenhouse and similar sites. There is a tendency for the offspring of each female to be all one sex.

The larvae begin feeding on the root hairs and roots usually in the upper centimeter of medium, working their way up the plant and into the stem; however, they also feed on any organic matter in the soil. Being somewhat gregarious, the larvae often form clusters in the soil. They mature in about 14 days, after which they construct a pupal case, made of silk and debris, in the soil. The pupal stage lasts about 3.5 days. The adults are weak fliers, but they run rapidly on the soil surface or may remain motionless.

Control

Avoid over-watering and overuse of manure and compost in soil media. Decoy pots of sprouting grain can be used to attract female fungus gnats, which will lay their eggs in these pots. Afterwards, the pots should be submerged in boiling water every 2 weeks to destroy the eggs and maggots. Fungus gnats have few efficient natural enemies. Clean cultural practices and lack of excessive watering many times will prevent fungus gnat infestations.

Greenhouse Whitefly

Trialeurodes vaporariorum

Description

Adult - About 1.5 mm long, the adult is white insect which resembles a tiny moth.

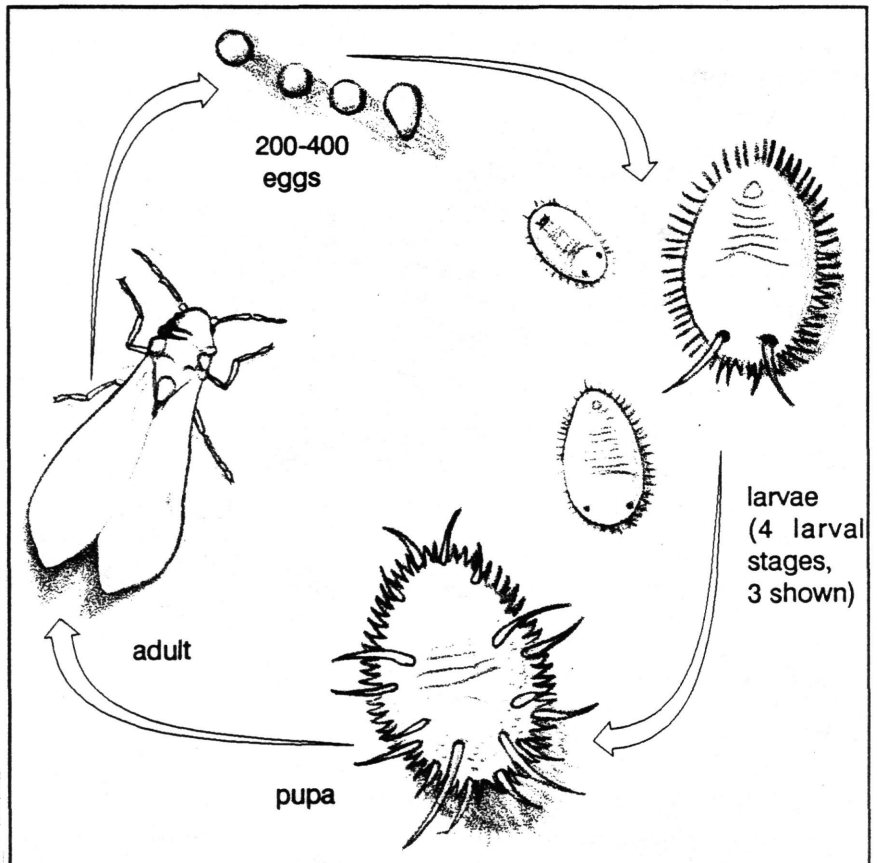
Egg - The oblong eggs, pale green to purple, are inserted into the lower leaf surface, often in a circle or a crescent.

Larva - The tiny larva, yellow with red eyes, becomes a flattened scale-like insect lying flat against the lower leaf surface.

Pupa - The flattened, oval pupa is a pale green to black (parasitized) or white (empty) structure with a fringe of long hairs and with long hairs on its back. Also found on the underside of the leaf.

Biology

Host Plants - Greenhouse whiteflies infest a wide variety of ornamental, foliage and vegetable crops, and they can survive outdoors during the growing season, particularly in sheltered locations. Even trees may be infested (redbud



Greenhouse Whitefly (18-57 day life cycle)

and Kentucky coffee berry tree). Whiteflies are more common in conservatories than interior landscapes.

Damage - Infested plants become chlorotic and unthrifty. Honeydew and sooty mold further detract from the appearance of the crop. Unless controlled, greenhouse whiteflies may completely destroy the commercial value of floricultural crops and ravish indoor plants.

Life History - Greenhouse whiteflies reproduce relatively slowly (1 generation every 30 to 45 days), but each female may lay up to 400 eggs and live as long as 2 months. Adults are usually found on the lower surface of new leaves. Here they insert their eggs which hatch 5 to 7 days later. The new crawlers move about the plant for a day or two, often from leaf to leaf before inserting their mouthparts to feed. Once this occurs they probably do not move again until mature. The crawlers molt into larvae and then into pupae. Finally, a new generation of whitish yellow adults emerges. They are soon covered by a white, waxy bloom.

Lower greenhouse temperatures used in the culture of some bedding and potted plant varieties tend to encourage infestations, because naturally occurring parasitic wasps (*Encarsia formosa*) are reproductively inhibited at temperatures below 24°C (75°F).

Control

Control of whiteflies is difficult because the eggs and immature forms are resistant to many aerosol and insecticide sprays. One must make regular applications of pesticides to control emerging adults until the last of a whole generation of immature whiteflies has emerged. However, some of the synthetic pyrethroid and synthetic insect growth-regulator pesticides are extremely effective and need not be applied as often. Do not put infested plants into commercial accounts.

Green Peach Aphid

Myzus persicae

Description

Adult - The small adult is colored light to dark green or pink, with red eyes and piercing-sucking mouthparts. Three darker lines run down its back. Wings may or may not be present.

Egg - Found only in the northern United States, the egg is black and shiny.

Larva - The wingless larva resembles the larger adult.

Biology

Host Plants - Green peach aphids have been collected from over 100 plants, including a wide variety of vegetable, foliage, flowering plants and ornamental crops. Spinach, tobacco, potatoes, and peaches (the host on which eggs are laid) seem to be especially favored hosts.

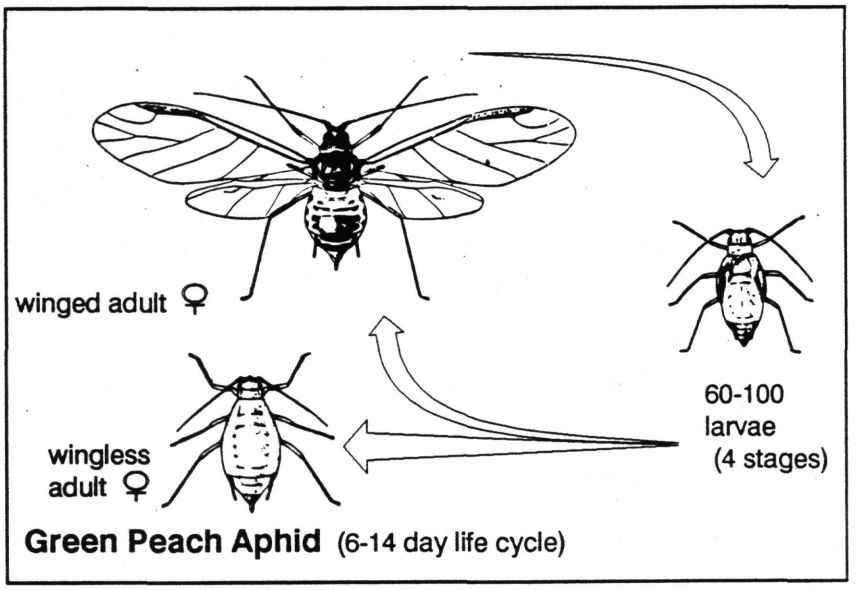
On chrysanthemums, green peach aphids feed on all parts of the plant (melon aphids feed only on the buds and leaves, and chrysanthemum aphids feed only on the stems and leaves). Green peach aphids will not become established in the presence of the other 2 aphids unless pesticides are applied. In that case, green peach aphids outlive both melon aphids and chrysanthemum aphids.

Damage - Green peach aphids suck plant sap and contaminate the host with honeydew and cast skins. When honeydew builds up on plant foliage, the likelihood of sooty mold developing increases. Aphids are often found feeding on buds, tender plants parts and especially on new growth. Their feeding by sucking causes poor plant growth and distorted leaves.

Aphid infestations are often evident by the white cast skins that are shed and left by the aphid when molting.

Green peach aphids are also the vector of a number of plant viruses including tobacco, tomato, lettuce, dahlia, canna, and beet mosaics.

Life History - The reproductive capacity of green peach aphids has been described as "fantastic." Adult female aphids give birth to live young females. High reproductive rate and resistance to pesticides make the green peach aphid a formidable pest in the greenhouse and indoor landscapes. Ladybugs, lacewings, syrphid flies, damsel bugs, wasps and parasitic fungi tend to regulate green

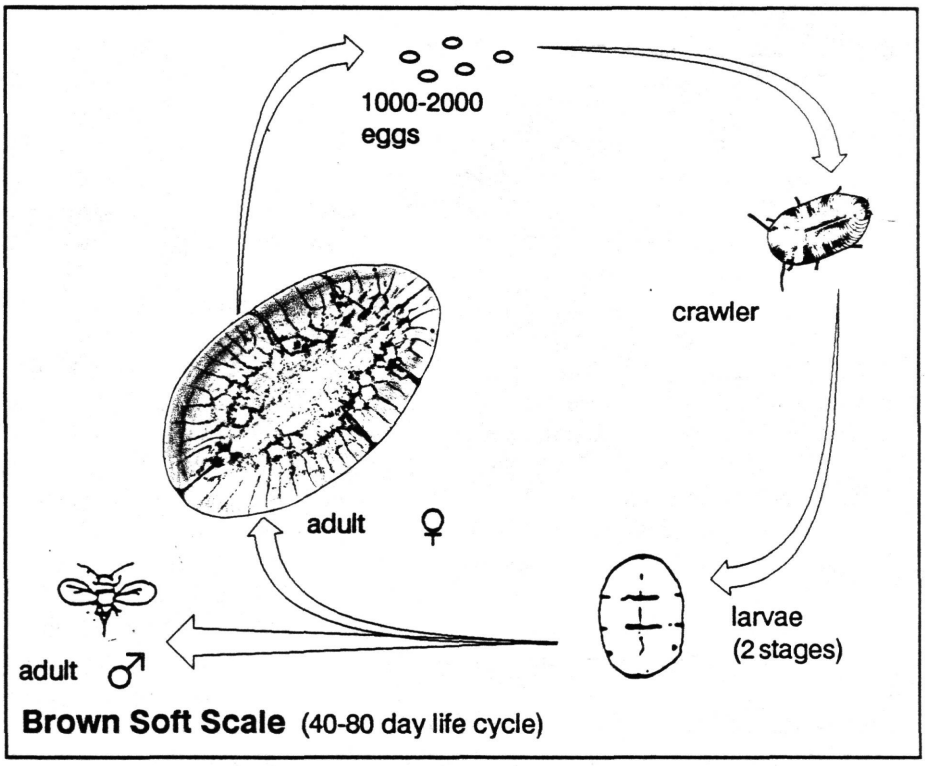


Green Peach Aphid (6-14 day life cycle)

peach aphid populations outdoors. Rain, wind and mud also help check aphid populations outside.

Control

Because green peach aphids overwinter on weed hosts, infestations can occur in the greenhouse and interior plantscapes any time of year. Although the amount of damage per aphid is often not serious, these aphids reproduce so rapidly that serious harm can be done in a short time. Moreover, these aphids' resistance to pesticides calls for thorough applications whenever a new infestation is found.



Brown Soft Scale (40-80 day life cycle)

Brown Soft Scale

Coccus hesperidum

Description

Adult - The reddish brown adult is slightly convex and oval with sucking mouthparts, but the shape varies according to the scale's attachment to the host plant.

Egg - The egg is slightly oblong (0.3 mm long and 0.3 mm wide) and yellowish pink.

Larva- The crawler (first instar) is pink and oval (0.5 mm long and 0.25 mm wide) with piercing-sucking mouthparts. It has well-developed legs and 2 long hairs projecting from the rear. The passive larva (second instar) is pale brown and flat, with the legs and antennae underneath the body.

Biology

Host Plants - The brown soft scale feeds on hundreds of plants, but it is especially harmful to ferns. A few other hosts are holly, oleander, rose, poinsettia and gardenia.

Damage - Although plants are seldom killed by brown soft scales, the large amounts of honeydew they excrete allows dark fungi (sooty mold) to grow on the host. Sooty molds detract from the beauty, hence, from the value of infested interior plants. The most likely way an indoor landscape becomes infested with scale is by bringing in new, but infested, plant material.

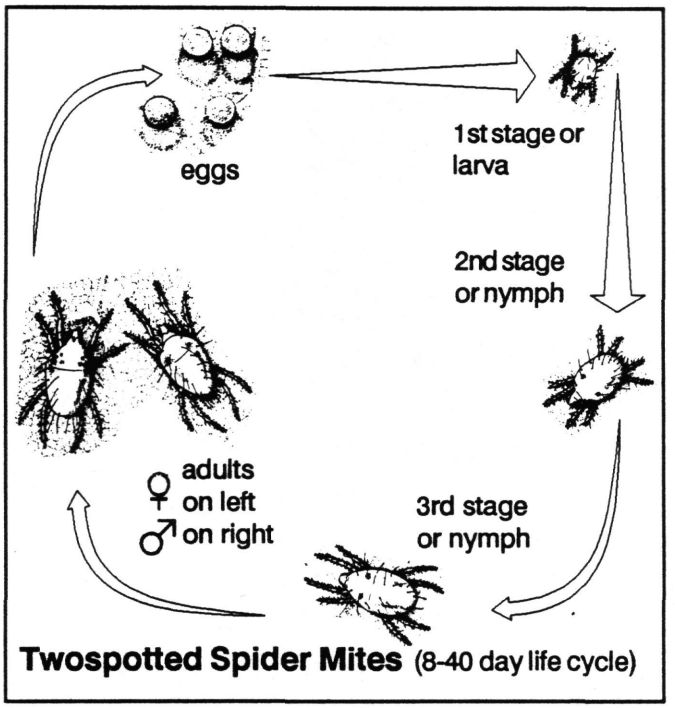
Life History - Brown Soft Scale has become a serious pest to commercial greenhouse growers, citrus growers and homeowners.

Eggs are retained within the female. The young scales hatch from the eggs as they are laid. The female protects the new larvae with her body. Only when she raises herself from the leaf surface, do the larvae escape. They then disperse and settle in a new location, inserting their mouthparts into the plant to feed. They exhibit a preference for shady areas and for young branches and leaves. Mobile for several days, they molt about 1 week after they attach themselves to the plant. The cast skins (exuviae) look like dust.

The second larval stage lasts about 3 weeks. Adult females live 2 to 3 months; the males, which are rare, live only a couple of days. Ensuring the continuance of the species, the development of the sexes is synchronized. The fertility of the female varies with temperature, but the average number of eggs per female is about 80.

Control

Many natural enemies may limit population growth. There may be six to seven generations per year in interior landscape settings. See Table 2 on page 6-10. Horticultural spray oils can suppress adult scales if thorough coverage is obtained. Other insecticides are targeted to the more vulnerable crawler stage of brown soft scales.



Twospotted Spider Mites (8-40 day life cycle)

Twospotted Spider Mite

Tetranychus urticae

Description

Adult - The 8-legged adult can be pale green, greenish amber, or yellowish. Usually having 2 (sometimes 4) black spots on top, it is about 0.4 mm long. As they are usually found on lower leaf surfaces, a 10 power hand lens is useful in identifying these pests.

Egg - The spherical egg ranges from transparent and colorless to opaque straw yellow.

Larva - The 6-legged larva is colorless, pale green, or yellow.

Nymph - Similar to the adult except in size, the nymph has 8 legs and is pale green to brownish green. Large spots of black may develop on each side of the body.

Biology

Host Plants - Twospotted spider mites have been reported on over 180 host plants, which include over 100 cultivated species. Very few indoor plants are immune to attack.

Damage - Twospotted spider mites pierce the epidermis of the host plant leaf with their sharp, slender mouthparts. When they extract the sap, the mesophyll tissue of the leaf collapses in the area of the puncture. Soon a chlorotic speck forms at each feeding site, giving an overall light color and stippled (specked with extremely tiny dots) effect to the leaves. After a heavy attack, an entire plant may become yellowed, bronzed, drop its leaves or be killed completely. The mites may spin so much webbing over the plant that it becomes entirely covered.

Life History - Though insects and mites are in a group called the Arthropoda (meaning jointed foot) because jointed legs are common to both, **spider mites are not actually insects.** Being more closely related to spiders, they derive their name from the thin web which some species spin.

Twospotted spider mites overwinter as adults in the soil or on weed hosts such as violets and hollyhocks. In warm weather the females soon lay eggs. From the eggs hatch 6-legged larvae. They develop into 8-legged nymphs which pass through 2 nymphal stages. After each larval and nymphal stage, there is a resting stage. The adults mate soon after emerging from the last resting stage. Each female may lay over 100 eggs in her life and up to 19 eggs per day. Development is rapid in hot, dry conditions. Each generation may take as many as 20 or as few as 5 days to mature. At 75°F, it takes about two weeks for mites to go from egg to adult.

Control

Avoid hot, dry conditions that favor mite development. The resting stages and eggs of the twospotted spider mite are more tolerant to pesticides than the mobile forms. Consequently, a second application of pesticide may be necessary at 4 or 5-day intervals in hot conditions (7 to 10 days in cool conditions) to kill those mites which may have survived the first application.

Flower Thrips

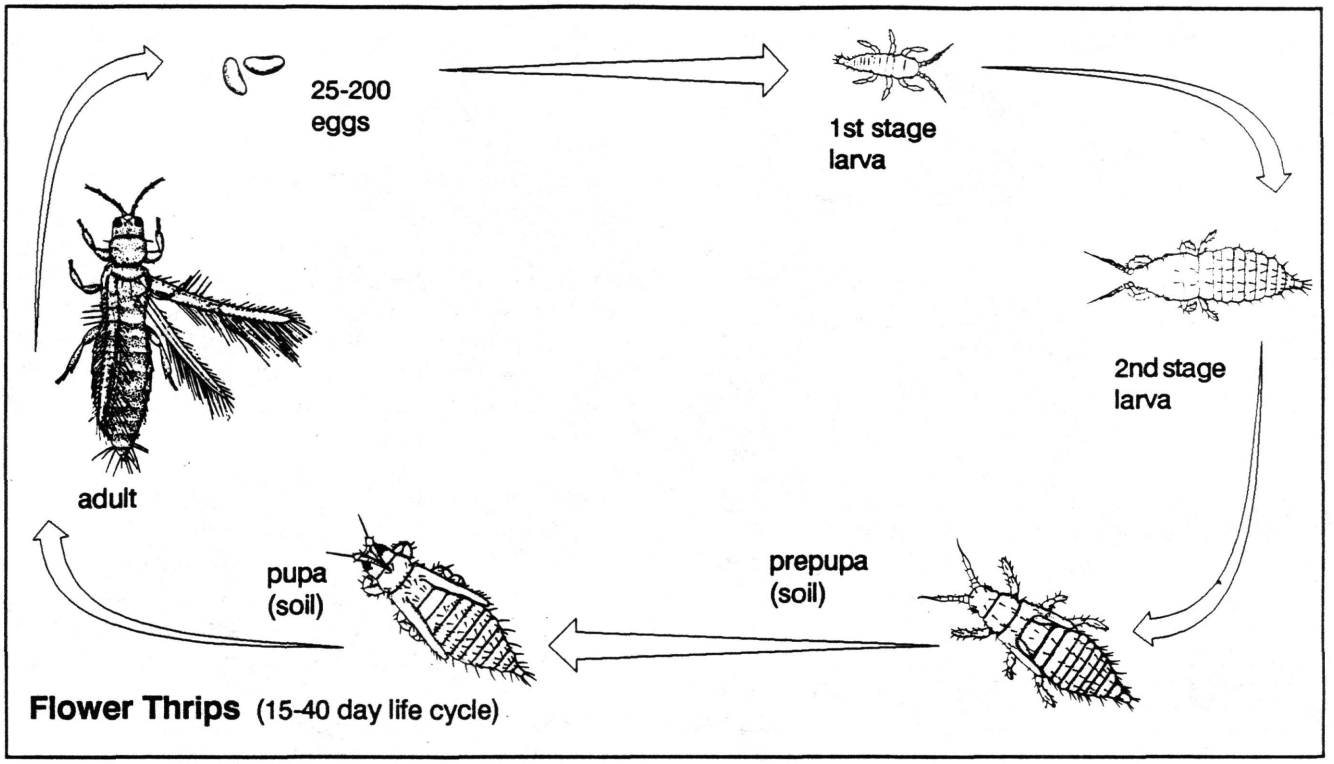
Frankliniella tritici

Description

Adult - The adult flower thrips is winged, small (1.25 mm) and yellowish brown to amber with an orange thorax. The male is slightly smaller and lighter in color than the female. Adults have rasping mouthparts.

Egg - The flower thrips' delicate egg is cylindrical, and slightly kidney-shaped, with a smooth pale or yellow surface.

Larva - The tiny young thrips is lemon yellow, resembling the adult except for its lack of wings.



Flower Thrips (15-40 day life cycle)

Biology

Host Plants - Flower thrips have been collected from 29 plant orders including various berries, day lilies, field crops, forage crops, grass flowers, legumes, peonies, rose, trees, vines, and weeds. They seem to prefer grasses and yellow or light-colored blossoms. Roses are most susceptible in June. In the indoor landscape, thrips are most commonly found on flowering plants brought into the job site to provide color; e.g. chrysanthemums and poinsettias. Chrysanthemum blossoms are among thrips favorite hosts.

Damage - Flower thrips feed by rasping the leaf or petal surface and drawing sap from injured cells. The epidermis and relatively few mesophyll cells are affected. Leaf surfaces become whitened and may appear flecked. Leaf tips wither, curl up and die. Flower buds fail to open normally. The petals, distorted with brown edges, seem to stick together. Black dots of feces may also be present.

Life History - Flower thrips are one of the most numerous insect pests of ornamental crops. Their large numbers account for considerable and rapid damage to flowers. Flower thrips are generally found at the base of the flower's petals. They reproduce throughout the year in mild climates or greenhouse conditions. Flower thrips pass through egg, two larval, prepupal, pupal and adult stages. The eggs are inserted into flower or leaf tissue, and the prepupal and pupal stages are spent in the soil. In summer, flower thrips may live 26 days, though overwintering thrips may live all winter. Flower thrips can overwinter as far north as North Dakota in grass clumps and other sheltered refuges.

Control

Flower thrips are preyed upon by green lacewings, lady beetles, insidious plant bugs, and salamanders. Control of thrips is difficult because of their constant migration from plant to plant and the various life cycles present at the same time. The life stages spent in the soil are particularly difficult to manage. Pesticides used according to the label and at close intervals help eliminate the soil emerging stages.

Longtailed Mealybug

Pseudococcus longispinus

Description

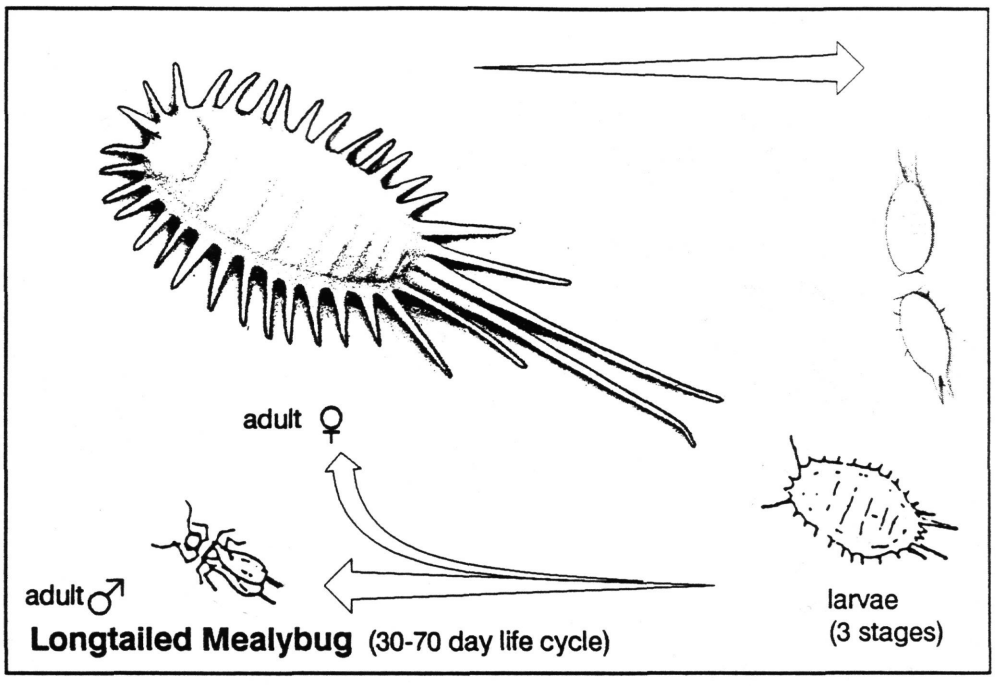
Adult Female - Up to 3 mm long, the adult has 17 pairs of waxy filaments extending from the edges of the body. The caudal (tail) filaments are as long as or longer than the yellowish to grayish body. They are soft-bodied and wingless. Overall length may be 6 to 7 mm.

Nymph - The nymph is similar to the larger adult female except that its lateral filaments are shorter.

Biology

Host Plants - Longtailed mealybugs have been found on at least 26 plant families. *Dracaena* appears to be the favored host, but most flowering plants are susceptible.

Damage - Longtailed mealybugs feed by sucking out plant sap from leaves and stems. This sucking stunts growth and may kill the plant. Honeydew , which can lead to sooty mold, further disfigures infested plants. These pests also secrete a fluffy white wax which detracts from the appearance of infested plants.



Longtailed Mealybug (30-70 day life cycle)

Life History - Females give birth to live young, which are born on a shallow pile of white waxy secretions. Because the females are wingless, they must be brought into proximity of a host plant before it can be infested.

Control

A small wasp, *Anagyrus nigricornis*, parasitizes longtailed mealybugs, and a small predaceous, brown lacewing insect feeds on them. In outdoor settings, ants sometimes protect longtailed mealybugs from parasites and predators and feed upon the honeydew which the mealybugs excrete.

There are several species of mealybugs. Longtailed mealybugs are less difficult to control than other species that infest indoor plants. If many plants are infested, they should be dipped or sprayed thoroughly with a pesticide mixture back at the greenhouse or treat the entire greenhouse with an aerosol. It is best to retreat two or more times at weekly intervals. Re-treatment will control mealybugs which are missed by earlier control efforts.

A maintenance program including periodic wiping of foliage with a 2% soap solution is also recommended for preventing infestations of mealybugs. Inspect all new plants being brought into the interior landscape setting for mealybug to avoid contaminating existing plants.

Citrus Mealybug

Planococcus citri

Description

Adult - The female citrus mealybug appears to have been rolled in flour. It grows to 3 mm long and 1.5 mm wide. A fringe of small waxy filaments protrude from the edges of the body. The male is small, but with its wings it appears to be 4.5 mm long.

Egg - The oblong yellow egg is enmeshed in a dense, fluffy, white ovisac.

Larvae - The tiny newly hatched larva is oval and yellow, with red eyes. The antennae are rather distinct. As they begin to mature, female larvae resemble the larger adult females. Male larvae are narrower and often occur in a loose cocoon.

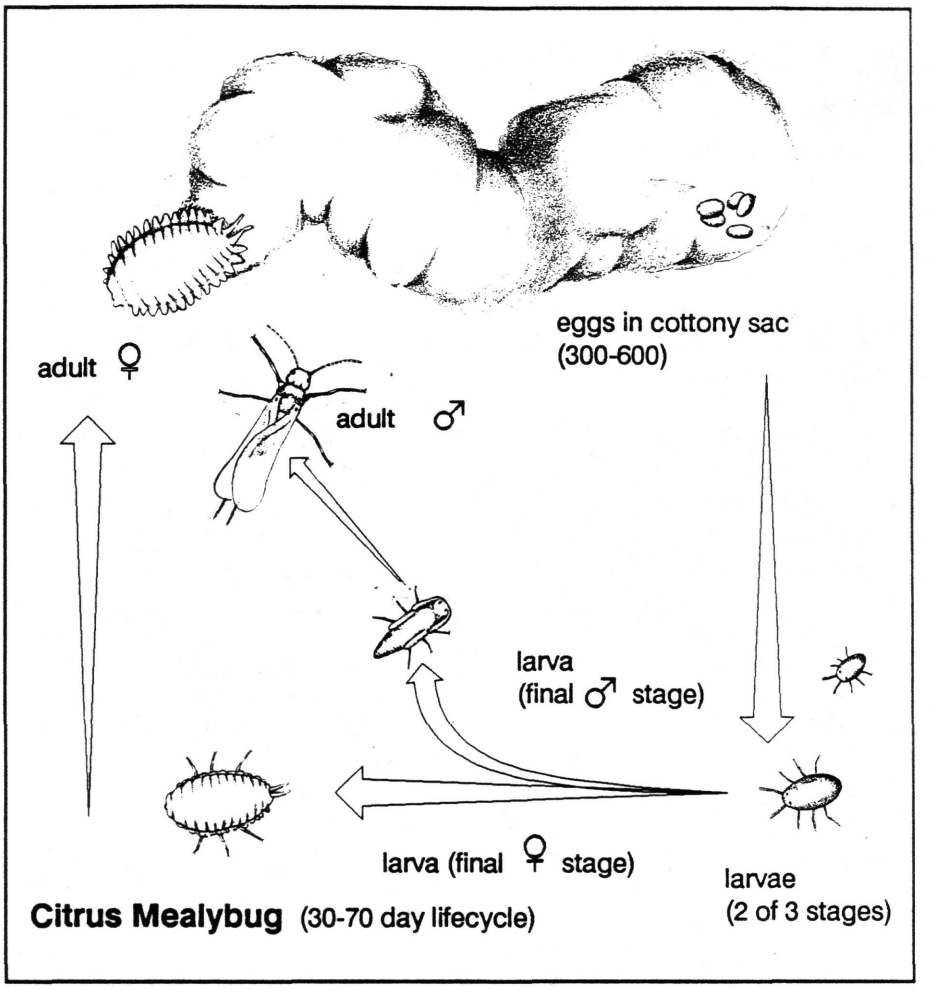
Biology

Host Plants - Citrus mealybugs have been collected from at least 27 host plant families. Many ornamental plants grown in greenhouses are susceptible to attack. The citrus mealybug thrives on soft-stemmed and succulent plants including *Codiaem*, Oleander, *Coleus*, *Fuchsia* and Cactus.

Damage - Citrus mealybugs damage hosts by sucking out plant sap, by excreting copious amounts of honeydew which may result in the growth of sooty mold, and by causing distorted growth, stunting and yellowing and premature leaf drop with their toxic saliva. They further

disfigure plants by secreting cottony wax. Infested plants usually die unless the pests are controlled.

Life History - Since female citrus mealybugs have no wings, they must be transported to the proximity of the next host plant. They can, however, travel short distances by crawling and the immature can be blown about. Males are small, winged insects. After mating, each female may lay hundreds of eggs in a dense, fluffy secretion called the egg sac or ovisac. Within a few days, newly-hatched mealybug larvae begin to squirm out of the ovisac. Light infestations are easily overlooked because the mealybugs tend to wedge into crevices on the host plant. As their numbers increase, mealybugs of all sizes can be seen slowly moving around or feeding on all exposed plant surfaces.



Citrus Mealybug (30-70 day lifecycle)

Control

Control of citrus mealybugs is amazingly difficult. Some flower growers merely discard infested plants when only a small number are infested. If many plants are infested, they can be dipped or sprayed thoroughly with an insecticide mixture. An entire greenhouse may be treated with an aerosol. Consult pesticide labels for interior landscape uses. Re-treat two or more times at weekly intervals. Re-treatment will control mealybugs or eggs which were missed by earlier control efforts.

A good maintenance program including periodic wiping of foliage with a 2% soap solution is also recommended for preventing infestations of mealybugs. Inspect all new plants brought into the interior landscape to assure they are "pest-free" and will not contaminate existing plants.

Biological Pest Management

There are numerous approaches to controlling plant pests in the indoor landscape setting. Several of these have been mentioned in the Integrated Pest Management section of this manual. In any plant management system emphasis should be on the combined or integrated use of all available tactics which include cultural, chemical and biological controls. Biological control is the use of living organisms such as **parasites and predators** that feed on less desirable species to reduce pest populations. Biological control elements are typically introduced in the interior landscape while they can occur naturally in the exterior landscape. Certain pathogens are also effective biological control agents.

With increased consumer awareness for environmental concerns and personal safety the opportunity for incorporating biological control agents into interior plant management programs is expanding. Some indoor plant management settings will be more accommodating to introduced biological controls than others. Let it be understood that a biological management approach:

- does not look after itself.
- requires time, commitment from yourself and the client, an understanding of the principles involved, and good communication amongst those involved.
- requires time to establish and provide results in your selected plant setting.
- involves use of other pest management techniques especially sanitation and quarantine procedures and includes pesticides compatible with your biological control plan of action.
- requires accurately identifying your pests and the parasites or predators that prey on or parasitize them.

Table 1: Some Insect and Mite Pests and the Indoor Plants They Infest

Pests

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

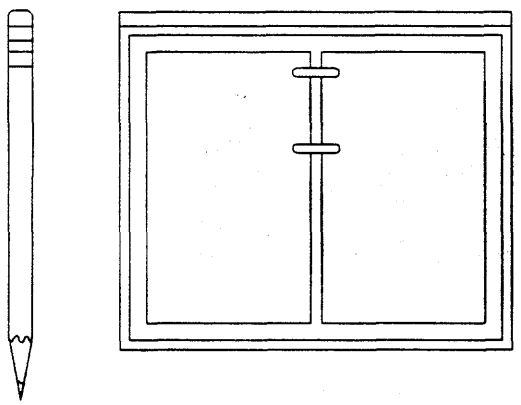
Hosts

Aphelandra spp.--1,7
Aralia--5
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--3
Ficus spp.--2,3,4
Gynura spp.--1,2,7
Hedera helix (see English Ivy)
Hoya spp.--1
Maranta spp.--2,3,6
Palms--2,6
Philodendron spp.--4
Polyscias (see Aralia)
Pothos--2
Sansevieria spp.--4
Schefflera spp.--1,2,3,4,6
Scindaspsus spp. (see Pothos)

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

The 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.

- requires locating a reliable source of the biological control agents. (Importing beneficial insects from Canada requires special permits. Contact the U.S.D.A. Plant Protection & Quarantine, Federal Center Building, Hyattsville, MD 20782 to obtain the necessary forms.)
- will require reintroduction of the biological agents if the population fails to become established, or, conversely, is so successful they run out of food and die.



- requires an effective monitoring and record keeping system as all pest management systems do.

When properly carried out, the rewards of a biological pest management program are many; expanded personal expertise with the use of biological control agents, reduced pesticide use and inventory, elimination of chemical injury to plants, far less likelihood of pesticide resistance build-up, and fewer public concerns.

The interaction between each pest and their respective biological control agent requires special knowledge and attention. Table 2 lists the pest and predator or parasite that may be an effective biological control agent, but does not emphasize the special conditions and procedures required for successful implementation. Consult with other experienced plant managers who work with biological agents, university specialists and refer to the booklet, *Biological Pest Management For Interior Plantscapes, Second Edition.* The address for this booklet can be found in the resource section of this manual. It is not necessary to know the scientific names of the insects for the state pesticide certification exam.

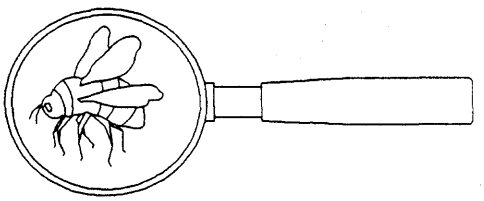


Table 2. Summary of Primary Predators and Parasites of Major Plant Pests

Pest	Predator	Parasite	Comments
Greenhouse Whitefly (*Trialeurodes vaporariorum*)	—	*Encarsia formosa* a chalcidoid wasp	Size of a spider mite, readily available from insectories.
Green Peach Aphid (*Myzus persicae*)	Various lady beetles. Some results with *Aphidoletes aphidimyza* a predacious midge larva.	—	The adult midge lays 100-200 tiny orange eggs near the aphid colonies which hatch in two to three days. The larva is orange or red and depending on temperature and food supply, matures in three to five days.
Soft Scales (Coccids)	*Chilocorus nigritus* and *Lindorus lophanthae* Two small lady beetles	—	Both beetles will control soft scale and ornamental scale. *Chilocorus nigritus* development time is approximately one month.
		Metaphycus Helvolus, tiny black & yellow wasp.	Effective against hemispherical scale, but less so against brown scale.
Twospotted Spider Mite (*Tetranychus urticae*)	*Phtyoseiulus persimilis,* a predatory mite	—	Adults can consume 5-20 eggs or mites per day. These mites avoid bright lights.
Citrus Mealybug (*Planococcus citri*)	*Cryptolaemus montrouzieri,* Australian lady beetle	—	Will consume all species of above-ground mealybugs. Will feed on aphids and immature scale insects when mealybugs are not available.

Pesticide Products for Managing Insects and Mites

Intolerable insect infestations may require the use of an insecticide. It is crucial that the appropriate insecticide be applied during a vulnerable stage of the insect's life. Insecticides are specific in the types of insects that they control. Be sure the insecticide product you select is labeled for the pest you want to treat. You will not get the desired results if the wrong insecticide is used. Always read the pesticide label. Refer to current Extension bulletins for pesticide recommendations and additional information about vulnerable life stages.

Review Questions For Section 6 - Managing Insects and Mites

Write answers to the following questions and then compare your answers with those in the back of the manual.

1. Which insect spends at least one of its stages of life in the soil?

   a. Spider mites

   b. Thrips

   c. Fungus gnats

   d. All of the above.

2. What information about an insect is vital for implementing an effective management program?

3. What conditions promote heavy populations of fungus gnats?

4. What is the most likely way that a brown soft scale population gets started in an interior landscape?

5. How many legs do spider mites have?

6. Mealybugs are wingless but move rapidly on plant surfaces. (True or False)

7. What is the most likely way a mealybug infestation gets established in an interior landscape?

8. Once you have detected an insect in your indoor landscape, what is the next best step to take?

9. Even though all insects go through several growth stages, all the young ones are just smaller versions of the adults. (True or False)

10. Which insect excretes honeydew?

    a. Brown soft scale

    b. Aphids

    c. Thrips

    d. a and b

11. You will see immediate results when a biological parasite is released in an interior landscape for the management of a pest. (True or False)

12. What are some of the beneficial spin-offs from using biological controls?

13. The two-spotted spider mite can be managed with the help of a predatory mite. (True or False)

14. Soft scales can be managed with either predatory lady beetles or a parasitic wasp. (True or False)

15. Are lady bird beetles predators or parasites?

Section 7

DISEASES OF INDOOR PLANTS

The occurrence of diseases on indoor landscape plants is typically a result of adverse environmental conditions or the presence of infectious agents. Diseases solely caused by microorganisms (fungi, bacteria, virus or nematodes) are **not** common in the indoor landscape setting **if** the landscape was established using disease-free plant material and conditions conducive to disease development are avoided. It is critical to identify the causal agent or the **type** of disease that arises in the interior landscape in order to take appropriate correction measures. The two types of diseases are:

- **Abiotic or non-infectious;** caused by environmental, cultural, and non-living things. Things causing abiotic or non-infectious diseases do not grow, reproduce, or spread from plant to plant; they are not contagious.

- **Biotic, infectious or pathogenic;** caused by living microorganisms such as fungi, bacteria, viruses, nematodes, etc. These microorganisms are contagious and can spread from plant to plant.

To successfully manage diseases, plant maintenance technicians must be able to:

* Recognize symptoms and signs that indicate the presence of a disease.
* Accurately identify the cause and type of disease; abiotic or pathogenic or a combination of the two.
* Select the best method(s) for correcting conditions that contributed to the disease development.

Abiotic Disorders

Abiotic disorders produce a wide range of symptoms such as reduced vigor, yellowing leaves, leaf drop, or rapid death of plants. The abiotic conditions causing severe damage are easiest to recognize and correct. Less obvious symptoms may go unnoticed and therefore the unfavorable condition or cultural practices (abiotic disorders) may persist for a long period of time. During this time the plants are stressed and become more susceptible to the pathogenic diseases. For example, if powdery mildew (pathogenic) develops on a plant that is usually resistant to this disease, an investigation may reveal that the plant was consistently over-watered, resulting in high moisture and humidity (abiotic conditions) in the planting area. In this case, correcting the cultural practice that allowed the pathogen to become established may be the only corrective measure necessary for managing the powdery mildew.

Many cultural and environmental conditions that lead to poor plant health are mentioned throughout this manual. This section will focus on some of the most likely abiotic diseases found in an interior landscape.

Environmental Conditions Contributing to Disease Development

There are certain ranges of temperature, light and humidity that provide for optimal plant health. The importance of these factors is considered here in relation to abiotic disease development.

Typically interior spaces utilized for living or work environments provide temperatures adequate for growing foliage plants. A temperature range between 50 to 90 degrees Fahrenheit (13-32°C) can be tolerated by most foliage plants.

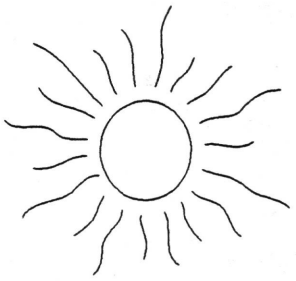
Attention must be given to temperatures during times when interior spaces are not occupied by people. With a more energy-conscience society the thermostat may be set to temperatures that may injure plants when they are exposed over a period of time. Foliage plants can be cold-damaged without freezing, which is referred to as **chilling injury.** A few plants that are injured by chilling temperatures between 35 and 50° F for short periods of time include *Aglaonema X* 'Silver Queen', *Dieffenbachia maculata, Dracena* spp. and *Polyscias fruiticosa.* Symptoms of chilling injury include yellowing or brown, water-soaked areas on leaves, loss of foliage, poor growth and wilting. This type of plant damage represents the symptoms of the abiotic disease, chilling injury.

Plants exposed to hot temperatures for prolonged periods of time can also suffer injury. Wilting, marginal burn on foliage and leaf drop may occur. Since most foliage plants can tolerate temperatures as high as 95°F provided they receive adequate water, the problem is not related entirely

to maximum temperature but to utilization of stored food reserves due to elevated respiration levels. When a plant depletes its stored carbohydrates it may become weak and predisposed to other stresses including invasion by pathogens.

Light affects numerous physiological conditions and processes in plants. When plants are subjected to inadequate light levels these functions may be disrupted causing stress. Plants may exhibit poor growth and color. These symptoms are easily mistaken for something other than poor environmental conditions.

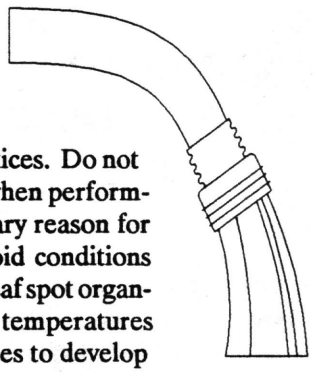
If your plants haven't been adequately acclimatized to the conditions of an interiorscape (i.e., lower light levels, lower temperatures and humidity) they may experience yellowing and leaf drop and possible death following installation.



Many growers are producing acclimatized plants which require more time to grow, but alleviate a significant amount of environmental stress at your job site, thus a better product and customer satisfaction. Be familiar with the growing practices of your supplier and symptoms associated with an inadequately acclimatized plant. If the grower doesn't acclimatize the plants, establish a method and facility to do so before installing the plants directly into an interior landscape.

Cultural Practices Contributing to Disease Development

Most plant replacements result from a combination of poor environmental conditions and poor cultural practices. The abiotic disease symptoms, resulting from poor environmental conditions and cultural practices, are extremely variable and are often misdiagnosed. Pesticide applications will not correct an abiotic disorder. It is vital that plant technicians understand the impact of their cultural practices on the plants they maintain and the potential for abiotic disease development.



The misapplication of water is the leading source of problematic cultural practices. Do not wet foliage or splash water when performing routine care. The primary reason for not wetting foliage is to avoid conditions that promote the growth of leaf spot organisms. Moisture and warm temperatures are required for most diseases to develop on healthy plants.

Water drops on leaf surfaces magnify the intensity of light as it passes through the drop. Plants in direct sunlight can develop burned spots beneath water drops.

Plants with hairy (pubescent) leaf surfaces, i.e. African violets, gloxinia, are easily damaged by cold water on their leaves. Damage from water that is 10 degrees cooler than the leaf surface will appear as distinct "fairy rings."

"Misting" plants is not recommended because disease agents can spread and infect with this added moisture. Foliage should only be wetted when dislodging insects or when removing dust.

Damage from the application of pesticides (phytotoxicity) can occur due to several factors. See the *Pesticide Application Procedures* section of this manual. Avoid products used for shining leaf surfaces which leave heavy residues and clog plant pores.

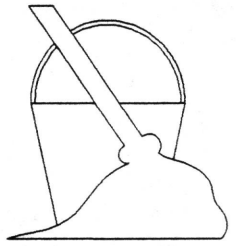
The misapplication of fertilizers is also a common culturally-induced abiotic disease. Under-fertilization can lead to nutrient-starved plants which appear sickly and may be more susceptible to biotic diseases. Over-fertilization can lead to nutrient-imbalances and high soil salts. High levels of salts in the growing media can damage plant roots which makes them more susceptible to attack by soil-borne pathogens. The use of water high in minerals may also lead to soil salts problems.

Soil pH may change over time. Maintaining a proper pH will minimize nutritional problems. When diagnosing plant problems, always check the soil pH to be sure it is in a range adequate for foliage plant growth.

Disease Development Due to Miscellaneous Activities

Environmental factors and cultural practices can be monitored and adjusted to provide the best possible conditions for plants. Yet, there may be harmful activities that occur in the interior landscape that are beyond the control of the plant technician. When symptoms seem to have no other explanation, the following possibilities should be considered.

Fumes from cleaning agents can be harmful to plants. Commercial strength ammonia fumes can blacken foliage and cause plant death. Other symptoms produced by exposure to toxic fumes include loss of foliage or curled leaves.



Air pollutants can harm plants, even at levels that are not a threat to human health. Many plants are sensitive to small amounts of **ethylene** in the air, especially orchids and ferns. Ethylene injury symptoms include leaves bending down at

the stems, the yellowing and dropping of older leaves and slowed growth.

Plants installed near indoor pools can be damaged by **chlorine** released into the air. Symptoms include bleaching of leaves and dying of plant tissues.

Heavy tobacco smoke can harm plants by settling on leaf surfaces and blocking the pores used for gas exchange. Routine washing prevents this from being a problem.

Biotic Disorders

It is helpful to understand which conditions influence biotic disease (also known as infectious disease) development when managing the health of plants. The "disease triangle" illustrates the primary factors that must be present and favorable for a biotic disease to infect and survive. The three factors found in the disease triangle that determine whether a biotic disease begins and how severe the disease becomes are:

1. **Pathogen:** the abundance, aggressiveness, and other characteristics of the agent causing the disease influence the disease development. Some pathogens are widespread and attack many plants; others are not.

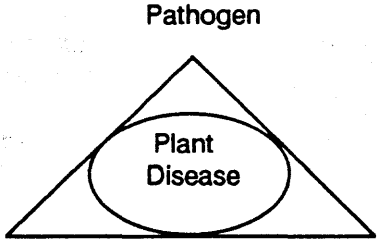
2. **Host Plant:** the genetic susceptibility and general condition of the plant influence disease development. Healthy, stress-free plants are less susceptible to pathogens than weakened plants. Different species or cultivars of plants may be more or less susceptible to attack.

3. **Environment:** certain environmental conditions favor the infection of the plant by pathogens including temperature, moisture, humidity, soil conditions, light, density of the planting, and location of the plant.

Time is another factor that influences disease development. When the disease begins and its duration influences disease development. Time and the three components of the disease triangle all interact with one another. While one factor may be most important in a particular disease and less important in another, no single factor acts alone.

The goal of a plant pest manager is to recognize and manipulate these primary factors to promote stress-free plants and eliminate conditions favorable to disease development. Remember, problems on plants generally do not arise from one isolated cause.

Disease Triangle



Three factors are required to have a plant disease; each of these are interrelated and influence the beginning of a disease and its severity.

Infectious Diseases on Indoor Plants

The disease triangle reminds us of the factors necessary for a pathogen to infect a plant. A susceptible host plant and a pathogen must be present along with the proper environmental conditions in order for a disease to occur. Conditions that favor the development of pathogenic diseases can be avoided in the interior landscape setting. Overhead irrigation, splashing water, prolonged leaf wetness, high humidity, crowded blocks of similar plants, propagation of infected stock are conditions more likely to occur in a greenhouse production setting.

Typically, pathogenic diseases in the interior landscape result as a secondary infection after a plant has been stressed by adverse cultural or environmental conditions. Correcting the stress often avoids the development of pathogenic diseases.

Pathogenic organisms can be widespread. A plant technician should be aware of the sources of infectious plant pathogens which include:

- Use of infected plant materials.
- Established plants harboring disease.
- Debris left after removing diseased plants.
- Infested soil used in the soil mix, or reused pots.
- Dust.
- Water dripping or splashing from infected plants overhead.
- Air currents carrying spores.
- Insects or mites carrying diseases from infected plants to healthy plants.
- Contaminated pruning or maintenance equipment spreading disease from infected plants to healthy plants.

When a disease appears in the interior landscape, it is possible that it is a continuation of a situation that began in the greenhouse. Plant growers aim to produce high-quality plants as free of pests as possible. Greenhouse growers commonly use pesticides to suppress the development of diseases. The suppressed diseases may become prominent in an interiorscape where routine fungicide applications are not practical and therefore not routinely carried out.

Interior landscapers are responsible for maintaining plants under favorable conditions before, during and after installation to avoid disease development. Prevention is always the preferred method of disease management. Otherwise, once diseases develop, more costly or hazardous methods must be used. Attention to maintenance practices reduces the opportunity for pathogens to become established. Best management practices include:

* using pasteurized potting media and sterile containers
* using only disease-free plants
* maintaining proper environmental conditions
* trimming out all damaged and infected plant parts prior to installation and as they develop on the job site
* not crowding plants; allowing air to circulate freely around foliage
* watering without splashing soil or wetting leaves
* not over-watering or allowing water to stand in bottom of containers
* routinely disinfecting tools, implements and hands
* managing insect and mite populations
* completely removing infected plants and contaminated materials

The use of fungicides is not always practical in an interior landscape setting due to the need for repeated treatments and the limited number of fungicides registered for use in interior landscapes. The only fungicides currently labelled for use in the interior landscape are those that are applied to the soil, typically as a soil drench. If there is a fungicide labeled for use on the plant(s) and for the disease agent you need to treat, but is not labeled for use in an interior landscape setting, you may temporarily relocate the plant to a location that is on the label (such as outdoors or in a greenhouse) and then make the treatment. By removing a plant from its interior landscape, your options for fungicide applications are expanded. Although temporarily relocating plants may not always be practical. Prevention is the most practical and effective way to manage disease pests.

Most pathogenic diseases of foliage plants are caused by three types of organisms: **fungi, bacteria and viruses.** Observing symptoms and signs provides clues to the type of pathogen (fungi vs. bacterial vs. virus) causing a disease but may not indicate the specific agent. Accurately diagnosing the specific pathogen causing the problem is critical for selecting appropriate corrective measures and is the key step for avoiding unneccesary application of pesticides.

Realize that a certain fungicide will only be effective in controlling those specific pathogens listed on its label. Knowing the exact pathogen causing your problem will lead you to select the most effective fungicide to manage it.

Accurate diagnosis of plant pathogens may require laboratory analysis. The Michigan State University Plant and Pest Diagnostic Clinic is one source you may wish to use. Diagnostic submittal forms are available at county Cooperative Extension Service offices or from the Clinic. Be sure to fill out the form completely.

A fresh, representative sample produces the most accurate diagnosis. It is best to collect and submit samples early in the week to avoid arrival of your sample during a weekend or holiday when there will be time for it to deteriorate. Large samples will generally enable a quick, correct diagnoses -- no additional fees are charged for large samples. Send a whole plant if feasible. Otherwise, collect leaves, stems, and roots from plants showing the symptoms. Include the full range of symptoms. Remember that leaf symptoms may be the result of a stem or root problem. Also include a small sample of soil from the roots.

Pack plant samples tightly with newspaper in padded envelopes or boxes. Roots and soil can be wrapped in plastic but all other plant parts should be wrapped in paper because plastic encourages rapid decomposition.

Most insects can be submitted in a vial containing alcohol but gently wrap moths and butterflies in tissue and submit in a box. Soft larvae such as worms should be dropped in boiling water for one to two minutes and then submitted in a vial with alcohol.

For information on how to collect and send in a plant or pest sample contact the:

MSU Plant and Pest Diagnostic Clinic
138 Plant Biology Building
Michigan State University
East Lansing, MI 48824-1312
(517) 355-4536

Disease symptoms on foliage or stems are the most likely to be noticed. A quick response can stop the spread of a pathogen on the host and to other plants. If damage is not severe and has been "checked" by your management procedure it may still be attractive enough to remain on site. Root diseases are less likely to be noticed until damage is severe. When a disease infection becomes severe the best alternative is removal of the plant and infested growing media.

Fungi

Fungi are the most prevalent plant pathogen of indoor ornamental plants. They cause a number of leaf spot, stem and root rot diseases. Most foliage diseases caused by fungi develop circular, dead spots or lesions on leaves, stems and flowers. The gray to brown center is dry and papery, with a darker edge. As surrounding tissue is invaded, lesions may exhibit concentric rings which gives the affected tissue

Table 1. Examples of Common Fungal Leaf Spots

Diseases	Pathogen	Hosts	Symptoms
Anthracnose	*Gloeosporium* spp. Colletotrichum spp. *Glomerella* spp.	*Dracaena* spp., *Ficus* spp., *Brassaia* spp., *Philodendron* spp., *Dieffenbachia* spp., *Sansevieria* spp., ivy palms and others.	Lesions form on leaf or stem, limited in size. Spots often have a raised edge.
Cephalosporium Leaf Spot	*Cephalosporium dieffenbachiae*	*Dieffenbachia* spp.	Young leaves develop small red spots with dark edges. Spots may merge before leaf yellows and falls. Fungus enters insect feeding wounds.
Cercospora Leaf Spot	*Cercospora* spp.	*Brassaia actinophylla, Cordyline* spp., *Ficus* spp., *Peperomia* spp., palms and others.	Pinpoint lesion on underside of leaves that look like edema. Some hosts have many small red to brown lesions with pale edges. Affected leaves yellow and fall.
Fusarium Leaf Spot	*Fusarium moniliforme*	*Dracaena* spp., *Pleomele* spp.	Attacks growing point, may be totally rotted away. Yellow to red rounded or oval leaf spots may appear. Cream-colored spores may appear under ideal conditions.
Gray Mold or Botrytis Blight	*Botrytis cinerea*	Wide range of hosts, including many flowering plants.	Quick rot of flowers, buds, stems and leaves. Gray-colored hyphaeand spores easily seen in severe cases.
Phyllosticta Leaf Spot	*Phyllosticta dracaenae*	*Dracaena* spp., *Cordyline* spp.	Irregular spots with brown centers and yellow halos, merge to destroy large areas of leaf.
Powdery Mildew	*Erysiphe cichoracearum Odium* spp. *Sphaerotheca humuli* and other fungi.	*Begonia* spp., *Kalanchoe* spp., African violets, and many others.	Usually leaves, but all above-ground parts can be affected. Gray-white spots or patches. Leaves may discolor before drying out, turning brown and falling. Infected buds fail.

a "target-like" appearance with a faded green halo forming the outer most ring. These circular lesions can overlap forming larger lesions producing a blotchy appearance. Also, look for black, pinpoint-like pustules within the lesion. These black specks are the reproductive structures of the fungus which develop on or in diseased tissue. (Not all fungi produce these structures.) Inside these structures are millions of spores that are easily carried by air currents, water or soil movement, and human activity. After reaching a host plant, spores can remain inactive for long periods until conditions are favorable for growth and infection of plants. Temperatures from 60 to 80°F and high moisture levels encourage fungus growth.

There are many different fungal pathogens found on foliage plants. They produce different sizes, shapes and colors of lesions. Refer to Table 1 for an overview of common fungal leaf spot diseases of foliage plants. The scientific names of the pathogens are included for your information but you will not be required to know them for the state pesticide certification exam.

Bacterial Diseases

Plant diseases caused by bacteria are less common than fungal diseases. However, these include a few of the most

economically damaging pathogens. Plus there are no chemical controls available for managing bacterial infections in indoor landscapes. Prevention is directed at reducing the number of bacterial sources, and avoiding conditions that are favorable for growth of bacteria. Cultural control and sanitation are important aspects of prevention.

Moist conditions and high humidity from splashing or misting contribute to the spread of bacterial disease. Bacteria are single-celled, microscopic organisms. There are two types of bacterial plant diseases:

1. **Systemic infections** which occur in the plant's vascular tissues (water and nutrient conducting tissue), and

2. **Localized infections** which appear as leaf and/or stem lesions.

Systemic infections are limited to the vascular tissues of stems, crowns, and sometimes roots. They cause wilting and general yellowing of plants. With the systemic bacterial diseases, you may occasionally see rotting or cankering of the stem tissue. These cankers or rots will be soft and mushy in appearance and may have an unpleasant odor. Early stages are almost impossible to diagnose. Later stages are easier to diagnose, however, the disease is so extensive by this point that treatment is impossible. If bacterial diseases are diagnosed, the best action to take is to remove the infected plant from the site and destroy it.

Localized bacterial disease symptoms can be in the form of leaf spots and/or stem rots. Bacterial leaf spots may be distinctly different from fungal leaf spots. They are dark green with a greasy, water-soaked appearance when viewed from the underside of the leaf. Eventually these areas turn tan, dark brown or black depending on the plant species and the bacterium involved. A distinct yellow to chlorotic band (referred to as a halo) often surrounds the periphery of infected tissues. A small slice of the lesion placed in a drop of water emits a brown stream of bacteria from the tissue. Early detection will allow you to prune out infected plant parts and possibly save the aesthetic value of the plant. Clean hands with soap and water and disinfect pruning tools in 70 percent alcohol after such removal actions.

The spots or lesions of localized infections can enlarge rapidly and consume the entire leaf within a short period of time. Such fast-moving infections often spread into leaf petioles and stems. Plant tissue becomes soft and mushy, often with a foul odor. In advanced stages, brown ooze is found in veins throughout the plant. Control of these diseases generally involves prompt removal of infested plant parts. Refer to Table 2 for an overview of bacterial leaf spot and stem rots. The scientific names of the pathogens are included for your information but you will not be required to know them for the state pesticide certification exam.

Viruses

Viruses are much smaller than bacteria. They enter the cells of a plant and are multiplied by the host. Viruses live and multiply only within living cells. Viral diseases are usually introduced into interior landscapes by the use of infected plants or by insects. They can be spread to healthy plants by feeding activity of sucking insects such as aphids and leafhoppers, or on the hands and tools of maintenance workers. Currently there is no chemical control for a virus once it infects a plant. Although most viruses are specific to only a few types of plants, prompt and complete removal is recommended when a virus is discovered to prevent its potential spread.

Depending on the virus, the symptoms they cause are very diverse. Some viral diseases can appear similar to fungi. Symptoms of viral infection include:

- mosaic patterns on leaves (a mixture of irregularly shaped dark and light green areas on the leaf)

Table 2. Examples of Bacterial Leaf Spots and Stem Rots

Disease	Pathogen	Hosts	Symptoms
Bacterial Leaf Spot	*Xanthomonas diefenbachie*	*Anthurium* spp., *Dieffenbachia* spp., *Philodendron* spp., and others.	Spots from pinpoint size up to 3/8" develop, merge to cover large areas, except for mid-rib of leaf. Spots round to oval, yellow or yellow-orange with a dull green center.
Erwinia Blight	*Erwinia chrysanthemi*	*Agleonema* spp., *Dieffenbachia* spp., *Philodendron* spp., *Syngonium* spp., and others.	Symptoms range from distinct spots on leaves mushy, foul smelling rot of main stem. New leaves can yellow and wilt. Also rapid, mushy leaf collapse.

Table 3. Examples of Viruses of Indoor Plants

Virus	Hosts
Cactus Virus X	cacti
Cucumber Mosaic Virus	maranta
Dasheen Mosaic Virus	aglaonema, caladium, dieffenbachia, philodendron
Fig Mosaic Virus	ficus
Tobacco Mosaic Virus	rhoeo, columnea
Tradescantia Mosiac Virus	wandering jew

- yellow streaking of leaves, especially monocots
- yellow ringspots or lines on leaves
- veins becoming distinctly yellow
- uniform yellowing, bronzing or reddening of leaves
- cup-shaped leaves
- crinkling or curling of leaf margins
- distortion of leaves and growing points
- stunting of growth

Diagnosing a viral disease should not be based only on its symptoms. If you suspect a virus, isolate the diseased plant and obtain a diagnosis from the MSU Plant and Pest Diagnostic Clinic.

Root Diseases

Root rots are the most common disease problem with indoor ornamental plants. Most root rot diseases are caused by fungi. See Table 4 for examples of fungal root rots.

Infectious root rots can be diagnosed to some extent by direct observation of the root system. Healthy roots of herbaceous plants should appear white and firm. Off color or brownish-to-blackish, limp roots often indicate root rot is present. Being able to pull off outer root tissue with your fingers (leaving the string-like center of the root behind) is a good sign that root rot is present. In order to determine the health of a root system, you should know what a healthy root system looks like. Conditions of the above-ground portions of the plant that indicate a root problem include smaller and less vigorous growth, new leaves may be smaller and fewer than normal, old leaves turn yellow and fall beginning at the base of the stem. Also, the plant may droop and new shoots may emerge from the lower stem.

Two of the most common root rotting fungi involved in root rot disease are the water molds, *Pythium sp.* and *Phytophthora sp.* These organisms are called water molds because of a spore stage that is adapted to spread by swimming in water. These organisms, even if present, are not a problem unless plants have been subjected to poor environmental conditions or cultural practices. High moisture levels in potting soil due to over-watering, poorly drained media or water standing in the bottom of the containers induce infection of roots by these fungi. Damage caused by over fertilization, a build up of salts in the soil, chilling or freezing temperatures, or phytotoxicity caused by improper soil drenches can also lead to root rots.

Drainage of the medium and establishing proper irrigation, fertilization and good sanitation practices help avoid and/or correct root rot diseases in general. Be aware of the changes in the physical structure of the plants' rooting media. As media ages it may settle and pack in the bottom of containers and hinder drainage.

Rhizoctonia solani is a soil borne organism which is especially damaging to roots and lower stems. Under high humidity and cool weather conditions this organism, as well

Table 4. Examples of Fungal Root Rots

Disease	Pathogen	Hosts	Symptoms
Wet Rots	*Pythium* spp. *Phytophthora* spp.	*Dieffenbachia* spp., *Maranta* spp., *Aglaonema* spp., *Philodendron* spp., *Brassaia* spp., and many others.	Begin at root tips, move toward stem. Roots turn brown to black, outer layer is mushy, may slip off leaving center of root intact.
Dry Rots	*Rhizoctonia solani* *Rhizoctonia* spp.	*Aglaonema* spp. *Dieffenbachia* spp., and many others.	Source of damping off in seedlings. Older plants develop dry, reddish-brown lesions at the soil line. Leaves can be affected if they are near soil level.

Table 5: Some of the Diseases Affecting Plants Used Indoors*

Diseases

1. **Systemic Bacterial Infections****
2. **Bacterial Leaf Spots**
3. **Nematode Diseases**
4. **Virus Diseases**
5. **Powdery Mildews**
6. **Water Mold Root and Crown Rots**
7. **Root and Stem Rots**
8. **Fungal Leaf Spots and Blights*****

Hosts

Aglaonema spp. --1,2,7,8
Aloe spp.-6,7,8
Aphelandra spp.--1,2,7,8
Aralias--2,6,7,8
Araucaria spp.--7,8
Ardisia spp.--6,7,8
Areca spp. (see Palms)
Asparagus spp.--1,8
Begonia spp.-1,2,5,6,8
Brassaia spp.--2.3.4.6.7,8
Caladium spp.--3,4,7
Clathea 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. (see Aralias)
Dracaena spp.--1,6,7,8
Epipremnum sp--1,2,3,6,7,8
Fatshedera (see Aralias)
Fatsia (see Aralias)
Ferns--2,3,7,8
Ficus spp.--4,7
Hedera helix--2,6,7,8
Howea (see Palms)
Hoya spp.--6,7,8
Ivies -- 5,7,8
Maranta spp.--1,3,4,6,7,8
Nephrolepsis (see Ferns)
Palms--3,7,8
Peperomia spp.--4,6,7,8
Philodendron spp.--1,2,3,4,6,7,8
Phoenix (see Palms)
Pittosporum spp.--7,8
Pleomele spp.--7,8
Podocarpus spp.--6,7,8
Polyscias (see Aralias)
Raphis (see Palms)
Sansevieria spp.--1,3,6,7,8
Schefflera spp.--2,8
Sedum spp.--8
Spathiphyllum spp.--2,4,6,7,8
Yucca spp.--8
Zebrina spp.--3,4,7

* Disease occurences 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 Pit. Ind., Fl. Dept. of Agr. and Consumer Services.

** Includes *Erwinia Carotovora*.

*** Includes anthracnose diseases.

This is not intended to be a comprehensive table.

as the water molds, can cause serious aerial blights (diseases of above-ground plant parts). Only occasionally is this a problem for indoor plants. *R. solani* has a wide host range and needs only minimal environmental requirements for disease development. Therefore, this organism poses a serious threat where poor horticultural practices exist or when this organism has contaminated the potting media.

Other pathogenic organisms which can be equally detrimental under the right conditions are *Fusarium* sp., *Cylindrocladium* sp., *Sclerotinia* sp., and *Thielaviopsis basicola*. These organisms are soil borne and persist in soil or artificial media for quite a while. Therefore, the best management of these pathogens, as all the others, is prevention; use only disease-free plants, avoid stressed plants or those with discolored roots or stems, closely monitor your watering practices, and practice good sanitation measures.

Nematode Diseases

Several types of tiny roundworms cause plant diseases on plants used indoors. Lesion nematodes (*Pratylenchus*) and spiral nematodes (*Helicotylenchus*) cause plant stunting and poor growth because their feeding weakens the root system. The root knot nematode (*Meliodogyne*) causes nodules to form on roots, thus impairing root function. This causes stunting. The foliar or spring crimp nematode (*Aphelenchoides*) lives within the leaf tissues of many indoor plants. It causes death of the leaf tissue, resulting in brown lesions on older leaves. Nematode diseases tend to be rare on indoor plants.

Good sanitation is the primary means of controlling these pathogens. Soil sterilization prior to planting will kill adults as well as eggs of root nematodes. Fumigants are as effective as steam for this purpose. Fumigants are not registered for use in interior landscapes. To use fumigants as a nematode management tool in a **production** setting, a person must be a certified pesticide applicator in the fumigation standard. Indoor landscapers should buy plants only from growers who practice good sanitation!

Review Questions For Section 7 - Diseases of Indoor Plants

Write answers to the following questions and then compare your answers with those in the back of the manual.

1. Which of the following is a non-contagious disorder?

   a. relative humidity

   b. powdery mildew

   c. high level of salts in root media

   d. a and c

2. What are the three components of the disease triangle and what is their significance?

3. It is not uncommon for a disease to begin simply because there are pathogenic agents in the area. (True or False)

4. What is the most problematic cultural practice that leads to plant health problems?

5. At what temperature can tropical plants begin to suffer chilling injury?

6. What are the symptoms of chilling or freezing injury?

7. The primary reason to avoid getting plant foliage wet when applying irrigation water is because;

    a. it leaves unsightly residues.

    b. water droplets magnify light intensity and can burn the foliage.

    c. cold water can damage the foliage.

    d. wet foliage promotes the development and infection of leaf spot organisms.

8. Which of the following is a pathogenic disease?

    a. Botrytis blight

    b. *Pythium* sp.

    c. low light levels

    d. high humidity and leaf wetness

    e. all of the above

    f. a and b

9. Which of the following is characteristic of a fungal leaf spot?

    a. circular, dead spots or lesions on the leaves

    b. lesions with concentric rings creating a "target-like" appearance

    c. black, pin-point specks in infected tissue areas

    d. All of the above

    e. None of the above, these describe a bacterial leaf spot.

10. When a plant has a bacterial disease the infected area may have a greasy, water-soaked appearance. (True or False)

11. What is the best management approach to take when a plant is suspected of having a virus?

12. What are the two most common root rotting fungi and why are they called water molds?

13. Which of the following conditions predispose roots to disease?

    a. excessive fertilizer

    b. excessive watering

    c. poorly drained potting media

    d. all of the above.

14. Nematodes are microscopic worms that cause diseases. (True or False)

15. What is the best management practice when defending against plant diseases?

Section 8

PESTICIDE SELECTION

If after making every effort to select a plant best suited for a site, optimizing environmental conditions, and implementing correct cultural practices, a pest outbreak occurs, the use of a pesticide may be necessary to manage that pest.

Pesticides are hazardous substances. The Environmental Protection Agency (EPA), the segment of government that administers the federal law regulating pesticides (FIFRA), classifies pesticides as highly toxic, moderately toxic, relatively non-toxic, etc. When you select, apply and dispose of pesticides with appropriate precautions, you will avoid inflicting harm to people, plants, the environment and other non-target organisms. The pesticide label provides important directions for selecting, handling, applying and disposing of the product appropriately.

Consult the label before any pesticide application. This will ensure the safety of plants, the public and yourself. Select a pesticide that:

- is registered for use in an interiorscape setting.

- controls the pest you are trying to manage.

- has the host plant you are treating listed on the label, indicating the product is legal to use on that species and damage will not be incurred with proper use.

- is the least toxic product that will produce the desired level of control. Refer to the "signal word" to determine the degree of hazard inherent to the product. Signal words:

  * **CAUTION** - This word signals that the product is slightly toxic orally, dermally or through inhalation or causes slight eye or skin irritation. Toxicity classes III and IV.

  * **WARNING** - This word signals that the product is moderately toxic orally, dermally, or through inhalation, or causes moderate eye or skin irritation. Aviso, the Spanish word for warning, may also appear on the label. Toxicity class II.

  * **DANGER** - Products with this signal word can cause severe eye damage or skin irritation. Toxicity class I.

  * **DANGER-POISON, Skull and Crossbones** - These words and symbol must appear (in red letters) on all products that are highly toxic by any route of entry into the body. Peligro, the Spanish word for danger, may also appear on the label. Toxicity class I.

- is compatible with other plant management strategies.

- is acceptable to the client/public; consider odor and visible residues.

- has a **mode of action** (manner in which a pesticide works) and **formulation** (physical characteristics of a mixture of active and inert ingredients) appropriate for controlling the target pest and suitable for indoor settings where there is a potential for people to be exposed to your treatment.

Your selection of pesticide products may be limited because interior landscape settings are not listed on the labels as a legal site for application. By relocating the plants requiring treatment to another site such as out-of-doors or to a greenhouse, you:

1) have more pesticide product options,
2) reduce the exposure of pesticides to interior environments and the people that occupy them.

When practical, consider moving plants from the interior landscape to another area for treatment to ensure the safety of yourself, people, and indoor furnishings.

Mode of Action

The manner in which a pesticide works, summarized in the accompanying table, influences its ability to limit pests and its potential for endangering nontarget organisms. In an interiorscape, non-target organisms refers mainly to the people that use or frequent interiorscape spaces. Pesticides can work as it contacts the pest, as a protectant or a systemic. Pesticides may be considered broad-spectrum, selective, non-selective or as a residual (see table).

An example of a systemic pesticide is a **systemic insecticide** which is absorbed into and travels within the host plant (translocated). Therefore, a systemic insecticide is contained within the host, and only those insects that consume the plant are directly exposed to the poison. Other organisms are less likely to be exposed. Although a systemic pesticide reduces exposure, there are other factors to consider.

Indoor plants endure sub-optimal light, water and temperatures and often have excessive soluble salts built up in the soil. Such plants do not translocate systemic pesticides well. Woody (woody stems vs. fleshy stems) interior landscape plants, in particular, seem to translocate systemic pesticides poorly, thus the desired results may not be obtained.

How Pesticides Work

Type of Pesticide	Mode of Action
Contact	Pesticides that kill pests by coming in contact with them.
Protectant	Pesticides that are applied prior to pests becoming established on plants.
Systemic	Pesticides that are absorbed into and move within a plant. Kills the pest without harming the host plant. Systemic herbicides that are applied to weed foliage will also kill the roots.
Broad-spectrum	Pesticides which limit two or more pests of a particular plant. Sometimes labeled as multipurpose chemicals. A broad-spectrum pesticide may be protectant or systemic in its action.
Residual	Pesticides which continue to be effective for an extended period of time after application.

In addition, many of the scale, aphid and mealybug pests of indoor ornamentals suck sap from the phloem through tiny threadlike mouthparts. Systemic pesticides move through the xylem tissue. Therefore, systemics are not effective against **stem-feeding** sucking pests. When pesticides become a selected tool in the integrated pest management program, most indoor pest controls tend to be accomplished by spraying.

Pesticide Formulation

There are advantages and disadvantages associated with the use of any one of the numerous pesticide formulations. Formulations vary in their cost, ease of application, phytotoxic affect on plants and potential threat to the applicator and other persons that occupy the interior landscape.

Which formulation characteristics are regarded most important when choosing a pesticide depends upon the pest management situation. For instance, pesticides formulated into a dry 'spike' which are inserted into the soil media, are generally more costly per application, but less likely to contaminate nontarget organisms than a spray residue or granules laying on the surface. You may opt for the spikes to treat a non-woody plant suffering from a minor aphid infestation to eliminate the risk of exposing humans to other formulations of insecticides.

The highest rate of all poisonings occur in young children. Avoid the use of granular pesticides in an interior landscape. The potential for curious onlookers being exposed to surface applied, granular pesticides is high.

Knowing the effectiveness of the various formulations and mode of action is critical in successfully managing pests. Although exposure is minimal with the spikes mentioned above, they are <u>not</u> very effective in reducing severe pest problems. Insect growth regulators are effective, yet, may work more slowly than other products and require follow-up applications. It is important to understand the characteristics of the pesticide products you choose to use in your IPM program. Chemical manufacturers are continually striving for safer pesticide formulations. Keep informed about new materials becoming available on the market. Chapter three of the Core manual (Extension Bulletin E-2195) discusses the various pesticide formulations.

You may need to treat for two or more different pests that are present at the same time. If these pests cannot be controlled with a single product, you may wish to combine products making one application and therefore effectively

using your time. Before using any chemical or combination spray on a group of plants for the first time, treat a few plants and wait three to four days to be sure no phytotoxic damage will occur from the treatment. In addition to the potential for causing phytotoxic injury, there may be other incompatibility problems with mixing pesticides. The formulations may not be physically compatible causing lumpy, gummy or other unusable mixture conditions. One pesticide may reduce the effectiveness of the other or conversely, cause it to be more effective thus risking personal safety and plant damage.

Adjuvants

An **adjuvant** or additive is a chemical added to a pesticide principally to increase its effectiveness. Most pesticide formulations already contain a small percentage of adjuvant. Different adjuvants cause pesticides to act in various ways. Adjuvants can:

- enhance the pesticide's ability to mix with water.

- allow the pesticide to spread evenly over a treated surface.

- increase the adherence of the chemical to a treated surface thus increasing its persistence.

- aid the absorption of a systemic pesticide by the plant.

- maximize the interaction of a pesticide with the treated surface.

Adjuvants should be added **only** if recommended on the product label. Some labels expressly prohibit the use of adjuvants.

Adjuvants increase the potential for phytotoxicity and present greater health risks to applicators. To reduce these concerns, follow a few basic guidelines when selecting a pesticide and adjuvant combination:

-**READ THE LABEL,** the product may already contain an adjuvant.

-Test the pesticide-adjuvant combination on a small sample before using on an entire interior landscape.

-Use the lowest dosage of adjuvant required to obtain desired coverage.

-When several applications are needed within a short time, use adjuvants with the first application only, or at a reduced rate with each spray; a buildup of adjuvants may burn plant tissue.

-Some adjuvants increase your skin's absorption of chemicals; rashes and skin reddening are more likely to occur when using adjuvants; always wear personal protective equipment and handle pesticide solutions carefully.

Purchasing Pesticides

Read the entire label of a pesticide before making your purchase. Be certain it is labeled for use on the pest you want to manage, the host plants you will be treating and for interior landscape sites. You may request Material Safety Data Sheets (MSDS) from your dealer for those products you purchase. These informational sheets are an effective communication tool when interacting with co-workers and clientele. They provide important information about the pesticide including toxicity, first aid, personal protection, active ingredient and other safety data.

Purchase pesticides in quantities that you will utilize in a short period of time. Refer to records of previous pesticide usage to estimate current and future needs. Purchasing only what you need will reduce your liability and the potential for storage related predicaments such as:

- having to maintain appropriate environmental conditions (temperature, humidity, ventilation);
- ripped, broken, or leaking containers;
- spills;
- faded labels;
- pesticide fumes;
- pesticide degradation (clumping, layering, ineffective active ingredients, etc.);
- changes in recommendations or legal product usage.

Check pesticide labels for special storage considerations and shelf life expectations. Keeping containers and bags tightly sealed, free of moisture, freezing temperatures and out of direct sunlight will help prevent premature degradation. Review the chapter on *Pesticide Handling, Storage and Disposal* in the Core Manual (Extension bulletin E-2195) for additional pesticide storage recommendations and requirements.

Review Questions For Section 8 - Pesticide Selection

Write answers to the following questions and then compare your answers with those in the back of the manual.

1. What source of written information provides directions on how to mix, apply and dispose of a pesticide?

2. Which of the following questions should be considered when selecting a pesticide for use in an interior landscape?

   a. Is the pesticide registered for use in the area where you want to apply it, i.e. in an interior landscape?

   b. Is the pesticide effective on the pest you are trying to manage?

   c. Is the plant you are treating listed on the product label as an acceptable target?

   d. Does the pesticide have an offensive odor or leave a residue?

   e. All of the above.

3. A pesticide's mode of action influences its ability to limit pests and its potential for endangering nontarget organisms. (True or False)

4. Which sector of the public suffer from the highest rate of poisonings?

5. Before using a combination of sprays on plants for the first time, you should treat a few plants and wait three to four days to be sure no phytotoxic damage occurs. (True or False)

6. Why are systemic pesticides not always effective for use on interior plants?

   a. They usually cause phytotoxicity.

   b. Plants living in suboptimal environmental conditions do not translocate the chemicals well.

   c. Systemic pesticides move through the xylem of plants, while the stem feeding insects feed on the phloem.

   d. None of the above.

   e. B and C

7. Mixing two pesticides together may:

   a. cause one or both pesticides to be more effective

   b. cause one or both pesticides to be less effective

   c. cause phytotoxic damage to the target plant

   d. all of the above

8. What is an adjuvant?

9. Most pesticide products contain a small percentage of adjuvant. (True or False)

10. What are MSDS sheets?

11. What kinds of problems are associated with the storage of pesticides?

12. When purchasing a pesticide product, how much should be purchased?

    a. The largest quantity available so the price is less per volume.

    b. Enough to last two years.

    c. Only what you will use in a short period of time.

    d. The amount indicated by your records of previous use.

    e. All of the above.

    f. C and D

Section 9

PESTICIDE APPLICATION PROCEDURES

Timing and Selection

When a pesticide application is necessary to manage a pest, choose the safest pesticide available that is labeled for interiorscape use and has the plant and plant problem you wish to treat listed on the label. Also, consider relocating a plant to be treated outdoors or to a greenhouse to enhance safety and possibly broaden your pesticide selection options. Having selected a pesticide means you have identified the problem and what caused it and have taken into consideration the life stage of the pest, and you are certain that pest is in a life stage vulnerable to the pesticide product you have chosen. Timing of your pesticide application is critical. Once you have selected your pest management strategy it must be timed to target the pest when it is susceptible.

Often single treatments made to major pest outbreaks do not provide acceptable results. Many pests have short life cycles which allows several generations to be present at the same time, each at a different stage. Repeated applications restrict successive generations as they reach a vulnerable stage. Continued monitoring between applications will indicate how fast pests are maturing under the conditions present. Remember high temperatures shorten the generation time of some pests. **Read the label** for the recommended frequency of applications. It is illegal to use a product more often than directed and in addition, pesticide buildup may create health risks or cause plant damage.

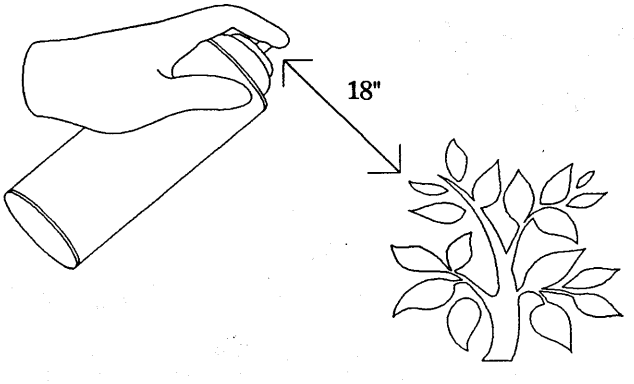
Refer to the signal words and the LD 50 to understand the relative toxicity of the product to humans and animals. Also, consider the **odor** of a pesticide. Some pesticides have offensive smells and even though labelled for use in an interior setting, they may not be appropriate. Another consideration is the visible residue that may be left on plant foliage after a treatment. The appearance of residues may not be acceptable to your client.

Phytotoxicity and Environmental Conditions

Plants targeted for a pesticide application should not be wilted or stressed. Certain plants, due to their physiological condition may be more sensitive to chemicals. Under certain environmental conditions or periods of stress, plants that could normally be treated safely may be damaged. This damage is called phytotoxicity. Symptoms of phytotoxicity include:

1. Leaf burn on the tips, margins or entire leaf.
2. Chlorosis or a bleached appearance on sections of the leaf or entire leaf.
3. Abnormal growth, distortion or reduction in number of flowers, etc.
4. Stunting of the entire plant or parts of the plant.
5. Russeting or bronzing of leaves.
6. Death of rapidly growing tissue.
7. Uniformly colored dead spots with distinct margins.

If plants are wilted, irrigate and allow time for plant turgor (water pressure within a plant) to be regained before making your pesticide application. Avoid making pesticide applications to plants exposed to high temperature conditions and excessive sunlight. Spray when air and leaf temperatures are moderate; both heat and cold encourage some forms of damage. Consider the temperature fluctuations within an interior landscape during the course of a day. Apply pesticides when conditions favor drying of sprays and while temperatures are at suitable levels. If using an aerosol, hold the can at least 18" from the plant's surface. Pesticide combinations may cause damage even



though the individual chemicals do not. Read the label for information on mixing different products and make a sample spray to test for phytotoxicity before treating an entire plant or area.

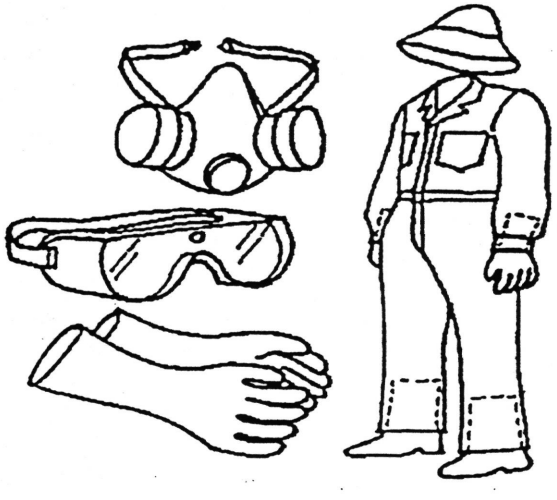
Possible factors contributing to phytotoxicity due to pesticide applications:

* Correct pesticide and method are used, but environmental conditions are adverse (direct sunlight, too cold, wilted plant).
* Use of incorrect pesticide or formulation for the plant being treated.
* Improper application procedures including lack of agitation after mixing or incorrect application equipment for the chosen formulation.
* Applying excessive dosages due to improper dilution, frequent applications, or poor application techniques.
* Drift or runoff from target plant reaching other sensitive plants or the target plant's root system.

Handling Pesticides

When handling pesticides, give full atention to your activity and exercise every precaution. Do not breath a pesticide. Keep it out of your eyes. Do not allow the pesticide to come in contact with your skin or things you eat and drink. Never eat, drink or smoke when using pesticides. Wash thoroughly and immediately after working with pesticides.

Always wear protective clothing. The pesticide product label will instruct you on what protective equipment is required when using the product. An applicator is at greatest risk when handling the pesticide in its concentrated form. Exercise every precaution when mixing and loading pesticides. When opening a container of liquid pesticide, keep your face away from and to the side of the cap or lid. Do not tear paper containers to open them; use a sharp knife or scissors.



For each job site, determine the amount of pesticide required to provide adequate coverage and mix **only** what you need. The Calibration section of this manual will help you prepare the correct amount of pesticide spray. Generally, the label will instruct to what point to spray such as runoff or to a glisten. **Never** exceed these recommendations. When finished measuring the appropriate amount of formulation, seal container tightly, avoid leaving the product where it is exposed to excessively high or low temperatures (as in your vehicle), and avoid direct sunlight and moisture. Return the product to its appropriate storage area upon returning to your home base. Keep inventories and records of pesticides used.

If you use the last of a chemical for your mixture, the pesticide container should be triple rinsed at that time because residues can become dried and difficult to remove later. Pour the rinsewater into the sprayer to avoid disposal problems and wasting product. Refer to the Core Manual for additional information on pesticide container recycling or disposal.

Some plant maintenance companies find it more practical to schedule visits and treatments to all accounts requiring the same pesticide application on the same day. In this way they calculate the total volume of pesticide solution needed for the entire day's schedule and mix and load the appropriate sprayer one time. This approach is often preferred over mixing a pesticide solution at each job site. First of all, your company should have a designated and approved site for mixing and loading. A designated area with the appropriate safety equipment is safer than trying to 'make do' with conditions at the various job sites. A one-time mixing operation of enough solution for the entire day's work, reduces the frequency of an applicators exposure to the concentrated chemical. This approach would also require less overall time for measuring and mixing.

If you choose to mix one total amount for all scheduled treatments on a single day, label the sprayer indicating what pesticide solution it contains. Always have a label of the product you are using with you. Extra manufacturer labels, as well as MSDS sheets, are available from your chemical dealer upon request. Also, if you are asked, you are responsible for providing evidence of **your** credentials. Be prepared and carry your pesticide certification card or registered technician number with you.

If there is a miscalculation and you have extra pesticide mixture remaining in your spray tank when the treatment is completed, **do not** pour this mixture down a drain. The best option for excess pesticide mixture is to apply it to plants listed on the label without exceeding label rates. Do not leave the mixture in the sprayer for a future application. Pesticides degrade over varying lengths of time. Also, a pesticide in an unmarked container and something other than its original container can be hazardous.

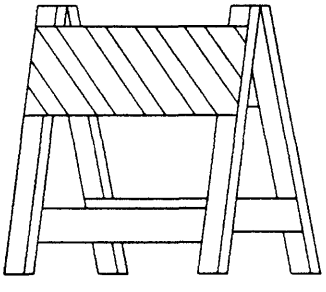
Applications in the Interior Landscape

Pesticide applications in interior landscape settings require special considerations for protecting the surroundings. When practical, consider relocating the plant outdoors or to a greenhouse for treatment. Always use the appropriate sized equipment to get the job done. Have back-up equipment and spare parts with you. Never allow people to touch your equipment. As a precaution do not pressurize tanks except when they're in use. Do not leave your materials and equipment where children or customers may accidentally come in contact with them.

Public Places: Malls, Atria, Lobbies, etc.
During all applications, take care to protect against damaging floors, walls, ceilings, fixtures and furniture. The petroleum distillates used to dissolve pesticides may permanently stain wood products. Carpeting and wall coverings can also be discolored by pesticide solutions. Yet, to achieve good control of the plant pest, pesticides must be applied thoroughly.

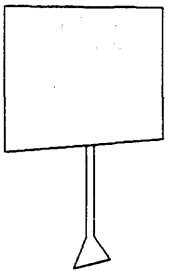
Whenever possible move the plant to an isolated area. Spread a plastic dropcloth under and around the plants to catch spray drift or drips. On jobs requiring treatment of large specimen plant material it is essential to protect all walls, ceilings, floors, carpets and furniture in the vicinity. Plan ahead with the building manager and adequately drape plastic tarps over walls and furniture and lay dropclothes to prevent damage to floors and carpet.

Block off all entrances to the area being treated. Observe and enforce re-entry periods according to the label. If re-entry periods are not listed, do not allow persons to enter the area until pesticides have dried or settled and the area is well ventilated. Watch for unauthorized or unexpected persons entering the area even though it may be posted.



Restaurants and Eating Areas
Treating for insect, mite and disease pests of ornamentals in restaurants and food handling establishments must be done with extreme care to avoid contamination of food and utensils. If possible, take plants to less critical areas for treatment. If it is not possible to remove plants for treatment, then all utensils and surfaces on which food is placed should be covered during treatment. Then any area which may have become contaminated during treatment should be washed down and covered with shelf paper before replacing food or utensils.

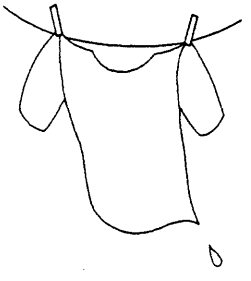
Post Treatment Procedures



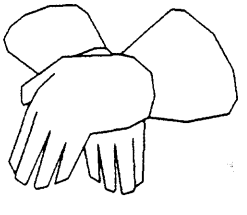
Refer to current state and federal laws to determine your responsibility for "posting" the plant, site or area where you have made a pesticide application. In Michigan these specifications are outlined in Regulation 637 of the Michigan Pesticide Control Act. Be sure these areas remain posted for the appropriate length of time and that the signs are removed after the specified duration.

Rinse all equipment including buckets, sprayer, nozzles and tools and empty pesticide containers. Puncture pesticide containers so they are not re-usable. (**Do not** puncture pressurized containers.) Capture all rinse water. This rinse water can be used as the diluent for the next application of the **same** pesticide or sprayed on plants. The rinse water will have minimal pesticide concentrations and it is legal to use pesticides at a weaker rate than listed on the label. **Never exceed label rates.** If you are going to use this rinse water as a diluent for the next application, clearly label the container or sprayer to indicate the type of solution it contains. This will avoid cross contamination and informs others of the containers contents and how to handle it.

Thoroughly wash yourself with plenty of soap and water after applications. Launder clothing worn while applying pesticides daily and separately from other family wash. Launder with hot water, the highest level of water and the longest wash cycle. Use a heavy-duty liquid detergent. Line dry. After laundering pesticide-soiled clothing, run the empty washing machine through a complete cycle with detergent.



Document your application. Include information such as date, location, plants treated, pest treated for, pesticide used, type of equipment and length of time spent doing the application including mixing and clean-up. This information is an important aspect of your integrated pest management program and is a **legal requirement** in Michigan; Regulation 637.



If handling treated plants always wear protective clothing. If plants are dry and have pesticide residues, protective gloves should be worn when working with them.

Symptoms of Pesticide Exposures and Basic First Aid Procedures

If you become ill or experience unusual symptoms during or after using a pesticide, immediately call or visit a poison control center or medical doctor. **Take the pesticide label or labeled container with you.** Refer to the Core manual chapter on *Pesticides and Human Health* for more detailed pesticide exposure symptoms and first aid procedures for pesticide exposures. These procedures should be learned **before** handling pesticides.

Most pesticide poisonings result from careless use, improper storage or ignorance. By law, everything you need to know to apply pesticides safely is on the pesticide label. Therefore, the most important rule to follow when using pesticides is: **Read and follow the instructions and precautions on the label.**

When working with *herbicides* or *fungicides*, some of the most common exposure symptoms and signs are:

***When a substance is touched:** skin irritation (drying, cracking), skin discoloration (reddening, yellowing) or itching.

***When the substance is inhaled:** burning sinuses, throat and lungs, accompanied by coughing, hoarseness and upper respiratory congestion.

***When the substance is ingested:** mouth and throat irritation, chest pains, nausea (stomach ache), diarrhea, muscle twitching, sweating, headache and weakness.

Some of the symptoms begin immediately upon exposure while others are delayed for several hours or even days.

When working with *insecticides*, symptoms will differ with the various products, but all are dependent on both the amount and timing of exposure. The most commonly reported symptoms, which often appear in progression and depend, in part, on whether the chemical was touched, inhaled or ingested, are:

* headache,
* visual disturbances (blurred vision),
* pupillary abnormalities (primarily pin-point pupils, but on rare occasions, dilated pupils), and
* greatly increased secretions such as sweating, salivation, tearing and respiratory secretions.

More severe poisonings results in nausea and vomiting, pulmonary edema (the air spaces in the lungs begin to fill with fluid), changes in heart rate, muscle weakness, respiratory paralysis, mental confusion, convulsions or coma and death.

If you experience a pesticide exposure, execute the following basic first aid procedures while additional help is on the way. Again, more detailed information about symptoms and first aid procedures can be found in the Core manual.

Dermal Exposure:
* Remove clothing, if it is contaminated.
* Rinse thoroughly using lots of soap and water.
* Wash and rinse again.

Inhalation Exposure:
* Get to fresh air immediately.
* Loosen all tight clothing.
* Victim should remain as quiet as possible.
* Prevent chilling but do not overheat.

Eye Exposure:
* Hold eyelids open and wash eyes with a gentle stream of clean running water. Use large amounts of water. **Do so immediately; delay of even a few seconds greatly increases the possibility of injury.** Continue washing for **15 minutes** or more.
* Do **not** use medications in the wash water--use pure water.

Oral Exposure:
* If a pesticide has gotten into your mouth, but has not been swallowed, rinse your mouth with large amounts of water.
* If the pesticide has been swallowed, the most important consideration is whether or not to induce vomiting; the decision must be made quickly and correctly. Where specific instructions are given, always follow label directions. Beyond that, never induce vomiting if:

(1) the victim is unconscious or is having convulsions; or

(2) the pesticide is **corrosive.** A corrosive substance is any material, such as a strong acid or alkali (base), which causes chemical destruction of living tissues. Poisoning symptoms include severe pain and a burning sensation in the mouth or throat.

In attempting to induce vomiting, it is important to use safe and effective procedures. Vomiting should be induced for an **adult** with two tablespoons (one ounce) of Syrup of Ipecac (this can be obtained from your pharmacist without a prescription) and two glasses of water. Induce vomiting in a **child** with one tablespoon (one-half ounce) of Syrup of Ipecac and one glass of water. If Syrup of Ipecac is not available, induce vomiting by drinking one or two glasses of water and then touching the back of the throat with your finger. **Salt water should not be used to induce vomiting.**

Pesticide emergency information telephone numbers are included at the end of this manual. Have these numbers readily available when working with pesticides.

Review Questions For Section 9 - Pesticide Application Procedures

Write answers to the following questions and then compare your answers with those in the back of the manual.

1. List at least five things to consider when selecting a pesticide to use in an interior landscape setting.

2. What is phytotoxicity and what are some of the damage symptoms?

3. List four reasons why phytotoxicity may occur.

4. An applicator is at greatest risk when handling a pesticide in its concentrated form. (True or False)

5. Why is it a good practice to triple rinse a pesticide container when the last of the chemical is mixed into solution?

6. It is unlikely that a pesticide solution will harm wood or fabrics. (True or False)

7. If no re-entry period is defined on the pesticide label, how long should you keep people out of the treated area?

8. Which Michigan law outlines the procedures for posting a pesticide treated site?

9. After rinsing your pesticide application equipment, what should be done with the rinse water?

10. What are the most commonly reported human symptoms of pesticide exposure?

Section 10

CALIBRATION

Safe and effective pest management is only possible through proper pesticide application. Accurately calibrating pesticide application equipment ensures that the correct amount of pesticide is applied over a specified area. There are different methods of calibration for the various types of application equipment. The following two methods are used to calibrate the majority of the types of equipment used in interiorscapes.

Concentration Method

When the label reads "mixing a known concentration and applying to the point of run-off," calibrate equipment using the concentration method. This type of application is usually used for spraying interior trees, understory plantings, groundcovers and flowers. One of the most important aspects of this calibration and pesticide application procedure is determining just the amount of material needed to complete the application. Avoid mixing too much spray material and associated disposal problems. This simple procedure will assist in calculating the spray material needed:

1. Put a known amount of clean water into the sprayer you will use for the pest management application.

2. Select a typical plant in the interiorscape to be sprayed and apply the water as you would the actual pesticide. When the label specifies applying the spray to run-off or to a glisten, spray until the surfaces are wet and almost begin to drip.

3. Measure the amount of water used to adequately spray that average plant. Multiply that amount by the total number of plants to be treated. This will tell you the total amount of material required for that interiorscape.

4. Figure how much pesticide concentrate must be added to the amount of water determined in step 3 to achieve the rate recommended on the label. Always wear appropriate protective clothing when working with pesticides. Mix thoroughly and apply to the plants in the same manner used in step 2 above.

5. Immediately following completion of the application, place clean water into the sprayer container, agitate and apply the wash solution in very light amounts to the foliage of the plants just treated or to other plants listed on the label. Repeat the wash procedure two times. Rinse water can be used as a diluent for future sprays of the same product. Clearly label the container or sprayer, indicating the type of solution it contains.

Volume Method (Active Ingredient)

The volume method of calibration is used when a product label calls for a specific amount of formulated product (the pesticide product as purchased, not diluted) to be applied to each plant or designated area. First you must determine the output of your equipment over a given area using the intended application techniques. Once we have this information we can adjust the concentration of the spray material to obtain the label rate. Use the following procedure to calibrate your equipment used to treat ground areas or areas of plants:

1. Measure and mark an area of known size on the ground, concrete, or asphalt that is a factor of 1000 ft^2 (such as 250 ft^2 or 500 ft^2). Practice spraying the area with water using uniform walking speeds, constant nozzle height and a uniform sweeping, overlapping motion. Observe the spray pattern and evaporating water. Areas receiving too much or too little spray will be apparent. Practice your application technique until the application is uniform over the entire area.

2. Fill the sprayer to a known level with water only and spray the area using your refined technique from step 1. Measure the amount of water remaining in the sprayer. The difference between your starting level of water and the water that remains in the sprayer, is the amount applied. Divide this difference by the practice area sprayed to determine your application rate. Some product rates for interiorscapes are given per 1000 ft^2. Therefore, you would need to convert your application rate to amount sprayed per 1000 ft^2. For example, let's say your application rate (as figured above) was .5

gallon per 250 ft² practice area. You know 1000 ft² is four times 250 ft², so multiply the amount you applied in your practice area by four (.5 gallons x 4 = 2 gallons of spray per 1000 ft²).

3. Determine the proper amount of pesticide product needed for the treatment area (may be more than one tankful) and add to water in the tank. Mix thoroughly and apply to the area using the refined technique of step 2. Always wear appropriate protective clothing when working with pesticides.

For Example: The label rate is 1.5 fluid ounces of formulated product per 1000 ft². You wish to apply this material to 300 ft² of groundcover. Your three gallon sprayer had an application rate determined in step 2 (above) of 2 gallons per 1000 ft2. *How much spray material needs to be applied to cover the 300 ft²? And, how much formulated product must be added to this spray water to obtain the label rate?*

First determine:

Amount of spray for 300 ft² = *your application rate* x *treatment area*

$$= \frac{2 \text{ gallons}}{1000 \text{ ft}^2} \times 300 \text{ ft}^2$$

$$= \frac{600 \text{ gallons}}{1000} = .67 \text{ gallons}$$

At your application rate, two-thirds of a gallon (.67) of spray material will be applied to the 300 ft² treatment area.

Now determine:

Amount of formulated product required to treat the 300 ft² at label rate = *label rate* x *treatment area*

$$= \frac{1.5 \text{ fluid oz.}}{1000 \text{ ft}^2} \times 300 \text{ ft}^2$$

$$= \frac{450 \text{ fluid oz.}}{1000}$$

= .45 fluid oz. of formulated product

Therefore, mix .45 fluid oz. (almost .5 oz.) of formulated product into .67 gallons of water to treat the 300 ft² of groundcover at the pesticide's label rate.

4. Upon completion of the pest management application, add water to the tank, agitate thoroughly, and apply the rinse solution to the treatment area or to other plants listed on the pesticide label. Repeat two times to complete the wash process. Rinse water can be saved and used as a diluent for future spray applications of the same pesticide. Clearly label the container or sprayer indicating the type of solution it contains.

Conversion Tables

The easiest way to weigh out small amount of pesticides is to weigh them using the same unit of measure by which they are sold. Liquid formulations (F, EC) are sold by liquid volume measures such as quarts or gallons. These large volumes can be reduced by converting to smaller liquid volume units such as fluid ounces, tablespoons or teaspoons. The following table presents the common conversions for liquid volume units of measure.

Remember, when using teaspoon or tablespoon measures, these must be level measuring spoons not disposable plastic spoons or spoons from a silverware set. Measuring spoons are designed for accurate volume measure, eating utensils are not! **Wear non-porous gloves while measuring pesticides. Measure in a ventilated area. Never allow measuring spoons, cups or other equipment used with pesticides to be used for food preparation or consumption. Do not put concentrated pesticides into unlabelled containers.**

Liquid Volume Measure Equivalents.

Measuring Unit	Tsp.	Tbsp.	Fl. Oz.	Cup	Pint	Qt.	Gal.
Teaspoon	1	.3	.167	.021	.010	.005	.001
Tablespoon	3	1	.5	.063	.031	.016	.004
Fluid Ounce	6	2	1	.125	.063	.031	.008
Cup	48	16	8	1	.5	.25	.063
Pint	96	32	16	2	1	.5	.125
Quart	192	64	32	4	2	1	.25
Gallon	768	256	128	16	8	4	1

*Decimal values of .0005 and over are rounded to the next highest 3 place value, .004 or less rounded to the next lowest 3 place value.

Review Questions For Section 10- Calibration

Write answers to the following questions and then compare your answers with those in the back of this manual.

1. Why is it important to calibrate pesticide application equipment?

2. A formulated pesticide is the mixed pesticide spray solution that is ready to apply. (True or False)

3. If a pesticide label rate is one tablespoon of formulated product per gallon of water, how much formulated product would you need if you had to treat seven plants and you used 1/3 of a gallon of water when you test sprayed a sample plant?

4. You need to treat 750 ft^2 of an interior landscape with a pesticide that has a label rate of one ounce per 1000 ft^2. When you practiced spraying water on a 500 ft^2 test plot you applied .75 gallons of water.

    a. Determine your sprayer's application rate per 1000 ft^2.

    b. At your application rate, how much water will you spray over the 750 ft^2 interior landscape area?

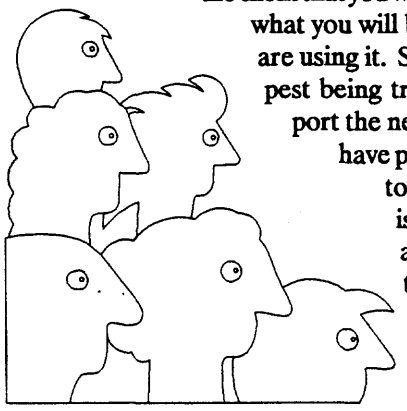
    c. How much formulated product is needed to treat the 750 ft^2 at the label rate? Give your answer in tablespoons and in ounces.

Section 11

PUBLIC RELATIONS

Pesticide applications on ornamental plants in public areas is a highly sensitive topic. Be prepared to discuss the risks and benefits associated with pest management measures.

Before any pesticide treatments are made, it is good practice for you or the account manager to always inform the client that you will be using a pesticide, what you will be using and why you are using it. Showing the client the pest being treated may help support the need for the action you have prescribed. According to Regulation 637, there is specific information and notification practices that you are obligated to provide your customer pertaining to your pesticide application. Be familiar with his regulation and follow the practices legally expected of you.



Realize the client and others may have different perceptions about your application. It is vital to accept their concerns and emotions as valid. Recognize you have chosen to become a professional pesticide applicator, you have considered your practices, you understand and you are familiar with the **hazards** (for example, pesticides are hazardous substances) and accept the **actual** risk (potential for injury or damage from using a pesticide.) However, when the public experiences risk for the first time or a new perception of risk, they respond with emotion. For them, their exposure to your pest management practice is **involuntary**. When people choose to take a risk, the risk is more acceptable. For example, when a person chooses to drive a car there are inherent risks, yet, this is a voluntary action and does not provoke the same fears or emotions as when they are subjected to a risk they did not choose. The public is also **unfamiliar** with the substances that you have become familiar with as a pesticide applicator. This unfamiliarity causes emotional responses to be even greater.

Communicating with your client **before** a pesticide application will help reduce uncertainties:

1. Be informative and professional.

2. Let the client know you understand and share his/her concerns about chemical usage.

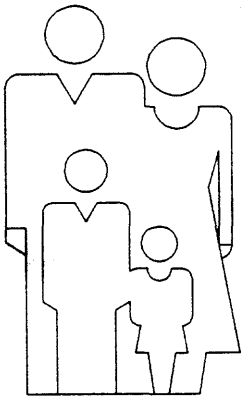
3. Explain that you are...
   * using a product labeled for use in an interiorscape.
   * using the safest product to get the job done.
   * treating with a product that has both the plant and pest listed on the label.

4. Be prepared to answer several questions. Avoid technical language, talk as simply and directly as possible.

5. If appropriate, remind the client that treatments for insects and diseases are included in the service contract.

6. Minimize the client's anxieties by emphasizing you will treat the plants in a separate location and/or after business hours when possible and appropriate.

Being prepared and knowledgeable about the pesticides you are using, the plants, their pests and their environment allows you to answer questions accurately. Effective communication will enhance your professional image, building your clients confidence in you and your company. If you cannot answer a question **never** make up an answer, rather, refer the person to a resource or reference, your supervisor or someone who can give them the correct information.



Section 11 - Public Relations

Write answers to the following questions and then compare your answers with those in the back of the manual.

1. In order to reduce the chance of public hysteria, never discuss the risks associated with your pesticide application. (True or False)

2. Which of the following obligates you to provide specific information about your pesticide application and notification to your customer?

   a. FIFRA

   b. Cooperative Extension Service

   c. MIOSHA

   d. Regulation 637

3. When talking with concerned citizens about your pesticide application you should use technical language associated with your line of work to demonstrate you are competent with the task at hand. (True or False)

4. Which of the following causes people to respond with emotions to your pesticide application?

   a. Experiencing the risk of potential pesticide exposure for the first time.

   b. Being unfamiliar with the product and procedure you are using.

   c. Being involuntarily exposed to your pesticide treatment.

   d. All of the above.

5. When confronted with questions about your pesticide application, which of the following should be done?

   a. Avoid their inquiries by telling them you are a certified pesticide applicator and are qualified to do the job, not to worry.

   b. Explain you are using a product labeled for use in interiorscapes.

   c. If available, provide written information about the product you are using such as MSDS sheets or a copy of the label.

   d. b and c

Section 12

RESOURCES

You may wish to purchase some of these resources to use as á reference for your work. Those identified as Extension Bulletins may be ordered from the Michigan State University Extension Bulletin Office (517-355-0240).

Pesticide Product Information

Agricultural Chemicals Book I - Insecticides, Acaricides and Ovicides. W. T. Thomson.

Agricultural Chemicals Book II - Herbicides. W. T. Thomson.

Agricultural Chemicals Book III - Fungicides. W. T. Thomson.

Tree, Turf and Ornamental Pesticide Guide. W. T. Thomson.

The Insecticide, Herbicide, Fungicide Quick Guide. B. G. Page and W. T. Thomson.

Herbicide Handbook of the Weed Science Society of America.

The 1991 Pesticide Directory: A Guide to Producers and Products, Regulators, Researchers and Associations in the United States. Lori Thompson Harvey and W. T. Thomson. (Updated annually)

Farm Chemicals Handbook. Richard T. Meister, editor. (Updated annually)

Pesticide Use and Safety

Safe Use of Pesticides in Interiorscapes, A Video Training Program. Interior Plantscape Division of the Associated Landscape Contractors of America. Available on a check-out basis from Agricultural Extension Education (AEE), Room 10A Agriculture Hall, Michigan State University, East Lansing, MI 48824 (517) 353-3175.

Fundamentals of Pesticides - A Self Instruction Guide. Dr. George W. Ware.

SARA Title III: The Farmer's Responsibilities under the Emergency Planning and Community Right-toKnow Law. Extension bulletin #E2173.

Natural Controls

The Encyclopedia of Natural Insect and Disease Control. Roger Yepsen, editor.

Biological Pest Mangement For Interior Plantscapes, 2nd edition. Marilyn Y. Steiner and Don P. Elliot. Alberta Environmental Centre.

Bio Integral Resource Center (BIRC), P.O. Box 7414, Berkeley, CA 94707

Praxis (distributor of biocontrols), Box 134, Allegan, MI 49010 (616)673-2793

Pest Management-General

MSU Plant and Pest Diagnostic Clinic
138 Plant Biology Building
Michigan State University
East Lansing, MI 48824-1312
(517)355-4536

Indoor Plants. George B. Briggs and Clyde L. Calvin. 1987, John Wiley & Sons, Inc.

A Pictorial Atlas of Foliage Plant Problems. Edited by Richard W. Henley, published by Central Chapter, Florida Foliage Association, 1983.

Plant Identification

Guide To Interior Landscape Specifications, 4TH Edition, 1988. The Interior Landscape Division of Associated Landscape Contractors of America.

Exotic Plant Manual, 4th Edition, Roehrs Company Publisher, East Rutherford, New Jersey, 1976.

Plant Care and Maintenance

Interior Plantscapes; Installation, Maintenance, and Management, Second Edition. George H. Manaker. Prentice-Hall, Inc. Englewood Cliffs, New Jersey 07632.

Indoor Plants. George B. Briggs and Clyde L. Calvin. 1987, John Wiley & Sons, Inc.

Conover, Charles A. *Acclimatization of Foliage Plants.* Horticulture Research Institute, 1250 I Street, NW, Suite 500, Washington, DC 20005. (202-789-2900) 1985. 7 pages.

Rice, Laura Williams and Robert P. Rice, Jr. *Practical Horticulture.* Reston Books Prentice-Hall, Englewood Cliffs, New Jersey 07632, 1986.

Professional Resources

Interior Landscape Industry, Published by the American Nurseryman Publishing Company. 111 N. Canal St., Suite 545, Chicago, Illinois, 60606. 1-800-621-5727.

When a Crisis Strikes, a videotape with accompanying workbook produced by DowElanco. Available through Agricultural & Extension Education (AEE)Room 10A Agriculture Hall, Michigan State University, East Lansing, MI 48824 (517) 353-3175.

Professional Organizations

Associated Landscape Contractors of America
405 N. Washington Street, Suite 104
Falls Church, VA 22046
(703) 241-4004 *FAX (703) 532-0463

National Council for Interior Horticultural Certification (NCIHC)
405 N. Washington St.
Falls Church, VA 44046
(703) 241-4007

Answers to Review Questions

Section 1 - Introduction

1. If plants are healthy they reflect a positive image on a business and attract people to the business. When plants are poorly maintained it may cause people to misjudge the level of service, quality of food, professionalism and cleanliness of the business establishment.
2. True
3. Horticultural knowledge, public relations skills, ability to perform cultural and mechanical practices including the application of pesticides.
4. True
5. No. This manual must accompany the Commercial and Private Pesticide Applicator Core Manual, bulletin number E-2195 (or the most current edition).

Section 2 - Laws and Regulations

1. d
2. d
3. c
4. d
5. c
6. True
7. One year
8. d
9. True

Section 3 - Care of Indoor Plants

1. True
2. To allow for physiological changes that reduce plant stress when plants are transferred from a production setting to an indoor landscape setting.
3. 1,000-3,000 footcandles; 100-1,000 footcandles
4. Pest and disease-free, well drained, well aerated, resistant to breakdown and compaction.
5. Light levels and the type of plant
6. True
7. Over-watering causes nutrients to be leached from the potting media, suffocates the roots by filling the pore spaces with water and eliminating the oxygen, stresses roots and predisposes them to diseases.
8. False
9. True
10. d

Section 4 - Integrated Pest Management

1. c
2. b
3. d
4. True
5. True
6. False; low relative humidity and high temperatures
7. a
8. d
9. e

Section 5 - E-2018, *Houseplants: Common Insects & Diseases*

1. True
2. Aphids, mealybugs, scale and whiteflies; they have sucking mouth parts.
3. Aesthetically and they can prevent water and air from penetrating the soil.
4. True

5. Honeydew excreted from insects.

6. c

7. c

Section 6 - Management of Insects and Mites

1. d

2. Knowing what life stage does the damage, knowing what life stage is present, and knowing what life stage is vulnerable to your management strategy.

3. High humidity and excessive watering.

4. By bringing infested plants into the site.

5. 8

6. False

7. By bringing infested plants into the site.

8. Identify the insect and determine if it is causing damage.

9. False

10. d

11. False

12. Reduced pesticide use and inventory, elimination of chemical injury to plants, less likelihood of a pesticide resistance build-up, fewer public concerns and improved personal expertise in working with biological control agents.

13. True

14. True

15. Predators

Section 7 - Diseases of Indoor Plants

1. d

2. Susceptible host plant, a pathogen, favorable environment. These components are interrelated and must all be present for a disease to develop and infect. The condition of these disease triangle components determines how severe the disease will become.

3. False. Diseases are usually a result of more than one cause.

4. Watering

5. 55 degrees F

6. Discoloration, loss of foliage, poor growth, brown and water-soaked areas, plant death, collapse of flower clusters, plant bending and leaf curl.

7. d

8. f

9. e

10. True

11. Isolate the plant and send in a sample to a diagnostic lab for analysis. Destroy the plant if necessary.

12. *Pythium* sp. and *Phytophora* sp. They have a spore stage that is adapted to spread by swimming in water.

13. d

14. True

15. Prevention

Section 8 - Pesticide Selection

1. The pesticide label.
2. e
3. True
4. Young children
5. True
6. e
7. d

8. A chemical added to a pesticide principally to increase its effectiveness.

9. True
10. Material Safety Data Sheets provide information about the pesticide including toxicity, first aid, personal protection, etc.

11. Degradation of the pesticide, containers and labels; fumes; potential for spills; changes in label uses, etc.
12. f

Section 9 - Pesticide Application Procedures

1. Select the safest product available to get to get the job done; the pesticide is labelled for use on the host plant and for the pest you are trying to manage; consider the life stage of the pest and its vulnerability to the product; consider the odor of the product and residues.

2. Phytotoxicity is the damage caused to plants as a result of a pesticide application. Damage includes burnt leaf tips, margins or entire leaves, chlorosis, abnormal growth, stunting, bronzing of leaves, death of rapidly growing tissue, etc.

3. Plants were stressed, wilted, high temperature conditions, excessive sunlight, wrong pesticide, pesticide mixed or applied incorrectly, drift, etc.

4. True

5. If residues are left in the container they are more difficult to remove after drying. Also, the rinse water can be added to your spray solution, thus eliminating a disposal problem.

6. False

7. Until the pesticides have dried or settled and the area is well ventilated.

8. Regulation 637 of the Michigan Pesticide Control Act.

9. The rinse water can be labeled and saved as a diluent for your next mixing of the same pesticide or it can be applied to a legal site (i.e. a plant listed on the label) as long as label rates are not exceeded.

10. Headache, visual disturbances, pin-point pupils or occasionally dilated pupils, increased sweating, salivation and tearing.

Section 10 - Calibration

1. To be sure the correct amount of pesticide is being applied to the target site, to assure adequate coverage and results, to avoid injury to yourself, the plants and the environment.

2. False

3. 2 1/3 Tablespoons *or* 2 Tablespoons plus 1 teaspoon (See table on page 12-2 for conversion)

4. a. $2 \times 500\ ft^2 = 1000\ ft^2$
   $2 \times .75$ gallons = 1.5 gallons, therefore your rate is 1.5 gallons per $1000\ ft^2$

b. $\frac{1.5 \text{ gallons}}{1000\ ft^2} \times 750\ ft^2 = \frac{1125}{1000} = 1.125$ gal

c. $\frac{1 \text{ ounce}}{1000\ ft^2} \times 750\ ft^2 = .75$ ounces of formulated product OR 1.5 tablespoons

Section 11 - Public Relations

1. False
2. d
3. False. Talk as simply and direct as possible.
4. d
5. d

PESTICIDE EMERGENCY INFORMATION

(Please post in an appropriate place)

For any type of emergency involving a pesticide, the following Emergency Information Centers should be contacted immediately for assistance.

Current as of March 1991

HUMAN PESTICIDE POISONING

Eastern Half of Michigan

within the Detroit city proper:
***(313) 745-5711**

within the 313 area code:
***1-800-462-6642**

Poison Control Center

Children's Hospital of Michigan
3901 Beaubien
Detroit, MI 48201

Western Half of Michigan

within the Grand Rapids city proper:
***(616) 774-7854**

Statewide
***1-800-632-2727**

Blodgett Regional Poison Center

Blodgett Memorial Medical Center
1840 Wealthy, S.E.
Grand Rapids, MI 49506

Upper Peninsula of Michigan

within the Marquette city proper:
***(906) 225-3497**

Upper Peninsula only:
***1-800-562-9781**

U.P. Poison Control Center

Marquette General Hospital
420 West Magnetic Street
Marquette, MI 48955

SPECIAL PESTICIDE EMERGENCIES

Animal Poisoning

Your personal veterinarian:

and/or

Animal Health Diagnostic Laboratory (Toxicology), Michigan State University:
(517) 355-0281

Pesticide Fire

Local fire department:

and

Fire Marshal Division, Michigan State Police:
(517) 322-1924

Traffic Accident

Local police department or sheriff's department:

and

Operations Division, Michigan State Police:
***(517) 336-6605**

Environmental Pollution

Pollution Emergency Alerting System (PEAS), Michigan Department of Natural Resources:
***1-800-292-4706**
(Toll free for environmental emergencies)

For information on pesticide disposal and local pick-up days:

Michigan Department of Natural Resources, Waste Management Division:
(517) 373-2730

* *Telephone Number Operated 24 Hours*

Cooperative Extension Service
Michigan State University
Extension Bulletin AM-37

PESTICIDE EMERGENCY INFORMATION:
Revised by Larry G. Olsen,
Pesticide Education Coordinator, Michigan State University.
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