UK COOPERATIVE EXTENSION SERVICE
UNIVERSITY OF KENTUCKY — COLLEGE OF AGRICULTURE

Pesticide Applicator Training Manual

Interior Plantscape Pest Control

Category 19

Pesticide Safety Education Program
UK College of Agriculture

INTERIOR PLANTSCAPE PEST CONTROL

Living plants are commonly used indoors, primarily for aesthetic purposes. Restaurants, shopping malls, and office buildings use plants to make the indoor environment more pleasing for customers and employees. To maintain healthy interior plants you must have an understanding of the optimal growing conditions for the species of plants involved. These include 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.

Indoor plants are susceptible to attack by many kinds of pests. In addition, the plants often are under great stress due to less than optimal growing conditions. Some plants may be struggling to stay alive and are growing slowly, if at all. These plants may be mistreated, too, such as having coffee, soda pop, or cleaning liquids poured on them. Under these stressful conditions plants are more susceptible to pests and less capable of recovering from an attack.

Treatment options in the interior plantscape are limited and indoor pest control is a highly sensitive issue. Control measures must be safe for humans and for the plants themselves. Pest control can be made safer by selecting pesticides carefully, limiting applications, using lowest practical rates and correcting improper cultural practices that contribute to the problem. 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 insect populations and disease problems at levels where aesthetic and economic losses are tolerable. Rarely is pest eradication a goal nor is it possible. All economically and environmentally sound practices that help prevent or reduce plant injury are used. Integrated pest management incorporates a wide range of pest controls such as resistant plant varieties, cultural practices, mechanical controls, biological controls and pesticides.

The basic components of an IPM program include:

- Regular monitoring and early detection of disorders.
- Proper diagnosis and identification of plant disorders.
- Determination of economic significance.
- Selection of management methods.
- Evaluation of management methods

MONITORING AND DETECTION

Typically, a plantscape manager visits an interior landscape on a regularly scheduled basis. Monitoring for plant pests or poor growing conditions should be an integral part of each visit. While watering, rotating, and cleaning, be alert to general plant health and watch for signs or symptoms of pest infestations. Early detection allows you to manage pests or alter conditions before host plants suffer serious injury. In addition, low levels of pest infestation are typically easier to manage and the use of less toxic management strategies will still be an option. Washing the foliage with a 2 percent 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, approximately 3-inches by 3-inches, have a sticky substance on the surface. Insects that come in contact with the card's sticky surface cannot escape. 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 thrips. Both colors also will attract fungus gnats. Observation of these cards will help to determine what insects are present and show relative changes in numbers from one visit to the next. It is important to write down the numbers and types of insects per card on 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, or after a pesticide treatment.

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, this background information will help in making a diagnosis. Record information useful for planning management strategies:

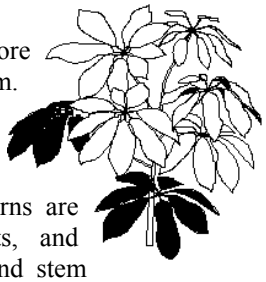
- Level of light (footcandles)
- Plant species
- Plant age and size
- Date of installation
- Size of container
- Type of soil media
- Life stage of the pest
- Type and level of damage
- Date of detection, etc.

DIAGNOSIS AND IDENTIFICATION

When damage or poor plant health is detected, the interior plantscape manager needs to determine what cultural or environmental conditions, diseases, insects, mites, or human activity is responsible. 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 observed. Below is a general guide to common symptoms and possible causes of indoor plant disorders.

Identify the plant



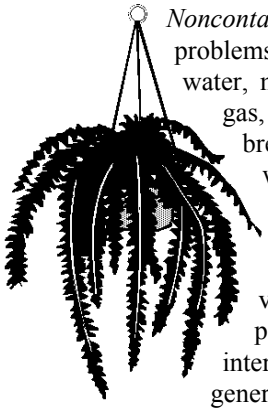
Certain plant species are more prone to specific pest problem. *Ficus* are susceptible to scales, *Schefflera* are susceptible to mealybugs, palms are susceptible to spider mites, ferns are prone to bacterial leaf spots, and *Dracaena* are prone to root and stem rots.. Inspect the whole plant, especially 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 do the symptoms occur on the plant? Are they at random locations, localized, or in a pattern? Are the symptoms that you identify the same as the symptoms your client is concerned about?

Categorize the cause of the problem as contagious or noncontagious

Contagious disorders may be caused by insect or mite infestations or disease



Noncontagious disorders may be caused by problems with light, temperature, humidity, water, media, pH, soluble salts, volatile gas, cleaning compounds, relocating, breakage, food/beverage wastes, watering with excessively cold water

Although fungal, bacterial, and viral infections can be common in production environments, the interior plantscape 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, is perhaps the best control for foliar diseases. Root rots can be a problem for indoor plants but generally only when the roots are first damaged by over- or underwatering or high levels of soluble salts in the soil. Therefore, if a root problem occurs, evaluate watering and fertilizing practices and the drainage of the soil and container.

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, or cleaning compounds?

SELECTION OF PEST MANAGEMENT METHODS

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. For every pest problem consider all available management tactics and evaluate the benefits and risks of each.

Choose methods that are:

- Practical in an indoor setting.
- Least toxic to nontarget organisms.
- Enhance natural controls and plant defenses.
- Likely to limit the pest permanently.
- Least hazardous for the applicator to handle.

Also, as a plant manager, consider the option of removing the plants to be treated from an interior landscape and temporarily relocating them outside or to a greenhouse. Relocating plants makes available a larger selection of products registered for use in those areas (including some that may have been canceled 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 in 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. Record pest counts 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, and special conditions.

A General Diagnostic Guide for Indoor Plants with Symptoms and Possible Causes

Brown or scorched leaf tips

1) Poor root health from overwatering, excessive soil dryness (especially between waterings), excessive fertilizer or other soluble salts in the soil or root rot disease.
2) Specific nutrient toxicities such as fluoride, copper or boron.
3) Low humidity.
4) Pesticide or mechanical injury.

Leaf spots, blotches, blemishes, blisters, or scabby spots

1) Intense light (sunburn) associated with a recent move of the plant or excessive soil dryness and wilting.
2) Chilling injury (below 50° F).
3) Chemical spray injury.
4) Overwatering.
5) Fungal or bacterial infections (not common unless plants have recently come from a field or greenhouse).

Older leaves yellow-green

1) Insufficient fertilizer, especially nitrogen.
2) Poor root health due to pot-bound growth, compacted soil, or poor drainage.
3) Insufficient light.
4) Senescence (natural aging process, individual leaves).

Newer leaves yellow-green

1) Soil pH (acidity) imbalance.
2) Trace element imbalance.

All leaves yellow-green

1) Too much light.
2) Insufficient fertilization.
3) High temperatures, especially when associated with dryness.
4) Insect infestation or root rot disease.

Leaf drop

1) Poor root health from overwatering, excessive dryness or excessive fertilizer or other soluble salts in the soil, compacted soil or pot- bound roots.
2) Sudden change in light, temperature, or relative humidity.
3) Root rot disease.

Wilting or drooping of foliage

1) Poor root health from overwatering, excessive dryness or excessive fertilizer or other soluble salts in the soil, compacted soil, or a poorly drained container or root rot disease.
2) A toxic chemical poured into the soil.

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.

1) Poor root health from overwatering, excessive dryness, excessive fertilizer or other soluble salts in the soil, compacted soil, or a poorly drained container.
2) A toxic chemical poured into soil.
3) Over or underwatering.
4) Root rot disease.

Yellowed leaves with tiny speckling; leaves later bronzed and drying; webbing noted near growing points.

1) Spider-mite infestation.

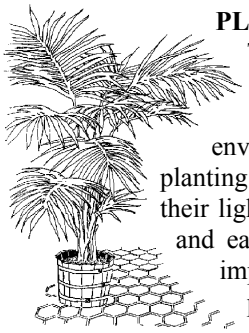
Leaves or stems covered with a sticky substance; mold growing on leaves; tiny brown or white objects seen on leaves or in crotches of branches; leaf drop or branch dieback; leaf or growing point distortion.

1) Scale, aphid, or mealybug infestation.

Material adapted from Michigan State University Extension Bulletin E-2308 Interiorscape Pest Management. A Training Manual for Commercial Pesticide Applicators. Julie Stachecki, Editor.

CHAPTER TWO

PLANT SELECTION AND MANAGEMENT



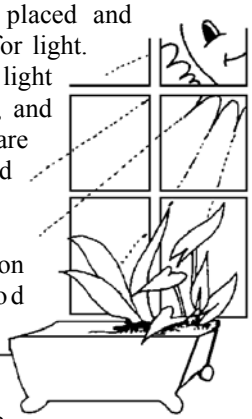
PLANT SELECTION -

The most important step in interiorscaping is the selection of plants matched correctly with the environmental characteristics of the planting site. Plants differ significantly in their light needs, sensitivity to temperature, and ease of maintenance. This, in turn, impacts their susceptibility to pest problems.

Consistent success with indoor plants is most likely to be achieved by:

- Selecting plants that match the conditions of a given interior environment.
- Purchasing high quality plants from a known and reliable source.
- Acclimating the plant before installation by reducing light, moisture, and fertilizer.
- Watering, fertilizing, cleaning, and pruning appropriately.

Light is probably the most important environmental condition and plants should be placed and grouped according to their need for light. Plants grown under correct light conditions are vigorous, compact, and bushy. Color is vibrant, leaves are normal in size, stems are sturdy, and flowering is promoted.



Light helps balance food production (photosynthesis) and food consumption (respiration) by the plant. The rate at which plants make their own food is determined essentially by the quantity and duration of available light. The higher the light level, the greater the supply of food. The rate of food consumption is basically determined by temperature. The warmer the temperature, the greater the demand for food. Therefore, in interiorscapes, the low light and warm temperatures create a high demand for food but a slow rate of production.

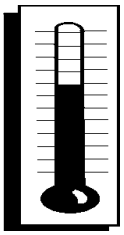
Plants grown at a light intensity below their optimum will have smaller leaves and less vivid color. They often grow more open and leggy, and pruning may be necessary for compact form. They need to be kept drier than those in bright light and fertilized less frequently. A plant that receives significantly less than its required amount of light may survive for several months to a year, while gradually deteriorating in appearance and vigor.

Three factors lower the light requirement for a plant moved indoors. First, the plant's growth slows dramatically or even stops. This growth reduction triggers a lesser demand for food. Second, while the existing leaves cannot change their structure, they can increase their chlorophyll content. Third, the new leaves that are produced in the indoor environment will be structured as shade leaves. This has been shown to result in a reduction in the plant's light compensation point.

The light compensation point is defined as the minimum light level at which the amount of food produced by photosynthesis is equal to the amount of food consumed during respiration. Shade leaves have lower light compensation points than sun leaves. Acclimation to low light involves a reduction in the plant's light compensation point either by changes in leaf metabolism so light energy is captured more efficiently in low light or by replacement of inefficient sun leaves with shade leaves tolerant to low light levels.

Artificial light can be used to supplement or replace natural sunlight. Cool-white fluorescent lights used alone or in combination with warm-light fluorescent lights are the most economical and best all-purpose lamps. Typically, a fixture holding two 40-watt tubes is positioned approximately 12 inches above the plants. Most plants need 12 to 16 hours of artificial light per day for good growth. For large specimen plants, use spot or flood lights to maintain good appearance and accent the plant. Lighting design should take into account anticipated use of indoor plants. Indirect and track lighting are very effective design features for this purpose.

Understanding how a plant reacts to **temperature** stress is important in making adjustments to correct problems and improve plant longevity. In addition to problems caused by chilling, heat from registers can dry out media and foliage quickly. A minimum/maximum thermometer will record temperature differences plants may be experiencing in the interior landscape.



Most public buildings are heated and cooled with human comfort in mind rather than the growth requirements of indoor plants. Fortunately, the desirable temperatures for humans fall within the optimum range for most foliage and flowering plants. Daytime temperatures of 70 to 80°F and a nighttime range of 60 to 70°F are satisfactory for most species. Many flowering plants bloom longer at the lower end of these day-night temperature ranges. Variations in temperature ranges should be considered in selecting plants for the interior environment.

Plants differ in their degree of sensitivity to chilling. Generally, most foliage plants cease to grow at 60°F. Temperatures between 45 and 55° F often result in chilling. Chilling causes changes in cell membrane structure, which,

in essence, causes the cells to "leak" their contents. This causes a loss in plant vigor and reduced growth. The damage may not be visible for months after chilling has taken place. Many times a secondary problem such as disease will begin to increase due to the loss of vigor. This secondary problem is then blamed for the damage, and chilling goes undetected.

Chilling damage is very subtle and may be very difficult to detect unless maintenance personnel are looking for it. Symptoms of chilling injury include:

- Foliage discoloration.
- Poor growth or wilting.
- Foliage bending or curling.
- Flower bud drop.
- Plant death.

The severity of chilling damage is a result of temperature and length of exposure. For example, exposure to 50°F for 12 hours may cause chilling injury as severe as exposure to 40°F for 2 hours. Chilling injury can result from only a few minutes exposure at freezing temperatures. Plants can get chilled in the truck going to a job site, during transfer from the truck to the indoors, and from exposure to cold winds near doorways. The following conditions can contribute to chilling injury in the interior environment:

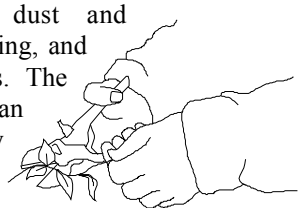
- Shopping malls and public buildings that maintain lower temperatures.
- Air drafts from air conditioning units, doorways, and windows can cause sudden changes in temperature.
- A reduction of temperature in public buildings on weekends and holidays.

MAINTENANCE IN THE INTERIORSCAPE

Once plants have been properly placed, their appearance needs to be sustained through proper maintenance and care. Usually, this is limited to watering, fertilizing, cleaning, and pruning.

Watering indoor plants is a widely misunderstood practice. Water content in the container and plant need for water are difficult to measure accurately. As a result, improper watering is the underlying cause of many plant problems.

Fertilization is necessary for growth and maintenance of plants. A plant's need for fertilizer depends on its growth rate, the amount of leaching that occurs during watering, soil volume, and other factors. Fertilizer levels that were ideal during production can severely damage plants in interiorscapes. Soluble salts in the media can cause root burn when too much fertilizer is applied, when the medium dries out, and when water quality is poor.



Plant cleaning includes dust and water-spot removal, leaf shining, and removal of senescent leaves. The leaves of indoor plants can become coated with a heavy layer of dust in a surprisingly short time. This dust and grime interferes with normal leaf functions and makes the plant less attractive. Accumulated dust will shade the leaves and may so drastically reduce light that the plant will eventually die. Dust with a soft brush or cloth moistened with warm water to clean both upper and lower leaf surfaces at least every two or three months.

Pruning to encourage branching or to remove an entire section of the plant to maintain its intended design or size may be necessary. Pruning may be used to remove insect pests, such as scales, that may accumulate on specific branches.

HAPTER THREE

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, viruses 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 corrective measures. Plants are subject to two types of disorders:

Abiotic or non-infectious disorders; 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 diseases; caused by living pathogenic microorganisms such as fungi, bacteria, viruses, or nematodes. These microorganisms can spread from plant to plant.

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

- Recognize symptoms and signs that indicate the presence of a disease or disorder.
- Accurately identify the cause and type of problem (abiotic or pathogenic or both).

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 may persist for a long period of time. During this time plants are stressed and become more susceptible to pathogenic diseases. For example, if powdery mildew develops on a plant that is usually resistant to this disease, an investigation may reveal that the plant was consistently overwatered, 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 disorders found in an interior landscape.

Environmental Conditions Contributing to Abotic Disorders

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 the development of abiotic disorders.

Typically interior spaces utilized for living or work environments provide temperatures adequate for growing foliage plants. A temperature range between 50 and 90° Fahrenheit 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-conscious society, the thermostat may be set to temperatures that may injure plants when they are exposed over a period of time. Foliage plants can suffer cold damage without freezing. This is referred to as chilling injury. A few plants that are injured by exposure to chilling temperatures between 35 and 50° F for short periods of time include *Aglaonema* X 'Silver Queen', *Dieffenbachia maculata*, *Dracaena* spp. and *Polyscias fruiticosa*. Symptoms of chilling injury include yellowing or brown water-soaked areas on leaves, loss of foliage, poor growth, and wilting.

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, disruptions of these functions may cause stress. Plants may exhibit poor growth and color. These symptoms are easily mistaken for something other than poor environmental conditions.

If plants haven't been adequately acclimatized to the conditions of an interiorscape (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 are more tolerant of environmental stress at the job site. 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 Plant Disorders

Most plant replacements result from a combination of poor environmental conditions and poor cultural practices. Abiotic disorders 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.

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 occur. These are:

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.

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.

Environment: certain environmental conditions favor the infection of the plant by a pathogen. These include temperature, moisture, humidity , soil conditions, light, density of the planting, and location of the plant.

Time is another factor that 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.

Infectious Diseases

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, and propagation of infected stock are conditions more likely to occur in a greenhouse production setting.

Typically, 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 prevents the development of diseases.

When a disease appears in the interior landscape, it is possible that it is a continuation of a situation that began in the greenhouse. The goal of plant growers is 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 fungicide applications are not routine.

The use of fungicides is not always possible 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 labeled for use in the interior landscape are those that are applied to the soil, typically as a soil drench. If a fungicide is labeled for use on the plant(s) and for the pathogen 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, the 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.

Most pathogenic diseases of foliage plants are caused by fungi, bacteria and viruses. Observing symptoms and signs provides clues to the type of pathogen 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.

Any fungicide will only be effective in controlling those specific pathogens listed on its label. Knowing the exact pathogen causing your problem is important. Accurate diagnosis of plant pathogens may require laboratory analysis. A fresh, representative sample produces the most accurate diagnosis. It is best to collect and submit samples early in the week so that the sample does not arrive during a weekend or holiday when there will be time for it to deteriorate. Large samples will generally enable a quick, correct diagnoses. 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. Diagnostic assistance can be obtained from your local Cooperative Extension Service.

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 plant damage is not severe and has been checked by your management procedure the plant may still be attractive enough to remain on site. Root diseases are less likely to be noticed until damage is severe. When an 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 a "target-like" appearance with a faded green halo forming the outermost 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.

Bacteria

Although plant diseases caused by bacteria are less common than fungal diseases, bacterial pathogens can cause some of the most economically damaging diseases. 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:

- Systemic infections which occur in the plant's vascular tissues (water- and nutrient-conducting tissue), and
- 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. Occasionally systemic bacterial diseases may cause 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 band (referred to as a halo) often surrounds the periphery of infected tissues. The yellow region can also be described as chlorotic, meaning the tissue becomes yellow because the chlorophyll has been destroyed. A small slice of the lesion placed in a drop of water may emit a stream of bacteria from the tissue. The water will appear cloudy. 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 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.

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 the 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 to prevent its potential spread is recommended when a virus is discovered.

Symptoms of viral diseases are very diverse. Some viral diseases have symptoms similar to fungal diseases. Symptoms of viral infection include:

- Mosaic patterns on leaves (a mixture of irregularly shaped dark- and light-green areas on the leaf).
- 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 symptoms. If you suspect a virus, isolate the diseased plant and obtain assistance from your local Cooperative Extension office.

Root Diseases

Root rots are the most common disease problem with indoor ornamental plants. Most root rot diseases are caused by fungi.

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. Offcolor or brownish- to-blackish, limp roots often indicate that 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 that may be smaller and fewer than normal, and old leaves that 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 rot fungi involved in root rot disease are the water molds, *Pythium* spp. and *Phytophthora* spp. 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 overwatering, poorly drained media, or water standing in the bottom of the containers induce infection of roots by these fungi. Root damage caused by overfertilization, 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 media 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 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 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* spp., *Cylindrocladium* spp., *Sclerotinia* spp., 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, monitor watering practices closely, and practice good sanitation measures.

Nematodes

Several types of tiny roundworms cause plant diseases on plants used indoors. Lesion nematodes (*Pratylenchus* spp.) and spiral nematodes (*Helicotylenchus* spp.) cause plant stunting and poor growth because their feeding weakens the root system. The root knot nematode (*Meloidogyne* spp.) causes nodules to form on roots, thus impairing root function. This causes stunting. The foliar or spring-crimp nematode (*Aphelenchoides* spp.) 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 can be used as a nematode management tool in a production setting but are not registered for use in interior landscapes.

Material adapted from Michigan State University Extension Bulletin E-2308 Interiorscape Pest Management. A Training Manual for Commercial Pesticide Applicators. Julie Stahecki, Editor.

CHAPTER FOUR

INSECT MANAGEMENT IN THE INTERIORSCAPE ENVIRONMENT

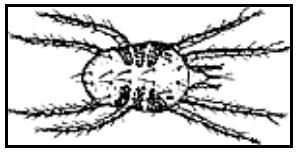
' Interiorscape Mites and Insects

Most pest problems on interiorscape plants originate because the plants were not grown in an indoor environment. Once introduced to the interiorscape, many insects and mites will thrive, and spread to other plants. The key to controlling insects and mites is to remedy the situation before permanent installation of the plants. There is much greater flexibility in control procedures (chemicals, application methods, etc.) in a greenhouse or even an acclimatization room than in the interiorscape.

The importance of early detection and diagnosis of the problem cannot be overemphasized. This is the key to controlling nearly all pests before significant plant injury or control expenses occur. Pesticides and natural enemies will control most insects and mites, if correct procedures are followed.

' Mites

Several mite species attack plants indoors, often causing severe injury. Most common among them is the **two-spotted spider mite**. They have a wide host range, so very few plants are safe from attack. Adult spider mites are about 1/50 inch long and are usually found on lower leaf surfaces. Feeding injury on many plant species involves light-colored, speckled or mottled areas on leaves. Webbing is also produced. Severe spider mite infestations cause leaves to dry and fall from the plant. At 75 F, about two weeks are required for mites to develop from egg to adult.

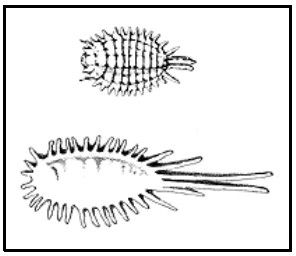


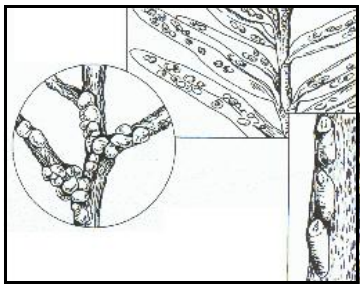
Other important mites include the broad mite and cyclamen mite. Because these mites are about 1/100 inch long, infestations are recognized by plant injury symptoms rather than by seeing the mites. Most feeding injury occurs on young foliage, where injury is characterized by thickened and brittle foliage, with leaf margins cupped downward and stunted. Many of these symptoms are characteristic of injury by pesticides, so infestations can go unnoticed for long periods of time. Since these mites are attracted to dusty conditions, removing dust from the plants with soapy water (which will also remove the mites) will help discourage their presence.

' Insects

Many insects cause injury to plants indoors.

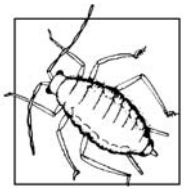
Mealybugs are very common and are difficult to control. Several species can be found on plants indoors, including some that feed on the roots. All foliar-feeding mealybug species have sucking mouthparts that remove plant fluids. A sticky honeydew is excreted, which coats foliage below the infested area, attracts ants, and promotes black sooty mold growth. Damage results in stunted plant growth or death of the plant. Each female mealybug may produce several hundred eggs. The egg-to-adult cycle is 6 to 8 weeks. Moving infested plant material into the interiorscape is virtually the only way mealybugs become established.



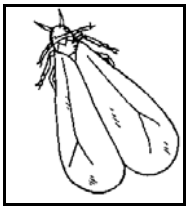


Several species of **scale insects** infest plants indoors, arriving on previously infested plants. One of the most common is the soft brown scale. Scales, like mealybugs, are sap-sucking insects, which also excrete honeydew. Females produce up to 1,000 eggs underneath their protective shell or "scale." The eggs hatch into tiny crawlers, which spread about the plant. After dispersing, crawlers settle and feed in one location for the remainder of their lives. The length of the life cycle varies with each species, ranging from 1 to 8 or more generations per year. Scale damage reduces plant vigor. The honeydew attracts ants and promotes the growth of a black, sooty mold.

Aphids also have piercing-sucking mouthparts and produce honeydew. They are soft-bodied, somewhat pear-shaped insects. Indoors, all aphids are female, reproduce year round, and multiply rapidly. Each mature female may produce up to 50 daughters that, in turn, will begin reproducing in 7 to 10 days. Aphid infestations often are evident by the white cast skins that are shed by the aphids when molting. Aphids reduce plant vigor and distort leaves. The honeydew attracts ants and promotes the growth of a black, sooty mold.

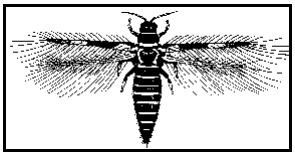


Whiteflies have piercing-sucking mouthparts which they use to suck juices from the plants. They excrete large quantities of honeydew. Whiteflies, especially the greenhouse whitefly, are common pests of many ornamental plants. Indoors, white flies are most likely to be found on



poinsettia, fuchsia, chrysanthemum, or other flowering plants brought into the location for color. All white fly life stages develop on undersides of leaves, but the adult is usually found on the upper leaves. The egg-to-adult cycle takes 21 to 36 or more days, depending on temperature.

Thrips cause problems indoors on both foliage and flowers.



These small, slender insects are less than 1/8 inch long. They feed by rasping plant tissues with their mouthparts and consuming plant fluids. Heavily infested areas on leaves appear silvery gray, with lighter infestations showing up as small whitish-colored areas.

Black dots of excrement also are present. Eggs are laid on or in plant tissues. The egg-to-adult cycle takes 18 to 21 days. Some species of thrips leave the plant and transform to the adult in the growing medium. Thrips are difficult to control indoors. Few insecticides are registered for use on plants indoors that provide effective control, unless the plants are moved to a greenhouse or outdoors prior to treatment.

Fungus gnats are small, dark gray or black flies that resemble midges or mosquitoes. Presence of fungus gnats may indicate an overly wet situation. The flies often get trapped in the moisture on leaf surfaces, which detracts from the plant's appearance. Decreased aesthetic value is the greatest damage done by adult fungus gnats; however, the larvae also damage plants by feeding on decaying or healthy organic matter (including roots) and fungi. Fungus gnats have increased in importance recently because of the prevalence of soil-less mixes in the plant industry. Some of these growing media, especially those that contain peat moss, apparently are excellent for survival of the insects.

' Control

Commercial indoor landscape accounts are perhaps the most difficult areas in which to attempt pest control. Interior plantscapes extend from public conservatories to extensive plantings in homes, hotels, office buildings, restaurants, shopping malls, hospitals, schools, and other environmentally sensitive areas. The use of insecticides in these areas is often greatly restricted because of the sensitivity of the surroundings. In addition, few chemicals are cleared for ornamental plant use in public areas, and public prejudice against pesticide odors can prevent application of pesticides in many situations.

An amazing variety of insects feed on flowering and foliage plants. The routine use of insecticides usually eliminates predaceous insects and mites. However, pests remaining after treatment sometimes tolerate commonly used insecticides. To stay in business, most commercial flower and foliage plant growers must become fairly sophisticated in using various types of pest management practices, insecticide formulations, application equipment, and in rotating insecticides from one chemical group to another.

COMPONENTS OF INTEGRATED PEST MANAGEMENT

' Pesticides

Thorough, timely applications of properly labeled pesticides are another important aspect of an integrated pest control program. Rotating infested plants back into a greenhouse where they can be treated thoroughly and revived in vigor before being returned to the indoor landscape is a sound practice but is often not practical. Treat commercial landscape areas at night, on weekends, or when a minimum number of people are present. The public should not be allowed in the vicinity of treated plants until the pesticide residue on the foliage has dried completely.

' Record Keeping

A written log should be kept of pest type, locality, abundance, and all pesticides applied. Such records can be of long-term benefit as many pests tend to appear at about the same time each year. However, the short-term benefits of written records may be greater. Knowing what pests survive a pesticide application alerts the grower to the possibility of poor timing, poor application, or pesticide resistance in the pest population. A change in strategy, application technology, or type of pesticide can be made before the crops are significantly damaged.

' Biological Control

Interest in biological control in indoor landscapes has expanded in recent years because of restrictions placed on interior plantscape pesticide applications, pesticide costs, poor control with pesticide products, phytotoxicity, and potential human health hazards. To be successful at managing pest problems with biological control agents requires a knowledge of the biology of the pest species, the biological control agent(s), and a great deal of time and commitment. Biological control systems do not look after themselves.

CHAPTER FIVE

PESTICIDE APPLICATIONS IN THE INTERIORSCAPE

Because conditions are so varied in the interiorscape, no single pest control program can be suggested. Chances of success using proper pesticides is possible only when the correct material is applied in the correct manner to a susceptible stage of the pest.

Maintenance or preventative sprays may be applied every one to three weeks, depending upon the pest, time of year, and residual activity of a pesticide. An effective maintenance spray program should control any initial invaders and prevent pest populations from developing. It is much easier to maintain pest-free plants than to control established populations. If a preventative program is not used, it will be necessary to inspect plants closely at frequent intervals and apply control measures before pests reach damaging levels.

' Spray Applications

Many pesticides are broken-down (hydrolyzed) in the spray tank when mixed with water above pH 7. Be aware of the water pH and when above 7 a buffering solution should be added to maintain pH in the 6.5 to 7 range.

Sprays should be applied only to thoroughly wet the foliage. Excessive volume of any pesticide may cause phytotoxicity. Both leaf surfaces, especially the underside, must be sprayed. Proper mixing by adequate mechanical agitation in the spray tank is necessary for best results. For safety and efficacy pesticides should be applied the same day they are mixed with water.

To obtain better coverage and residual persistence of the pesticide, a spreader-sticker may be recommended. Read the container label and use the material at the concentration specified by the manufacturer. If you are using a new spreader-sticker, be careful to evaluate it for any phytotoxic effects.

' Granular Applications

All granular materials should be applied in a manner to insure even distribution over the soil surface. DO NOT apply them to wet foliage. Following surface application of granular pesticides, the soil surface should be watered thoroughly to leach the pesticide into the upper layer of soil. This precaution will make the pesticide quickly available to the plants and position the granules where they are less likely to be contacted by those using the building.

' Compatibility

Spray tank mixtures of insecticides, miticides or fungicides may result in plant injury that does not occur from use of any one of the materials alone. Before materials are tank mixed, a
compatibility chart should be consulted and the manufacturer's label studied carefully.

' Phytotoxicity

Phytotoxicity is generally characterized as damage to foliage, usually exhibited as marginal burn, chlorosis or spotting. Distortion or abnormal growth is also a common symptom of plants injured by pesticides. Although any portion of the plant may be affected, the new growth is most likely to show damage.

Because many plantscapes are usually located adjoining large glass areas, plant damage can be minimized when pesticides are applied during the cooler part of the day. Although wettable powders are considered safer to plants than emulsifiable concentrates, they frequently leave objectionable residues on the foliage.

Read the label for plants that are sensitive to the pesticide. Regardless of the pesticide or mixture of pesticides used, it is strongly recommended that the effects be evaluated on a few plants, under your particular condition before treating all plants. There may be several formulations of a chemical compound available. Concentrations vary and consequently recommendations on the manufacturer's label should be followed explicitly.

' Warning

All pesticides must be handled with caution. Safety precautions, including the use of proper protective equipment, printed on the label must be followed. Be sure pesticides are labeled for interiorscapes and that you have a label in possession. Read the entire label, including the small print, before opening the container. Allow plenty of time after applying pesticides so plants are completely dry before people are present in the area. To prevent contamination of non-target areas (pools, seating and food areas, etc.) use low pressure, spray only to point of glisten and use plastic drop cloths.

Drop cloths used for shielding purposes should be handled carefully to avoid exposure. Store pesticides in their original labeled containers, out of reach of children, irresponsible people, pets, and preferably keep pesticides under lock and key. When containers are empty, rinse with water several times and pour rinsing into spray tank. Dispose of empty containers promptly and safely.