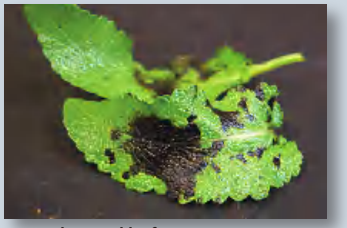
Botrytis

Salvia leaf spot



Diascia bacterial leaf spot

Disease and Arthropod Management in Greenhouse Floriculture

PENNSTATE

College of Agricultural Sciences

Prepared by Gary W. Moorman, professor of plant pathology.

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Disease and Arthropod Management in Greenhouse Floriculture

Contents

Specimens for Disease Diagnosis and Pest Identification

Effective control measures require an accurate diagnosis of the problem. Accurate and rapid diagnosis of poor plant health depends on an examination of specimens that are representative of the problem and a review of information concerning the growing of the crop. Often, you have resources close at hand to assist you. Give a specimen to the Penn State Cooperative Extension educator in your county or your Pennsylvania Department of Agriculture plant inspector, who can often determine the cause of a disease or identify the arthropod. If this is not possible, send the specimen and the cropping information to one of the locations below. If you are uncertain where to send a sample, send it to the Plant Disease Clinic as noted below and it will be directed to the appropriate expert.

For diseases *or* if you are uncertain of where to send the sample:

Plant Disease Clinic
The Pennsylvania State University
220 Buckhout Laboratory
University Park, PA 16802

For insects and mites:

Department of Entomology
ASI Building
University Park, PA 16802

For problems related to growing conditions, fertilization, and so forth:

Department of Horticulture
Tyson Building
University Park, PA 16802

Send a copy of the form in Appendix B (regardless of where you are sending the sample) with as much of the requested information as possible. Send the completed specimen information form in an envelope **attached to the outside** of the package. Any enclosures should be separated from the specimen material by a waterproof barrier such as plastic. Please note in the "Additional Comments" area of the clinic specimen information form if you suspect that the sample being submitted could contain moldy paper containers used in greenhouses or could harbor a select agent (such as Ralstonia solanacearum, race 3, biovar 2) as designated by the United States Department of Agriculture Animal and Plant Health Inspection Service (USDA-APHIS).

When possible, send entire plants, including roots. Leaf yellowing or browning frequently indicates root or stem problems. Enclose the soil ball around the roots in a plastic bag and tie securely around the stem to avoid drying of the roots and sifting of the soil onto the top portions of the plant during transit. If not practical to send entire plants, include affected portions of stems and roots. Place the plant parts in a plastic bag with a **dry** paper towel. **Do not add water to any specimen before shipping it.** Water encourages decay during shipping. It is not likely that an accurate diagnosis can be made if we receive plants in advanced stages of decay or if no supporting information is provided. Enclose the entire specimen in another plastic bag. Use strong containers such as corrugated cardboard boxes or mailing tubes that will not crush in transit when mailing large samples. Fill empty spaces in the mailing cartons with crushed or shredded paper to strengthen the carton and protect the specimens. Mail specimens early in the week to avoid delay in the post office over weekends or holidays. You are encouraged to use an overnight delivery service.

General Concepts in Disease and Arthropod Management

This guide summarizes disease and arthropod management practices for floral and foliage crops. Effective disease and arthropod control is improved when growers implement preventive programs that apply the following principles:

- Eliminate weeds, escaped crop plants, and other plants not being maintained within and around the greenhouse to prevent pathogen and arthropod population buildup, reduce humidity, and improve air circulation.
- Remove plant residues, trash, and other debris from the greenhouse to eliminate some sites that may harbor pathogens and arthropods.
- Disinfest tools, flats, and equipment regularly to reduce the presence of initial pathogen and arthropod populations.
- Grow disease- or arthropod-susceptible cultivars in blocks and frequently inspect these blocks to facilitate the early detection of problems and spot spraying.
- Keep records of what disease and arthropod problems you experience and which cultivars are affected. Also note which cultivars are problem-free.
- Grow disease- and arthropod-tolerant or resistant cultivars to reduce crop losses.

Using Pesticides Safely

General Guidelines for Pesticide Safety

Always read the label!

Only use pesticides when necessary. Before using any pesticide product, always read the label, as it is a legal document. The label provides information on which pests can be controlled, on which crops the pesticide product can be used, and the recommended rates and times of application. Any "off label" use is a violation of both Federal and state laws. Correct use of pesticides is essential to protect human, animal, and plant health as well as to protect the environment. Additionally, proper use will ensure chemical residues on crops and animals do not exceed legal limits (tolerances).

- Before using any pesticide, **read the label**.
- Become familiar with current federal and state pesticide laws and regulations.
- Follow all safety precautions on the label.
- Wear protective clothing and use protective equipment (both are referred to as PPE) according to instructions on the pesticide label.
- Minimum clothing requires long pants, long-sleeved shirt, socks, and shoes. In addition, chemically resistant gloves (nitrile, butyl, or neoprene) and unlined rubber boots should be worn.
- Be careful when handling pesticide materials to avoid spilling on skin or clothing.
- Never eat, drink, smoke, or use tobacco products while applying pesticides.
- When selecting pesticides, consider type of formulation and the application equipment required.
- Avoid drift to nontarget areas, which may endanger other plants or animals. Dusts drift more than sprays and airblast sprayers create more drift than boom sprayers.
- For record-keeping requirements, record the date, time, location, amount of each pesticide used, and any other required information as soon as possible.
- Bathe or shower in hot, soapy water after applying pesticides.
- Wash clothing worn while applying pesticides separate from other laundry, in hot, soapy water. Contaminated clothing must be handled with the same precautions as the pesticide itself.

Pesticide Toxicity

For all pesticides to be effective against the pests they are intended to control, they must be biologically active, or toxic. Because pesticides are toxic, they are also potentially hazardous to humans and animals. Any pesticide can be poisonous or toxic if absorbed in excessive amounts. Pesticides can cause skin or eye damage (topical effects) and can also induce allergic responses. However, if used according to label directions and with the proper personal protective equipment (PPE), pesticides can be used safely. For this reason, people who use pesticides or regularly come in contact with them must understand the relative toxicity and the potential health effects of the products they use.

The risk of exposure to pesticides can be illustrated with the following simple equation:

Hazard of Pesticide Use = Toxicity x Actual Exposure

Toxicity is a measure of the ability of a pesticide to cause injury, which is a property of the chemical itself. Pesticide toxicity is determined by exposing test animals to different dosages of the active ingredient. Tests are also done with each different formulation of the product (for example, liquids, dusts, and granulars). By understanding the difference in toxicity levels of pesticides, a user can minimize the potential hazard by selecting the pesticide with the lowest toxicity that will control the pest.

Applicators may have little or no control over the availability of low-toxicity products or the toxicity of specific formulated products. However, exposure can be significantly reduced or nearly eliminated by using personal protective clothing and equipment (PPE). For example, over 90 percent of all pesticide exposure comes from dermal exposure, primarily to the hands and forearms. By wearing a pair of chemically resistant gloves, this exposure can be reduced at least 90 percent. Therefore, by wearing the correct PPE, the hazard of pesticide use can be reduced to an insignificant level for the applicator.

Acute Toxicity and Acute Effects

Acute toxicity of a pesticide refers to the chemical's ability to cause injury to a person or animal from a single exposure, generally of short duration. The four routes of exposure are dermal (skin), inhalation (lungs), oral (mouth), and eyes. Acute toxicity is determined by examining the dermal toxicity, inhalation toxicity, and oral toxicity of test animals. In addition, eye and skin irritation is also examined.

Acute toxicity is usually expressed as LD_{50} (lethal dose 50) or LC_{50} (lethal concentration 50). This is the amount or concentration of a toxicant required to kill 50 percent of a test population of animals under a standard set of conditions. LD_{50} values of pesticides are recorded in milligrams of pesticide per kilogram of body weight of the test animal (mg/kg), or in parts per million (ppm). LC_{50} values of pesticides are recorded in milligrams of pesticide per volume of air or water (ppm). To put these units into perspective, 1 ppm is analogous to 1 inch in 16 miles or 1 minute in 2 years.

The LD_{50} and LC_{50} values are found in the product's Material Safety Data Sheet (MSDS), which is available from the supplier or product manufacturers when pesticide products are purchased. Most are also available from various online sources, including the manufacturer's Web site or through various search engines as listed on our Web site at http://www.pested.psu.edu/resources/web/labels.shtml. For many reasons, especially in an emergency situation, maintaining a file with copies of the label and MSDS for each pesticide product used is highly recommended.

The LD_{50} and LC_{50} values are useful in comparing the toxicity of different active ingredients as well as different formulations of the same active ingredient. The lower the LD_{50} value of a pesticide, the less it takes to kill 50 percent of the test population, and therefore the greater the acute toxicity of the chemical. Pesticides with high LD_{50} values are considered the least acutely toxic to humans when used according to the directions on the product label.

Signal Words

Acute toxicities are the basis for assigning pesticides to a toxicity category and selecting the appropriate signal word for the product label. Pesticides that are classified as "highly toxic," on the basis of either oral, dermal, or inhalation toxicity, must have the signal words **DANGER** and **POISON** (in red letters) and a graphic of a skull and crossbones prominently displayed on the package label. **PELIGRO**, the Spanish word for danger, must also appear on the label of highly toxic chemicals. Acute oral LD_{50} values for pesticide products in this group range from a trace amount to 50 mg/kg. An exposure of a few drops of a highly toxic material taken orally could be fatal to a 150-pound person.

Some pesticide products are labeled with the signal word **DANGER** without the skull and crossbones symbol. A **DANGER** signal word does not provide information about the LD_{50} value of the chemical. Instead, this signal word alerts the user of potentially more severe skin or eye effects from the product (caused by its irritant or corrosive properties).

Pesticide products considered "moderately toxic" must have the signal words **WARNING** and **AVISO** (Spanish) displayed on the label. Acute oral LD_{50} values range from 50 to 500 mg/kg. An exposure of 1 teaspoon to 1 ounce could be fatal to a 150-pound person.

Pesticide products classified as either "slightly toxic or relatively nontoxic" are required to have the signal word **CAUTION** on the pesticide label. Acute oral LD_{50} values are greater than 500 mg/kg.

Chronic Toxicity and Chronic Effects

Any harmful effects that occur from repeated small doses over a period of time are called chronic effects. The chronic toxicity of a pesticide is determined by observing symptoms of test animals, which result from long-term exposure to the active ingredient.

Some of the suspected chronic effects from exposure to certain pesticides include birth defects (teratogenesis); fetal toxicity (fetotoxic effects); production of tumors (oncogenesis), either benign (noncancerous) or malignant (cancerous/carcinogenesis); genetic changes (mutagenesis); blood disorders (hemotoxic effects); nerve disorders (neurotoxiceffects); and reproductive effects. The chronic toxicity of a pesticide is more difficult to determine through laboratory analysis than is acute toxicity. The product's MSDS also contains information regarding chronic symptoms of pesticide exposure.

Symptoms of Pesticide Poisoning

The symptoms of pesticide poisoning can range from a mild skin irritation to coma or even death. Different classes or families of chemicals cause different types of symptoms. Individuals also vary in their sensitivity to different levels of these chemicals. Some people may show no reaction to an exposure that may cause severe illness in others. Because of potential health concerns, pesticide users and handlers must recognize the common signs and symptoms of pesticide poisoning.

The effects, or symptoms, of pesticide poisoning can be broadly defined as either topical or systemic. Topical effects generally develop at the site of pesticide contact and are a result of either the pesticide's irritant properties (either the active and/or inert ingredient) or an allergic response by the victim. Dermatitis, or inflammation of the skin, is accepted as the most commonly reported topical effect associated with pesticide exposure. Symptoms of dermatitis range from reddening of the skin to rashes and/or blisters. Some individuals exhibit allergic reactions when using pesticides or when these materials are applied in or around their homes or places of work. Symptoms of allergic reactions range from reddening and itching of the skin and eyes to respiratory discomfort often resembling an asthmatic condition.

Systemic effects are quite different from topical effects. They often occur away from the original point of contact, as a result of the pesticide being absorbed into and distributed throughout the body. Systemic effects often include nausea, vomiting, fatigue, headache, and intestinal disorders.

Seeking prompt medical attention is important; however, the development of certain symptoms is not always the result of exposure to a pesticide. Common illnesses such as the flu, heat exhaustion or heat stroke, pneumonia, asthma, respiratory and intestinal infections, and even a hangover can cause symptoms similar to pesticide exposure. Carefully consider all possible causes of your symptoms.

Responding to Pesticide Poisoning Symptoms

Be alert for the early symptoms of pesticide poisoning. Responding immediately and appropriately when pesticide exposure is suspected will help minimize the effects of exposure and, in extreme cases, may save a life. If you are having symptoms but are unsure if they are pesticide related, at least notify someone in case your symptoms become worse. At this time, call the National Poison Center at 1-800-222-1222 for guidance on the proper response to your symptoms. This number will direct your call to the nearest poison center, which is staffed on a 24-hour basis.

If safe to do so, take the pesticide container to the telephone. (However, if the pesticide container is contaminated, write down the product name and percentage of active ingredients, and take that to the phone.) The product label provides medical personnel information such as active ingredients, an antidote, and an emergency contact number for the manufacturer of the product. If you must go to the hospital or doctor's office, take the entire container, including the label, with you. In order to avoid inhaling fumes or spilling the contents, make sure the container is tightly sealed and never put it in the enclosed passenger section of a vehicle.

If the Material Safety Data Sheet (MSDS) is available, take this with you also because it frequently contains additional information for medical personnel. In addition to posting emergency numbers or having them readily available by a telephone, keep these numbers in all service vehicles involved in transporting pesticides. Additional pesticide information can also be obtained by contacting the National Pesticide Information Center (NPIC) located at Oregon State University at 1-800-858-7378. The NPIC provides a variety of unbiased information about pesticides to anyone in the United States. (Medical professionals and government agencies can call NPIC at 1-800-858-7377.)

First Aid for Pesticide Poisoning

Reviewed by J. Ward Donavon, medical director of PinnacleHealth Toxicology Center, Harrisburg Hospital

Immediate and appropriate action, such as providing first aid, may be necessary to prevent serious injury to a victim of pesticide poisoning. The situation can be a life-or-death matter. The product label should be one of the first sources of information in a pesticide exposure emergency, in addition to calling the National Poison Center (1-800–222-1222) and 911. **First aid is only the "first response" and is not a substitute for professional medical help.**

General First Aid Instructions

- Most important, be sure to protect yourself by wearing appropriate protective clothing and equipment if there is a likelihood of being directly exposed to a pesticide while administering first aid or removing the victim from an enclosed area.
- Have current labels and Material Safety Data Sheets (MSDS) available.
- Have emergency response telephone numbers readily available.
- Assemble a first aid kit with necessary supplies.
- Always have a source of clean water available. In an extreme emergency, even water from a farm pond, clean water irrigation system, or watering trough could be used to dilute the pesticide.
- If oral or dermal exposure has occurred, the first objective is usually to dilute the pesticide and prevent absorption.
- If inhalation exposure occurs, first protect yourself, and then get the victim to fresh air immediately.
- Never give anything orally to an unconscious person.
- Become familiar with the proper techniques of artificial respiration; it may be necessary if a person's breathing has stopped or become impaired.

Specific First Aid Instructions

If the victim **IS NOT** breathing:

FIRST: Evaluate the surroundings of the victim. Protect yourself from pesticide exposure prior to and while giving assistance.

SECOND: Administer artificial respiration and call 911.

THIRD: Call National Poison Center (1-800-222-1222).

FOURTH: Decontaminate the victim immediately; wash thoroughly and quickly. Speed is essential.

If the victim **IS** breathing:

FIRST: Evaluate the surroundings of the victim. Protect yourself from pesticide exposure prior to and while giving assistance.

SECOND: Decontaminate the victim immediately; wash thoroughly and quickly. Speed is essential.

THIRD: Call 911 if the victim has ill effects from the exposure.

FOURTH: Call the National Poison Center (1-800-222-1222).

If the pesticide has been spilled on the skin or clothing, remove any contaminated clothing immediately and thoroughly wash the skin with soap and water. Avoid harsh scrubbing, as this enhances pesticide absorption. Rinse the affected area with water, wash again, and rinse. Gently dry the affected area and wrap it in a loose cloth or blanket, if necessary. If chemical burns of the skin have occurred, cover the area loosely with a clean, soft cloth. Avoid the use of ointments, greases, powders, and other medications unless instructed by medical personnel.

Heavily contaminated clothing should be disposed of properly. If clothing is not heavily soiled, wash all contaminated clothing separately from any other laundry in hot water, at a high water level, and with a heavy duty liquid detergent. Run the washer through a complete cycle with detergent and no clothes to remove pesticide residue before another wash. Store washed protective clothing separately from other clothes. Also, do not store protective clothing and equipment in pesticide storage areas.

If the pesticide has entered into the eyes, hold the eyelid open and immediately begin gently washing the eye with clean running water. Do not use chemicals or drugs in the eye wash water. Continue washing for 15 minutes. If only one eye is involved, avoid contaminating the other one. Flush under the eyelids with water to remove debris. Cover the eye with a clean piece of cloth and seek medical attention immediately. If contact lenses are worn, remove and discard the contacts, then wash the eyes as described above.

If the pesticide has been inhaled, get the victim to fresh air immediately. However, do not attempt to rescue someone who is in an enclosed area unless you are wearing appropriate protective equipment. Have the victim lie down and loosen their clothing. Keep the victim warm and quiet. If the victim is convulsing, watch their breathing and protect their head. Keep the chin up to keep air passages free for breathing. If breathing stops, administer artificial respiration and call 911. Call the National Poison Center (1-800-222-1222) after the victim is stabilized for further advice.

If the pesticide has been swallowed, contact the National Poison Center (1-800-222-1222) and provide them with the name and approximate amount of material that was ingested. Call 911 immediately if the victim has symptoms from the exposure. If the pesticide has entered the mouth but has not been swallowed, rinse the mouth with large amounts of water. *Inducing vomiting is rarely advised for any poisoning, including pesticide poisonings.*

If a petroleum product (kerosene, gasoline, oil, lighter fluid, EC pesticides) **has been swallowed,** call the National Poison Center (1-800-222-1222) and 911 immediately for further instruction.

If a corrosive poison (a strong acid or alkali) **has been swallowed,** dilute with water or milk immediately. Consult the National Poison Center (1-800-222-1222) and 911 immediately. The victim may experience severe pain and have extensive mouth and throat burns. Fortunately, most commonly used pesticides are not corrosive, but some household disinfectants and germicides fall into this category.

Safe Storage of Pesticides

- Read the label for specific storage instructions and precautions.
- Store pesticides in a clean, cool, dry, and well-ventilated building. Always lock the area to prevent entry by children and untrained persons. Mark the storage facility with an appropriate warning sign.
- Maintain proper temperature control. For example, if emulsion-type materials freeze, the emulsion may be destroyed, resulting in loss of effectiveness and possible serious plant injury.
- To avoid the danger of cross-contamination, do not store herbicides with other pesticides.
- Keep dry materials above liquid materials.
- Do not store pesticides where food, water, feed, seeds, fertilizers, or personal protective clothing and equipment (such as respirators) can become contaminated.
- Store pesticides in their original containers. Never store pesticides in any food or drink containers.
- Do not remove the labels.
- Keep lids tightly closed.
- Check containers frequently for leaks.
- Clean up spilled chemicals promptly and properly. Dispose of broken or damaged containers and any pesticide waste in an approved and safe manner as directed on the product label.
- Keep an inventory of all chemicals. Mark each container with the year of purchase.
- Inform your local fire department of any chemicals (including fertilizers) stored in large quantity.

Safe Disposal of Pesticides

- Read the pesticide label for specific disposal instructions.
- Avoid disposal problems by purchasing only the amount of material needed for one growing season. Do not stockpile.
- Use proper personal protective clothing and equipment when you dispose of pesticide wastes and containers.
- Mix only the amount of pesticide required for a particular application. If you mix too much, use the surplus by applying the material at the recommended rate to one of the crops listed on the label.
- Do not dump pesticides or pesticide rinsates on the ground or pour them down sinks, toilets, or other drains, including storm sewers.
- Pressure rinse or triple rinse empty pesticide containers with water and pour the rinse water into the spray tank. Drain 30 seconds each time.
- After rinsing metal, plastic, or glass containers, puncture, break, crush, or in some way render unusable. Recycle plastic containers through the Plastic Pesticide Container Recycling Program sponsored by the Pennsylvania Department of Agriculture (PDA). Contact your regional PDA office for further information. Disposal in a sanitary landfill is desirable if conducted in accordance with local regulations.
- If stated on the label and permitted by local ordinances, combustible containers can be burned. However, do not burn pesticide containers near residential areas or where the smoke can contact humans. Avoid exposure to the smoke; it may contain toxic vapors. Bury the ashes, since they also may be toxic.
- Send large metal drums to a reconditioning company.
- Before disposing of pesticide concentrates, check with PDA's CHEMSWEEP Program, which provides disposal options for unwanted and outdated pesticide concentrates free of charge.
- Do not reuse empty pesticide containers for any purpose.
- Clean up thoroughly after handling and disposing of pesticides.

Current Status of Restricted-Use Pesticides In Pennsylvania

Under the authority of the amended Pennsylvania Pesticide Control Act of 1973 and the amended Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), applicators who apply restricted-use pesticides (RUP) in the production of an agricultural crop must be certified as a private applicator or must work under the direct supervision of a certified applicator. Furthermore, only certified applicators can purchase restricted-use pesticides. The pesticide dealer is required by law to record the name, address, and certification number of the purchaser of RUPs, as well as the identity of the product, amount sold, and date of purchase. Commercial and public pesticide applicators must be certified to use both general and restricted use pesticide products.

The official list of Pennsylvania's RUPs includes all pesticide products designated as restricted-use by the U.S. Environmental Protection Agency, and, in the interest of the public health and welfare of the citizens of the Commonwealth, any other product designated for restricted-use by the secretary of agriculture, Commonwealth of Pennsylvania. If a pesticide is restricted-use it will be clearly marked on the label. In this guide, restricted-use pesticides are denoted by †.

Worker Protection Standard for Agricultural Pesticides

In 1992, the U.S. Environmental Protection Agency (EPA) revised its Worker Protection Standard (WPS), which addresses the protection of agricultural workers from pesticide exposure (40 CFR Part 170). The WPS includes requirements designed to reduce the risks of illness or injury to agricultural workers and pesticide handlers from occupational or accidental exposure to pesticides in the production of agricultural plants on farms and in nurseries, greenhouses, and forests.

The WPS expands the scope of prior worker protection regulations to identify two types of agricultural employees:

- **pesticide handlers**—those who handle agricultural pesticides (mix, load, apply, clean or repair contaminated equipment, act as flaggers, etc.), and
- **agricultural workers**—those who perform tasks related to the cultivation and harvesting of plants on farms or in greenhouses, nurseries, or forests where pesticides are used.

The WPS holds growers/employers responsible for compliance. The regulations expand requirements for the employer to make sure that employees are provided with the following:

- Warnings about pesticide applications
- Clean and properly maintained personal protective equipment (PPE), which employers must ensure is used
- Restrictions on reentry by personnel to treated areas (all pesticides used on farms and in forests, nurseries, and greenhouses have specific restricted entry intervals (REI's) that are listed on the label under the "Agricultural Use Requirements" section)
- Decontamination facilities
- Pesticide safety training and information
- Notification of pesticide applications and information about the pesticide(s) used
- Maintained contact with handlers when applying highly toxic pesticides
- Emergency assistance when required
- A pesticide safety poster placed in an area where it can be seen easily by all workers and handlers
- Information for pesticide handlers and early-entry workers about pesticide label safety information
- A centrally located listing of recent pesticide applications on the premises

Under WPS, labels now include statements specifying personal protective equipment, restricted-entry intervals (REIs), and (on some pesticide labels) a requirement to provide both oral warnings and posting of treated areas.

EPA developed these regulations with the non-English-speaking worker specifically in mind. Safety warnings, information, and training must be given in "a manner the worker can understand."

The Pesticide Safety Fact Sheet *EPA Worker Protection Standard for Agricultural Pesticides* describes these requirements in some detail. It is available from the Publications Distribution Center, The Pennsylvania State University, 112 Agricultural Administration Building, University Park, PA 16802; phone 814-865-6713, or online at http://www.pested.psu.edu/resources/facts/.

Disinfesting Equipment and Tools

Avoid contamination of potting soil with weeds, insects, and disease-causing organisms. Avoid transmitting diseases on pruning tools, dibble boards, cutting knives, or other equipment. Tools and equipment used to handle soil or diseased plants should be cleaned and disinfested. Disinfestants should be prepared freshly and discarded after use. All objects should be free of soil before treating.

Material	Application	Target Pests
Steam or Dry Heat	Heat materials to 180–200°F for 30 minutes under a cover to contain the heat.	Bacteria, fungi, insects, nematodes, weeds, viruses
70% Alcohol (grain, rubbing, or wood alcohol)	Dip or swab the object and let dry. Do not rinse.	Bacteria, fungi, nematodes
Sodium Hypochlorite (Clorox* EPA Reg. No. 5813-50)	Mix 1 gal in 9 gal of water. Dip, spray, or brush on and let drain. Rinse metal objects to prevent corrosion.	Bacteria, fungi, nematodes, viruses
Hydrogen Dioxide (ZeroTol*, EPA Reg. No. 70299-1; Terraclean*, EPA Reg. No 70299-5)	Mix as directed by the label. Dip, spray, or brush on or soak tool. Rinsing is not required to prevent corrosion of metal.	Bacteria, fungi, nematodes, viruses
Quaternary Ammonium (Green-Shield*, EPA Reg. No. 499-368; Physan*)	Wash floors, benches, cutting knives, and other impervious surfaces.	Bacteria, fungi, nematodes, viruses

*Trade Name

Disinfesting Soil

The soil or potting medium should be treated to reduce the numbers of weeds, insects, and disease-causing organisms.

Material	Treatment
Steam	Maintain soil temperature between 180 and 200°F for 30 minutes once the entire pile has reached the desired temperature.
Aerated Steam	Maintain soil temperature between 150 and 160°F for 30 minutes once the entire pile has reached the desired temperature.
Dry Heat	Heat small amounts of soil to 180°F and hold for 30 minutes.

Insecticide/Miticide-Fungicide Compatibility

The label is the first piece of information to be considered. Keep records of the mixes used and the reactions of the crops treated. The rule of thumb is that emulsifiable concentrates (ECs) are not mixed with wettable powders (WPs). Before mixing two or more pesticides, read all product labels involved for special instructions. To determine the compatibilities of pest control chemicals, combine the chemicals in a jar to determine whether or not they mix, test the mix on only a few plants, and observe the results.

Mix a small portion in a jar as follows:

1. Put about 1 pint of water in a quart jar.
2. Add the proper amount of each pesticide in the same order that will be followed when the actual spray is prepared. Pesticides are usually added in the following order: (a) wettable powders (WP), (b) flowables (F), (c) water solubles (S), (d) spreader-stickers, and (e) emulsifiable concentrates (EC). Remember that WPs are usually not mixed with ECs.
3. Shake the jar vigorously to thoroughly mix the contents and let stand for 30 minutes. The chemicals are suitable for mixing if
   - materials mix uniformly or only some separation occurs;
   - no sludge or clumps form; and
   - oil disperses.

NOTE: These procedures only mean that the chemicals can be mixed. **They do not mean that the mix is safe or effective to use on the crop! The user assumes all risks of personal injury or crop damage.**

Test the mix on a few plants. Treat only a small portion of the crop on a trial basis. Possible problems with mixing materials or short intervals between application of two materials include the following:

- Combined application may result in phytotoxicity.
- Combined application may result in loss of effectiveness of one or both materials.
- Combinations may be more toxic to the applicator than either material used alone.

Phytotoxicity

Plant injury (phytotoxicity) may occur when chemicals are employed to protect plants from pests, fertilize plants, regulate plant growth, and so on. Phytotoxicity can occur when

- a material is properly applied directly to the plant during adverse environmental conditions;
- a material is applied improperly;
- a spray, dust, or vapor drifts from the target crop to a sensitive crop;
- a runoff carries a chemical to a sensitive crop; or
- persistent residues accumulate in the soil or on the plant.

Symptoms

- Poor germination, especially if a soil drench was used
- Death of seedlings
- Death of rapidly growing, succulent tissues
- Stunting or delayed plant development
- Misshapen or distorted plants, fruits, or leaves
- Russeting or bronzing of leaves or fruit
- Dead spots or flecks on leaves
- Dead leaf tips or leaf margins
- Dead areas between the veins of the leaves

Other Clues

- No signs of plant-pathogenic organisms.
- Injured leaf tissue is sharply defined with little or no color gradation from dead areas into healthy areas.
- Dead spots are of uniform color and may go entirely through the leaf.
- Cropping history indicates that the previous crop or a nearby crop was treated with a chemical to which the injured crop is sensitive.
- Injury occurs over a relatively short period and does not spread from plant to plant.
- Only tissue of a certain age may show damage (only young leaves).
- Plants on ends of rows or ends of benches are the primary ones affected.

Factors That Influence Phytotoxicity

1. Chemical—Certain crops are very sensitive to certain chemicals. Be certain the crop to be treated is listed on the chemical label. Some chemicals are persistent. Repeated applications result in accumulation of the chemical to a toxic level.
2. Formulation—Dusts and wettable powders are generally less phytotoxic than emulsifiable concentrates.
3. Additives (adjuvants) such as spreaders, stickers, and wetting agents may cause injury.
4. Concentrations—Using a chemical concentration higher than the label recommendation or using it more frequently than the label recommends is likely to cause plant injury **and is illegal**.
5. Method of application—Always use the method recommended by the label. Apply the chemical thoroughly and evenly. Spray dripped on the ends of rows or benches when slowing down to begin the next sweep and excessive overlapping result in some plants receiving too much chemical. High-pressure sprays may force chemical into sensitive tissues.
6. Growing conditions:
   a. Temperatures during and after treatments should be moderate. High temperatures favor chlorinated hydrocarbon and sulfur toxicity. Low temperatures favor oil, carbamate, and organophosphate toxicity.
   b. Humidity or plant wetness—Wet foliage at the time of application or prolonged wetness of foliage after spraying can result in injury.
7. Growth stage of plants—Seedlings and fast-growing, succulent plants are usually sensitive to chemical treatment.
8. Mixing incompatible chemicals—This can occur when two materials are deliberately applied as a mix or if a material is applied too soon after a previous material was used.

Overfertilization

Overfertilization of commercial pot- or container-grown crops results in high concentrations of soluble salts in the potting medium, which are damaging to roots directly by slowing the net flow of water into the roots and indirectly by predisposing the plants to certain root diseases and damping-off.

Symptoms and Signs of Overfertilization

- Crust of fertilizer on soil surface
- Yellowing and wilting of lower leaves
- Browning leaf tips and margins
- Browned or blackened limp roots
- Defoliation
- Very slow or no growth
- Death of seedlings

Origin of the Problem

- Adding excessive amounts of soluble fertilizer at one time
- Applying soluble fertilizer several times with little or no leaching
- Using excessive amounts of slow-release fertilizers
- Improperly using a slow-release fertilizer in combination with a soluble fertilizer
- Poorly draining the medium
- Excessively steaming (too hot, too long) the potting mix
- Growing plants under moisture conditions too dry for the fertilization rates employed
- Moving plants from high-fertilization, high-watering, fast-growing conditions to less-rapid growing conditions without first leaching fertilizer that will not be needed by the plant in the new environment

Measuring Soluble Salt Levels

A conductivity meter is used to measure how well a current flows through the solution. The higher the soluble salt concentration, the higher the reading will be. Readings are determined and reported in units of mhos x 10^{-5}/cm or mhos x 10^{-3}/cm (mhos/cm), depending on the instrument used.

100 mhos x 10^{-5}/cm = 1.00 mhos x 10^{-3}/cm = 1.00 mS

The most accurate method of measuring soluble salt concentration is to first make a water-saturated paste of the potting medium. The saturated paste should be so wet that it glistens but not so wet that it puddles. After waiting and stirring intermittently for 1 hour, the liquid is then filtered off with a vacuum apparatus or squeezed out. The conductivity of the saturated paste extract is an accurate measure of the salts to which the roots are exposed.

The most common method of measuring soluble salts is to take a certain weight of air-dried mix and add twice or five times that weight in water. Stir intermittently. Filter or squeeze off the water through cheesecloth. The salt solution in this liquid is more dilute but usually provides an adequate estimate of salt levels. The soil pH can also be measured using liquid from either method.

Acceptable conductivity levels vary from crop to crop (e.g., poinsettias and seedlings are sensitive to high salts while chrysanthemums and zygocactus are relatively tolerant) and from potting medium to potting medium. In general, the upper limit of acceptable readings are as follows:

- **Mixes containing soil:** 100 mhos x 10^{-5} = 1.0 x 10^{-3} (1:5 dilution)
  or 800 to 1,000 mhos x 10^{-5} = 8 to 10 mhos x 10^{-3} (saturated paste)
- **Soilless mixes** (saturated paste or 1:5 dilution): 250 mhos x 10^{-5} = 2.5 mhos x 10^{-3}

Management

- Purchase and routinely use a conductivity meter.
- Record which conductivity readings are consistently associated with high-quality plants and which are associated with plant damage in your potting mix.
- Avoid overfertilizing by always adding enough liquid fertilizer so that 10 percent of what is added leaches out the bottom of the container.
- Do not use slow-release fertilizer in combination with soluble fertilizer.
- Do not mix slow-release fertilizer into the potting medium unless absolutely certain of using the proper amount.
- Double check the weight of soluble fertilizer being added to the injector or watering can.
- Leach excess fertilizer from plants prior to moving them to environments where they will have a slower growth rate or drier conditions.
- If a mix has been steamed too long or at too high a temperature, leach the mix before use as outlined below or allow it to “rest” for 2 to 3 weeks.

- When salts are excessive due to a soluble fertilizer, leach. Apply plenty of tap water so that it pours out the bottom of the pot. Repeat this leaching once more 2 to 3 hours later or the next day.

Pots or Containers

- 6 inches of water applied will reduce salts by half.
- 12 inches of water will reduce salts by four-fifths.
- 24 inches of water will reduce salts by nine-tenths.

Benches

- Apply 0.5 to 1 gallon water per square foot. Wait 1 hour and repeat.
- If salts are excessive because slow-release fertilizer was used improperly, repot the plants or scrape some of the slow-release fertilizer from the medium surface.
- If salts are excessive because of a combination of slow-release fertilizer and soluble fertilizer, repot the plants.

Measuring Soluble Salts and pH

- Prepare a saturated paste extract by retaining about 0.25 cup of mix and wet 1 to 1.5 cups of mix as follows:
  - **Soil** (25 percent or more of mix is composed of soil)—Using distilled water, wet the soil until it is so wet that it readily slides off the spoon or spatula but not so wet that it puddles.
  - **Soilless** (25 percent or less of the mix is composed of soil)—Using distilled water, wet the mix until it is so wet that it glistens but not so wet that it puddles. If this becomes stiff and looses the glisten upon standing, carefully add more distilled water.
- If too much water has been added, add some of the dry mix you retained.
- Stir intermittently for 20 to 30 minutes.
- Saturated paste extract:
  - Lay out a piece of cheesecloth and place two layers of paper towels on top of the cheesecloth.
  - Dump out the saturated paste onto the paper towels and gather it up into a ball.
  - Surround the ball with the cheesecloth.
  - Gently squeeze out the water into a clean container. Try not to squeeze so hard that the paper towels burst.
- Discard the mix towels and cheesecloth.
- Measure the conductivity and pH of the liquid.

Calibrating the Conductivity Meter for Accuracy

Place 2 to 3 tablespoons of calcium sulfate (plaster of Paris) in a clean jar and fill the jar with distilled water. Let this stand overnight.

The liquid above the powder in the bottom of the container is saturated with calcium sulfate. This liquid will give a reading of 220×10^{-5} mhos/cm = 2.2×10^{-3} mhos/cm = 2.2 mS. If the meter does not give this reading, it is very likely that the probe must be replaced.

Be certain that the meter has been set to the temperature of the liquid if the meter has such an adjustment knob. For each degree off the proper temperature, the conductivity reading will be about 5 percent incorrect.

Diseases of General Importance

Several diseases and pathogens affect a large number of different plants in greenhouse production. It is important to maintain a history of the problems encountered in each crop so that similar problems can be anticipated in future crops. Note which varieties are most affected, those that are least affected, and areas in the greenhouse where the disease outbreak first occurred. Also keep track of the sources of all plants purchased from other greenhouses so that the origin of a problem can be traced. Maintain a record of when plants are received and when symptoms are observed. It is best to keep new plants separate from other plants in the greenhouse until you are certain they are healthy and apparently disease and insect free.

Bacterial Diseases in General

Bacteria are microscopic, single-celled organisms that have a cell wall. Their genetic material, a circular strand of DNA, floats inside the cell and is not surrounded by a nuclear membrane. Therefore, bacteria do not have a true nucleus as do plants, animals, and fungi. Bacteria have other small gene-carrying entities within them called plasmids. Some bacterial characteristics, such as resistance to streptomycin, copper, and other antibiotics, are controlled by the plasmid genes. While most bacteria in the environment are beneficial, several are able to cause leaf spots, stem rots, root rots, galls wilts, blights, and cankers.

Plant-pathogenic bacteria generally survive in infected plants, in debris from infected plants, and, in a few cases, in infested soil. Most require a wound or natural opening in the plant to gain entry and require warm, moist conditions in order to cause disease. Bacteria grow between plant cells on the nutrients that leak into that space or within the vascular tissue of the plant. Depending on the species of bacteria involved and the tissue infected, they release enzymes that degrade cell walls, toxins that damage cell membranes, growth regulators that disrupt normal plant growth, and complex sugars that plug water-conducting vessels. In most bacterial diseases, photosynthesis and respiration are severely altered to the detriment of the plant.

Bacteria reproduce very rapidly. They are splashed easily from the soil to the leaves and from leaf to leaf by overhead irrigation. They are also easily moved from soil or debris when a worker handles such material and then handles the live plant. The most important means of avoiding ornamental crop losses caused by bacteria is to purchase plants that have been shown to be free of such pathogens by the process of culture indexing. In this procedure, pieces of plant tissue are incubated in a nutrient broth that will encourage the growth of plant-pathogenic bacteria. If the test is repeated two to three times and no pathogenic bacteria are detected, the plant is said to have been indexed and free of bacterial pathogens. Plants are usually indexed at the same time for fungi that grow within the vascular tissue of the plant. In different procedures, elite propagators also index plants for viruses. Plants found to be free of the organisms for which they are tested are said to be culture/virus indexed.

The strict sanitation practices required to control bacterial diseases include the destruction of infected plants as well as cleaning and disinfesting tools, benches, flats, and pots that are used repeatedly. Soil used in potting should be treated to kill all pathogens. Soil in which infected plants were grown or rooted should be discarded or thoroughly treated. Workers should be trained to not handle soil or debris and then the living plant tissue unless they stop work immediately and wash their hands. Perform plant-handling procedures and debris/soil-handling operations completely separately.

The most important cultural practice used against bacteria is irrigating in a manner that keeps foliage surfaces dry and avoids splashing. Overhead irrigation should not be used in crops particularly susceptible to bacterial diseases. When overhead watering is employed, watering should be done early in the day so that free moisture evaporates quickly. Provide good air circulation within the crop canopy. It is best to force air under benches and up through the canopy. Horizontal airflow, with rows of plants oriented parallel to the air movement, can greatly reduce relative humidity within the canopy. Various types of trickle irrigation and capillary mat watering are techniques that avoid providing the conditions required for bacterial spread and infection. Some bacteria have been shown to spread in ebb and flow systems. Steps should be taken to filter crop debris out of the water and chemically treat the water.

Once disease begins on the plants, chemical control is not effective. Chemicals containing copper or phosphorus acid slow disease development and suppress bacterial populations but do not prevent infection. Although research reports may indicate 80 to 90 percent control with chemicals under experimental conditions, often less than 50 percent control is achieved under commercial conditions with chemicals.

Erwinia chrysanthemi and *Erwinia carotovora* survive in plant debris that is not completely decomposed, on or in infected plants, on other greenhouse plants without causing disease, and, under some conditions, in soil. Both species infect a wide range of plants in the greenhouse. *E. chrysanthemi* has been shown to survive on plants that it does not actually infect. They can cause a mushy, brown, smelly, soft rot or leaf spots.

Pseudomonas cichorii can cause leaf spots and blights on chrysanthemum, geranium, impatiens, and many other ornamental plants. The spots are generally water soaked (wet looking) and dark brown to black. Depending on the plant infected, the leaf spots may have a yellow halo.

Xanthomonas is another genus of bacteria containing important plant-pathogenic species. *Xanthomonas campestris* pv. *pelargoni* causes bacterial blight or wilt of geranium. Other species of *Xanthomonas* attack *Dieffenbachia, Philodendron, Syngonium, Aglaonema,* and other foliage plants.

Rhodococcus fascians (formerly *Corynebacterium*) causes abnormal branching and stem development near the base of infected plants such as geranium. The bacterium is carried on infected cuttings and may enter the propagation medium.

Ralstonia solanacearum (formerly *Pseudomonas*) causes vascular wilting of many herbaceous ornamentals, including geraniums. Gross symptoms in geraniums mimic those of bacterial blight caused by *Xanthomonas campestris* pv. *pelargoni*. Unlike most other bacteria, *Ralstonia solanacearum* survives well in the soil. Once a greenhouse is contaminated with this organism, it is difficult to eliminate and poses a threat to many different crops. Symptoms include leaf wilting, discoloration of the vascular tissue, leaf yellowing, and death of the plant.

Management

1. Purchase culture-indexed plants known to be free of the most important bacterial pathogens.
2. Discard infected plants.
3. Do not use overhead irrigation.
4. Pasteurize the propagation bed and medium between crops.
5. Do not handle soil or debris on the potting soil surface and then the plant.

In some cases, phosphites or salts of phosphoric acid and copper or copper + mancozeb combinations have been found to suppress certain bacterial diseases. See the specific crop information in this guide for chemical recommendations.

Bacterial Wilt (*Ralstonia solanacearum*)

Bacteria called *Ralstonia solanacearum* attack almost 200 plant species in 33 different plant families. This constitutes one of the largest known host ranges for any plant-pathogenic bacterium. Although Solanaceae (potato family) contains the greatest number of susceptible species, many other dicot and a few monocot plants are also susceptible. It can be moved from outdoors into the greenhouse industry in and on plants propagated in warm, wet regions and then sold to growers throughout the world. Although the primary location of survival in the environment is in crop and weed hosts, it can also survive in soil. It can be readily spread through the movement of contaminated soil and infected vegetatively propagated plants, in contaminated irrigation water, on the surfaces of tools (cutting knives) and equipment used to work with the plants, and on soiled clothing.

The bacteria were first named *Bacillus solanacearum*. After several revisions, they were called *Pseudomonas solanacearum* for many years. The latest revision has settled on the name *Ralstonia solanacearum*. Race 1 lives in the United States, where it attacks many floricultural and vegetable bedding plant crops including geraniums (all *Pelargonium*), *Catharanthus*, *Impatiens*, *Ageratum*, *Chrysanthemum*, *Gerbera*, *Tagetes*, *Zinnia*, *Salvia*, *Capsicum*, *Lycopersicon*, *Nicotiana*, *Petunia*, *Solanum melongena* (eggplant), *Tropaeolum* (nasturtium), and *Verbena*. Race 3 is tropical in distribution and does not occur naturally in North America. Race 3 biovar 2 (R3B2), inadvertently introduced to the United States in vegetatively propagated geraniums grown in Central America and Africa, is considered to be a major threat to U.S. agriculture because it causes brown rot in potato. Some of the other known hosts of R3B2 include *Pelargonium*, tomato, peppers, eggplant, bean, and beet. Weed hosts include black nightshade, climbing nightshade, horsenettle, Jimson weed, purslane, mustards, lambsquarters, and bittergourd. The bacteria can infect plants through roots and any fresh wounds. The bacterium can be difficult to work with in the laboratory because it quickly loses pathogenicity and viability in artificial culture.

Symptoms

Aboveground symptoms include wilting of one to two leaves on young plants during the heat of the day. Such plants tend to recover at night. On large-leafed plants, only the tissue on one side of the mid-vein may wilt. This is very characteristic for plants such as *Nicotiana*. Affected leaves turn yellow and remain wilted after a time. The area between leaf veins dies and browns. Usually the main stem of the affected plant remains upright even though all of the leaves may wilt and die.

Internal symptoms include light-tan to yellow-brown discoloration of the vascular tissue. Long sections of infected stems reveal dark-brown to black streaking in the vascular tissue as the disease progresses. As invasion proceeds, the pith and cortex of the stem become dark brown.

Symptoms in geraniums are very similar to those caused by the bacterial blight pathogen *Xanthomonas campestris* pv. *pelargonii* (Xcp). However, while Xcp can cause leaf spotting, *Ralstonia* does not.

Signs of the Pathogen

Slimy, sticky ooze forms tan-white to brownish beads where the vascular tissue is cut. When an infected stem is cut across and the cut ends are held together for a few seconds, a thin thread of ooze can be seen as the cut ends are slowly separated. If one of the cut ends is suspended in clean water (use a clear container), bacterial ooze will form a thread in the water.

Management

Growing and propagating from pathogen-free plant material is the main way to avoid problems with *Ralstonia*, regardless of the race and biovar involved. Propagators must use pathogen-free potting soil or other media, establish stock plants that are tested and known to be free of the bacteria, train workers handling the stock plants in methods and procedures that prevent the pathogen from contaminating the potting soil or coming in contact with the stock plants, and then maintain this system throughout the propagation phase of crop production.

No chemicals or biological agents adequately control these bacteria. Infected plants **must** be discarded as soon as possible.

As is the case with all pathogens carried on vegetatively propagated crops, the purchaser of cuttings or pre-finished plants must isolate all new, incoming plants as if the health of the plants were unknown, even if the plants have been certified as healthy. New plants **must not** be commingled or dispersed among other plants in the greenhouse from other sources. This procedure is crucial because keeping plants originating from one source together allows you to observe those plants as a group, detect any abnormalities within that group, and treat or discard those plants as a group without affecting or damaging plants from other sources. Keeping them together as a group in a defined area of the greenhouse also limits the area that may need to be quarantined, sanitized, or isolated should a pathogen requiring a "stop sale" (such as *Ralstonia solanacearum*) be found.

Botrytis (Gray Mold)

The plant pathogenic fungus *Botrytis* is found virtually everywhere plants are grown. It is fast growing, can grow on many different sources of nutrients, survives well in the greenhouse, and can attack many different types of plants. The disease caused by *Botrytis* is commonly called Botrytis blight or gray mold.

The Fungus

Botrytis at first appears as a white growth on the plant but very soon darkens to a gray color. Smoky-gray, "dusty" spores form and are spread by the wind or in water. In greenhouses, any activity will result in a release of spores. Even automated trickle irrigation systems, when turned on, trigger a release of spores. These spores are often found on the outside of seeds. The spores can remain dormant on plant surfaces, in some cases, for as long as the life of the plant. *Botrytis* forms two types of resting structures on or in infected plant tissue: (1) very dark-brown or black multicelled structures called sclerotia and (2) single-celled, thick, dark-walled chlamydospores.

Infection

Botrytis must have nutrients or some food source before it invades the plant. Nutrients leaking from wounded plant parts or from dying tissue such as old flower petals provide the required nutrients. From this food base, the fungus becomes more aggressive and invades healthy tissue. A dark- to light-brown rot forms in the diseased tissue. High-humidity conditions favor the growth of this fungus.

Sites of First Infection

- Wounded tissue such as large stubs left after taking cuttings
- Fading flowers
- Leaves on which fading infected flowers have fallen
- Broken stems or injured leaves
- Leaves damaged by overfertilization, spray damage, or mechanical injury
- Seedlings grown under cool, moist conditions
- Cuttings taken from plants with heavy infestations of *Botrytis*

Management

Sanitation is the first important step. Remove dead or dying tissue from the plants and from the soil surface. Remove this refuse from the greenhouse. Do not throw debris under benches or on walks. Sanitation alone is not

sufficient to control this fungus. The fungus can produce 60,000 or more spores on a piece of plant tissue the size of your small fingernail. Even one spore can infect a plant and cause disease.

Avoid injuring plants in any way. Do not leave large stubs of tissue on stock plants when taking cuttings.

Heat and ventilate greenhouses to prevent high-humidity conditions. This may only require extra venting early in the day when moisture has condensed and before sunlight has warmed the air. Even lowering the humidity slightly can have a significant effect on *Botrytis*. Outdoor planting should be planned to provide good air circulation patterns. This is the most important means of inhibiting *Botrytis* activity.

Added protection is available for many crops by applying a fungicide or biological control agent. Note that some *Botrytis* populations are resistant to certain chemicals. *Botrytis* resistance to benzimidazole fungicides is common in greenhouses, and resistance to dicarboximides also occurs in many greenhouses. Refer to the "Fungicide Resistance Management" section on page 28 for more information. Below is a list of fungicides used for gray mold management. To manage resistance, use a material from a Fungicide Resistance Action Committee (FRAC) Group only once or twice (as recommended on the product label) and then switch to a product in a different FRAC Group. If a mixture of chemicals is to be used, select them from different FRAC Groups.

Fungicides in FRAC Groups 2, 11, 12, and 17 are particularly at risk for the development of resistance and should be used in strict accordance with label recommendations concerning resistance. FRAC Groups M and NC and the biological control agents for *Botrytis* are at very low risk for the development of resistance.

FRAC Group	Class	Active Ingredient	Trade Names
2	Dicarboximide	iprodione	Chipco 26GT, Chipco 26019, Iprodione, Sextant
		vinclozolin	Curalan
11	Strobilurin	azoxystrobin	Heritage
		trifloxystrobin	Compass
12	Phenylpyrrol	fludioxonil	Medallion
17	Hydroxyanilide	fenhexamid	Decree
M	Chloronitrile	chlorothalonil	Daconil, Echo, Exotherm Termil, ConSyst, Concorde, Spectro 90
	Copper, Complex	copper sulfate	Camelot, Phyton 27
	Copper, Fixed	copper hydroxide	Kocide
	Dithiocarbamate	mancozeb	Mancozeb, Dithane, FORE, Junction, Manzate, Pentathlon
		manganese + zinc	Protect T/O
NC	Bicarbonate	potassium bicarbonate	Armicarb, First Step, Milstop, Kaligreen, Remedy

Biological Control Agent Name (Type of Organism)	Trade Name (EPA Reg. No.)
Streptomyces lydicus (actinomycete; fungus-like bacteria)	Actinovate (73314-1)
Streptomyces griseoviridis (actinomycete; fungus-like bacteria)	Mycostop (64137-5)
Trichoderma harzianum (fungus)	PlantShield (68539-4)

Damping-Off

Damping-off is the rotting of seeds in the soil and destruction of newly emerged seedlings by fungi. The entire seed may decay before germination or the seedling may rot just below the soil line. Older plants usually are not killed but often develop stem and root rots. The fungi most often causing this disease belong to the genus *Pythium*. *Fusarium* and *Rhizoctonia* species can also cause damping-off.

Conditions Favoring Damping-Off

- Excessive soil moisture and excessive overhead misting
- Low soil temperatures before germination (below 20°C or 68°F)
- High soil temperatures after emergence (above 25°C or 77°F)
- Overcrowded flats or seedbeds

Control in the Greenhouse

- Start seeds and cuttings in pasteurized soil or a soilless mix using only sterile flats or pots.
- Do not contaminate soil or containers by placing them on floors or dirty benches or by using dirty tools.
- Buy fungicide-treated seeds or treat the seeds yourself.
- Supply bottom heat so that the soil in the containers is 70 to 75°F (22 to 24°C).

Fungicides Recommended to Control Seed and Seedling Damping-Off

Determine if a fungicide is registered for use on your particular crop. This information is on the product label.

Fungicides Recommended to Control Rots of Cuttings

Certain fungicides, in particular rooting mixes, can inhibit root initiation and development of specific cultivars. It is best to avoid applying pesticides to cuttings being rooted. However, if unavoidable, the following can be used with caution. It is suggested that only a portion of the crop be treated the first time this is done. If, after comparing the rooting to that of the portion of the crop not treated, no inhibition is noted, it is safe to use that specific chemical on that variety of crop rooted in the specific medium used. For example, it has been observed that granular formulations of etridiazole can inhibit rooting of white rhododendron varieties but not white azalea varieties—other formulations of etridiazole do not have this effect.

Downy Mildew

Downy mildew is the common name for a group of highly specialized obligate parasites of vascular plants. These organisms are distinctly different from the powdery mildews. Although they have traditionally been included taxonomically with true fungi, these organisms and their relatives in the genera *Phytophthora* and *Pythium* and others in the Oomycota are now not believed to be closely related to true fungi. Morphologically, they are similar to fungi and have absorptive nutrition. The chemicals used to control downy mildews are similar to those used for *Phytophthora* and *Pythium* and are different from most of those used for true fungi.

Symptoms

Downy mildew colonies often appear first on the underside of leaves, and they sometimes have a bluish tinge. In many cases, they can grow systemically throughout the plant. If growing abundantly on a leaf, downy mildew colonies can be confused with gray mold (*Botrytis*) or powdery mildew. Microscopically, they are very easy to tell apart from powdery mildew and *Botrytis*. On the foliage, small, yellow spots develop on the upper sides of the leaf while white to bluish-white, fluffy growth forms on the underside of the leaf. As the leaf spot dies, the fluffy growth darkens to gray in color. Infected leaves and branches may be distorted and die.

Life History

Downy mildews are generally favored by cool temperatures (15–23°C = 58–72°F) and relative humidity above 85 percent at the leaf surface. While some downy mildews survive from year to year locally in plant debris, in the soil, or on weeds, others do not survive in cold climates and must be blown back to our region from southern climates each spring. Species of downy mildews reproduce sexually via oogonia and antheridia and asexually via sporangia. From the time of infection until new spores form can be as short as 4 days but is usually 7 to 10 days. In all species, the sporangia germinate directly by forming a germ tube that penetrates the plant. In some species (*Sclerospora* and *Plasmopara*), sporangia can also germinate "indirectly" by releasing zoospores. *Peronospora*, *Pseudoperonospora*, and *Bremia* rarely, if ever, form zoospores.

Management

Plant debris should be removed from the area around the plant and buried, burned, or placed in a closed container. Plants should be spaced to ensure good air circulation around them so that leaf surfaces dry quickly when irrigated or subjected to rainfall. Overhead irrigation should not be used when the weather is generally cool. It is important to scout highly susceptible plants during cool, damp weather in the spring in order to detect first infections. In particular, roses, pansies, and impatiens should be monitored carefully.

Foliar Nematode

While most nematodes are soil dwelling, the foliar nematode *Aphelenchoides* lives only briefly in soil. More importantly, it lives on the aboveground portions of plants, often without causing any obvious symptoms. *Aphelenchoides*, like all other nematodes, is a nonsegmented roundworm. Compared to other plant-infecting species, it is rather large—often 0.5 to 1.2 millimeters (0.02 to 0.05 inches) long. It has a fine, needle-like, hollow spear mouth part ("stylet": a structure characteristic of plant-parasitic nematodes and lacking in free-living and animal-parasitic nematodes) that is pushed into the plant cell. The worm forces enzymes through the stylet into the cell, where cell components are digested and then drawn

back into the nematode's digestive system through the stylet. Of the more than 220 known species in this genus, the most important species on ornamentals are *Aphelenchoides besseyi*, *A. fragariae*, and *A. ritzemabosi*.

Many different plants are susceptible to *Aphelenchoides*, including African violet, *Anthurium*, Boston fern (*Nephrolepis*), bird's-nest fern (*Asplenium*), columbine, begonia, *Crossandra*, *Cyclamen*, gloxinia, *Dahlia*, *Gerbera*, *Hibiscus*, *Lantana*, *Mimulus*, geranium, cineraria, *Primula*, *Ranunculus*, Thanksgiving cactus, India rubber tree (*Ficus elastica*), and iris.

The nematodes can remain on the outside of the plant or can force their way into leaf and stem tissue. Wetness on the stems and leaves provides an excellent environment for their movement. Splashing water during irrigation readily moves the nematodes from leaf to leaf and plant to plant. In some cases, such as with certain types of begonias (Elatior hybrids), the nematodes can move into the water-conducting tissue and develop large populations without causing any symptoms. Optimum temperatures for foliar nematode development are between 70 and 75°F (21–24°C). Nematodes reproduce by laying eggs, which hatch to release a larva. The larva molts as it enlarges and develops into a mature worm.

Symptoms

Plants with symptoms such as the following characteristically occur in scattered clumps because of the splashing of nematodes from one or two plants to neighboring plants.

- Yellow, brown, purple, to black, wet-looking areas on leaves
- Angular, yellow areas on the leaf bounded by the veins of the leaf
- General yellowing, reddening, or bronzing of leaves, not limited in shape by veins (begonia)
- Death of leaves that remain attached to the plant
- Cupping and distortion of leaves (especially African violets)
- Small, sunken areas on the undersides of leaves
- Stunting of the entire plant
- Chlorosis similar to that of iron deficiency

Detection

- Remove tissue showing symptoms or symptomless tissue you desire to examine.
- Using tweezers, needles, or some other clean instrument, tear the tissue into small pieces and place in a clean drop of water in a clear glass container or on a microscope slide. Use as little water as possible but enough so that some of the pieces are submerged. Allow the pieces to soak for a few minutes.
- Using at least 10x magnification, look for small worms moving in rapid, snake-like motions. It is important to have the lighting correct and a dark background color to see the worms. The nematodes will sink to the bottom of the container over time.

Management

- Plant nematode-free material.
- Discard infected plants.
- Do not use overhead watering.
- Space plants well so that any splashing during watering is minimized and plant surfaces dry quickly.
- If foliar nematodes are encountered, examine symptomless begonias for the presence of the worms.
- While some insecticides greatly suppress the activity of foliar nematodes and can reduce the nematode population, none are known to totally eliminate foliar nematode from an infected plant. In some cases, the rate of insecticide necessary to suppress this nematode is phytotoxic to the plant.

Powdery Mildew

Powdery mildew occurs on many different flowers, including roses, snapdragons, African violets, kalanchöe, English ivy, zinnias, photinia, and begonias. Several different genera of fungi cause powdery mildew. In some cases, one genus specifically attacks one or two different plants. Some species of powdery mildew (such as *Golovinomyces cichoracearum*, formerly *Erysiphe cichoracearum*) attack a wide range of plants. All of the powdery mildew fungi are obligate parasites, which require live tissue to grow and reproduce. In greenhouses, the fungus survives by spreading from the diseased plants to the new plants of that same crop. If that crop is not grown for several weeks, the fungus dies out and diseased plants must be brought into the greenhouse to establish the fungus again. Outdoors, fungal structures form on leaves and twigs that allow the fungus to survive winter conditions.

Symptoms

- White, powdery fungus grows on the upper leaf surface of the lower leaves.
- Leaves may be twisted, distorted, then wilt and die.
- On some plants, such as kalanchöe, infected leaves have dry, corky, scab-like spots and fungal growth is not obvious.

Conditions Favoring Powdery Mildew

The following conditions, which prevail in spring and fall, favor powdery mildew:

- High relative humidity at night
- Low relative humidity during day
- 70–80°F (22–27°C) temperatures

The spores are carried by air currents and germinate on the leaf surface. Liquid water on leaves inhibits spore germination. The fungus grows on the leaf surface but sends fine threads (haustoria) into the cells to obtain nutrients. From the time a spore germinates to the time new spores form may require only 48 hours. High humidity favors spore formation while low humidity favors spore dispersal. Some powdery mildews are inhibited by free moisture on leaves while others are favored by wetness on leaf surfaces.

Management

- When conditions are favorable for 3 to 6 consecutive days, heat and ventilate in late afternoon to reduce night humidity.
- Apply a fungicide or biological control to protect the plants. Bicarbonates and oils have been found to be effective for powdery mildew control and are less toxic than many other fungicides.

Pythium

While root rot can be caused by several different species of the fungus-like organism *Pythium*, the four most commonly encountered species are *Pythium irregulare*, *Pythium aphanidermatum*, *Pythium cryptoirregulare* (a newly named species), and *Pythium ultimum*. *P. ultimum*, *P. cryptoirregulare*, and *P. irregulare* are often found in field soil, sand, pond and stream water and their sediments, and dead roots of previous crops. *P irregulare* and *P. cryptoirregulare* have been isolated from almost every type of greenhouse crop grown, but *P. aphanidermatum* seems to be associated primarily with poinsettias. *Pythium* can be in commercially available soilless potting mixes. It is easily introduced into pasteurized soil or soilless mixes by using dirty tools, dirty pots or flats, walking on or allowing pets to walk on the mixes, and by dumping the mixes on benches or potting shed floors that have not been thoroughly cleaned. Fungus gnat and shorefly activity may also be involved in moving *Pythium* from place to place in greenhouses. When introduced into a soil mix that has been heat treated for too long or at too high a temperature, *Pythium* can cause severe root rot because it has few competitors to check its activity. *P. aphanidermatum, P. cryptoirregulare,* and *P. irregulare* pose a threat to crops grown in ebb and flow systems because they form a swimming spore stage that can move in water. This is likely to occur only if irrigation times are long (45 minutes or longer) or if pots sit in puddles of water because the bench or floor does not drain completely. If *Pythium* infests a cutting bed or if contaminated water is used in propagation, large losses occur. *Pythium ultimum* is primarily associated with soil and sand. As growers switched to soilless mixes, this species became less important than when growers used field soil in the potting mix. *P. ultimum* does not form the swimming spore stage but can be a problem in ebb and flow systems if the reservoir becomes fouled with potting mix and plant debris particles harboring it. Almost all plants are susceptible to Pythium root rot. Root tips, very important in taking up nutrients and water, are attacked and killed first. *Pythium* also can rot the base of cuttings.

Symptoms

- Plants are stunted.
- Root tips are brown and dead.
- Plants wilt at mid-day and may recover at night.
- Plants yellow and die.
- Brown tissue on the outer portion of the root easily pulls off, exposing a strand of vascular tissue.
- The cells of roots contain round, microscopic, thick-walled spores.

Management

Pythium root rot is difficult to control once rot has begun. Every effort should be directed toward preventing the disease before it begins by using heat-pasteurized potting mix (entire pile heated to 180°F and held at that temperature for 30 minutes; longer times and higher temperatures will kill beneficial organism in the soil). Cover the treated soil and store it or commercial soilless mixes in an area that will not be contaminated through the introduction of non-treated soil.

If pond or stream water is used for irrigation, be certain the intake pipe is well above the bottom so that sediment is not drawn in. If the water supply is suspected of being a source of *Pythium*, it may be necessary to treat the water before use. First, contact the Penn State Cooperative Extension office in your county to arrange to have the water tested for *Pythium*. Slow sand filtration has been shown to be an effective, simple, and inexpensive method for removing *Pythium* from water. Heat, ultraviolet light, ozone, and chlorination can be effective but are expensive and require some training to be used properly.

Cover ebb and flow system reservoirs to prevent contaminated debris from entering the system. Pass

return water over a coarse screen to remove potting soil and plant debris in order to help keep *Pythium* out of the reservoir.

Disinfect all bench surfaces, potting benches, tools, and equipment that will contact the potting mix. Periodically, thoroughly clean and disinfect ebb and flow reservoirs, benches, and flood and drain floors.

In a greenhouse operation with a history of Pythium root rot, apply a fungicide or a biological control agent as early in the cropping cycle as possible. Biological agents should be applied to the potting mix before, during, or immediately after transplant. They can even be applied to plants in plug trays before transplanting. Do not apply *any* chemical pesticides to the potting mix for 10 days before or 10 days after applying the biological control agent. Biological control agents and fungicides may have to be applied more than once in order to maintain adequate protection.

If considering using a chemical to control *Pythium*, please first read the Fungicide Resistance Management section on page 28. Some populations of *Pythium* (particularly some populations of *P. cryptoirregulare* and *P. aphanidermatum*) have resistance to metalaxyl, mefenoxam, and/or propamocarb. If these chemicals do not appear to be protecting your plants, switch to another product and contact Penn State's Department of Plant Pathology or the Penn State Cooperative Extension office in your county for assistance in assessing the cause of the problem.

Rhizoctonia

The pathogenic fungus *Rhizoctonia* is known to cause root rots, stem rots, damping-off, and, in some cases, a blight of leaves. It is a soilborne fungus favored by warm, moderately moist soil conditions. The fungus is able to persist in the soil as hyphae, sclerotia, and basidiospores. Once the fungus begins to grow in the plant, the infected areas decay quickly, causing brown to reddish-brown lesions to form at or just below the soil line. If conditions remain favorable for disease development, the lesions will enlarge, forming dry, sunken cankers that may eventually girdle the plant. The young hyphae are colorless but turn brown with age. Soil particles often cling to the cankered areas of the plant when removed from the soil because of the coarse, brown mycelium. Leaves touching the soil can be infected. The fungus will web to neighboring leaves quickly under high-humidity conditions and will rot leaves quickly. Under magnification, hyphal branches are at 90-degree angles to the parent hypha and there is a cross wall and a constriction of the cell at the base of each branch.

Symptoms

- Plants wilt during midday.
- Stems rot at soil line with brown to reddish-brown lesions.

Conditions Favoring *Rhizoctonia* Growth

- Warm soil temperatures, 70–90°F (12–32°C)
- Even, moderate soil moisture (65 percent soil saturation); if plant is injured, then higher soil moisture favors growth

Control

- Eliminate *Rhizoctonia* from the potting mix through proper soil pasteurization.
- Encourage prompt growth (older plants are more resistant).
- Fungicides: Be sure to treat the crop as listed on the fungicide label.

Thielaviopsis (Black Root Rot)

The fungus *Thielaviopsis basicola* (Berk. & Br.) Ferraris is a soil-inhabiting fungus that can cause root rot and branch dieback on a number of woody and herbaceous plants, including holly, begonia, geranium, poinsettia, cyclamen, gerbera, and pansy. Soil temperatures between 55 and 65°F generally favor this fungus, particularly if the soil is wet. The fungus can be found in field soil but has also been found in commercial peat moss.

Symptoms

- Stunting of foliage and root systems
- Blackened areas on roots
- Yellowing of leaves between the veins or along the margins
- Branch dieback

Signs

- Dark-brown, multicelled spores form in the infected roots. The individual cells appear to snap apart.
- Light-colored spores are formed in a long tapering cell and extruded in chains.

Management

- Steam field soil and peat moss. Heat to 180°F and hold at that temperature for 30 minutes.
- Apply a fungicide as a soil drench.

Virus Diseases in General

Viruses are submicroscopic entities capable of causing disease. They are a piece of nucleic acid (genetic material) surrounded by a protein coat. Once inside the plant cell, the nucleic acid portion directs the plant cell to produce more virus nucleic acid and virus protein, disrupting the normal activity of the cell. Viruses can multiply only inside a living cell. While some viruses such as cucumber mosaic die quickly if outside a cell or if the cell dies, other viruses such as tobacco mosaic retain their ability to infect for years after the infected plant part dies. Many different viruses can infect plants.

Depending on which virus is involved, viruses are spread from infected plants to healthy plants as follows:

- Mechanically on workers' hands or on tools
- By aphid, thrips, whitefly, leafhopper, mite, or nematode feeding
- Through dodder
- Through grafting

Vegetative propagation perpetuates virus diseases. Cuttings taken from an infected plant usually are infected even if no symptoms are immediately exhibited by the cutting. The virus particles are found in all parts of the plant except the few cells at the tips of the growing points. It is these few cells that are removed and grown into a healthy plant free of virus by the process called meristem tip culturing.

Symptoms

Symptoms vary with the virus involved, the species of plant infected, and the environmental conditions. In some cases, such as virus disease of geraniums, certain environmental conditions bring out symptoms while other conditions mask or hide symptoms. The following symptoms are associated with virus infections:

- Reduced growth resulting in stunting
- Mosaic pattern of light and dark green (or yellow and green) on the leaves.
- Malformation of leaves or growing points
- Yellow streaking of leaves (especially monocots)
- Yellow spotting on leaves
- Ring spots or line patterns on leaves
- Cup-shaped leaves
- Uniform yellowing, bronzing, or reddening of foliage
- Flower color breaking
- Distinct yellowing only of veins
- Crinkling or curling of margins of leaves

Some of the above symptoms can also be caused by high temperature, insect feeding, growth regulators, herbicides, mineral deficiencies, and mineral excesses. Virus diseases cannot be diagnosed on the basis of symptoms alone.

Management

- No chemicals cure a virus-infected plant, nor do any protect plants from becoming infected.
- Purchase virus-free plants.
- Maintain strict insect and mite control.
- Remove all weeds since these may harbor both viruses and insects.
- Remove all crop debris from benches and the greenhouse structure.
- Immediately set aside plants with the above symptoms and obtain a diagnosis from your plant disease clinic.
- Discard virus-infected plants.
- Frequently disinfest tools used for vegetative propagation.
- Propagate plants via seed rather than vegetatively (note that certain viruses of certain crops can be carried in or on the seed).

Impatiens Necrotic Spot Virus

Two closely related viruses, impatiens necrotic spot virus (INSV) and tomato spotted wilt virus (TSWV; once called the I-strain and L-strain of tomato spotted wilt), have been widespread and devastating in the greenhouse industry. Hundreds of thousands of dollars' worth of crops have been destroyed by these viruses. However, growers aggressively attacking the problem can avoid crop losses by controlling thrips, carefully inspecting new plants brought into the greenhouse, and maintaining the health of plants already in the greenhouse. Below are the steps required to aggressively attack INSV and western flower thrips in greenhouse production.

The virus causes a wide variety of symptoms including wilting, stem death, stunting, yellowing, poor flowering, "chicken pox–like" sunken spots on leaves, etches or ring spots on leaves, among others. In other words, symptoms will not tell you anything except that there is *something* wrong with the plant. That "something" could be virus or any one of 1,000 other things. Virus symptoms depend on what time of year the plant is infected, its age when infected, its physiological state when infected, growing conditions in the greenhouse, the strain of virus present, and other factors not fully understood at this time. In fact, some plants found to be infected do not exhibit any unusual symptoms.

Positive diagnosis is made by submitting the plant to a plant disease clinic capable of either inoculating special indicator plants or running chemical tests to determine if the virus is in the sap. Separate tests are run to look for each strain of the virus. A plant may have either or both in its sap. The Pennsylvania Department of Agriculture Bureau of Plant Industry Clinic in Harrisburg (contact through your state plant inspector) can test for the virus. If a sample is sent to the Penn State Plant Disease Clinic, we will forward it to a commercial company that specializes in running the test.

Management of INSV-Caused Diseases

- Inspect all incoming plants for symptoms. Those found with suspicious symptoms must be immediately isolated until the presence or absence of the virus is confirmed.
- Isolate incoming plants from all other plants in the greenhouse until you are certain they are free of the virus. If the plants are free of the virus, maintain their isolation unless certain all other plants in the greenhouse are free of the virus. In other words, don't put all your plants in one greenhouse.
- Destroy infected plants—infected plants cannot be cured. Do not vegetatively propagate infected plants. The only way the virus is maintained and spread in a crop is through vegetative propagation if western flower thrips are not present.

Detection of Western Flower Thrips Activity

Inspect all incoming plants, especially white and yellow flowers, for thrips. Isolate incoming plants from all other plants in the greenhouse until you are certain they are free of thrips. If the plants are free of thrips, maintain their isolation unless certain all other plants in the greenhouse are free of thrips. Use a hand lens. Tap the plant with a pencil while holding a sheet of white paper to catch any falling insects.

Since the thrips are very small and stay hidden most of the time, they are difficult to detect. Yellow or blue sticky cards placed at crop height are excellent for monitoring thrips. Blue is effective for thrips, but not a good all-around color for other insects. One to three cards per 1,000 square feet is recommended. Effectiveness depends on number used per square foot and placement rather than size of the card. Place some near vents, doors, and other openings. If you are uncertain of the identity of the insects you have trapped, contact your state inspector, the Department of Agriculture, your county extension educator, or the Penn State Department of Entomology for assistance. Change the cards regularly. For ease of handling, cover used cards in one layer of cellophane or similar clear plastic wrap when they are removed. Record the number of thrips trapped each week to determine if the population is increasing or decreasing.

The Thrips–Virus Relationship and Controlling Thrips

A single application of any material is not adequate. Applications are made at 5-day intervals if allowed as stated on the chemical label. Use one pesticide for one generation of thrips. That means apply one pesticide two to three times over a 14- to 15-day time. Then switch to a different class of pesticide. **Do not use tank mixes of different chemicals.** Thrips lay their eggs inside the plant tissue, where they are protected until they hatch and emerge 3 to 4 days later. The first instar (larva) is clear. Feeding larvae acquire the virus but do not transmit it from plant to plant. The larvae retain the virus until they mature into feeding adults. The second larva is yellow at first. Both the first and second larval stages hide among the bud and flower parts of the plant. The second larva turns white just before it molts and moves to the soil or leaf litter. Adults emerge from the soil 2 to 5 days later and may be yellow or dark brown. They hold their wings flat over their backs. Adults can live 30 to 45 days and transmit the viruses to plants throughout their life. The viruses do not pass into new eggs. Each new generation of larvae must feed on an infected plant to acquire the virus. The first chemical application should kill winged adults while the second and third should kill newly emerged, wingless individuals. Thorough coverage is required. Methods of application should be rotated. Fogging and spraying should be employed.

Maintain strict thrips control on all plants kept in the greenhouse. Eliminate all weeds in the greenhouse and ones close to the building and all plants not being carefully tended from inside the greenhouse. Such plants may harbor both the thrips and the viruses. Western flower thrips are known to survive outdoors in Pennsylvania.

If there are no INSV- or TSWV-infected plants in the greenhouse, no crops will be lost to this virus even if western flower thrips are present.

Be certain the chemical is registered for use on the plants to be treated. Some populations of thrips have resistance to certain insecticides. Please read the Insecticide/Acaricide Resistance Management section before selecting chemicals for thrips control. Consult with a plant inspector at the Pennsylvania Department of Agriculture or an entomologist at Penn State to determine which materials are registered and recommended for thrips control on your specific crop.

Tobacco Mosaic Virus

Tobacco mosaic virus (TMV) is named for one of the first plants in which it was found in the 1800s. However, it can infect well over 350 different species of plants. TMV is made up of a piece of nucleic acid (ribonucleic acid; RNA) and a surrounding protein coat. The complete virus is a submicroscopic, rigid, rod-shaped particle. Once inside the plant cell, the protein coat falls away and nucleic acid portion directs the plant cell to produce more virus nucleic acid and virus protein, disrupting the normal activity of the cell. TMV can multiply only inside a living cell, but it can survive in a dormant state in dead tissue, retaining its ability to infect growing plants for years after the infected plant part dies. Most other viruses die when the plant tissue dies.

The most important way that TMV can be spread from plant to plant is on workers' hands, clothing, or tools. This is called mechanical transmission. When plants are handled, the tiny leaf hairs and some of the outer cells inevitably are damaged slightly and leak sap onto tools, hands, and clothing. If the sap contains TMV, it can be introduced into other plants when those come in contact with this sap. Sucking insects such as aphids do not spread TMV. Chewing insects such as grasshoppers and caterpillars occasionally spread the virus but are usually not important in spread. Vegetative propagation perpetuates TMV and other virus diseases. Cuttings taken from an infected plant are usually infected even if the cutting does not immediately exhibit symptoms. The virus particles are found in all parts of the plant except the few cells at the tips of the growing points. Infected stock plants should be discarded immediately.

TMV can also survive outside the plant in sap that has dried on tools and other surfaces. If you handle a TMV-infected plant and then open a door with that hand, you have now put TMV on the door handle. The next person to open the door can pick up the TMV and spread it to any plant they touch.

Tobacco products, particularly those containing air-cured tobacco, may carry TMV. Flue-cured tobacco (used in making cigarettes) is heated repeatedly during its processing, thereby inactivating most, if not all, TMV. When tobacco products are handled or kept in pockets, hands and clothing can become contaminated with TMV and be a source of virus. TMV is *not* spread in the smoke of burning tobacco.

Symptoms

Symptoms vary with the species of plant infected and the environmental conditions. In some cases, environmental conditions bring out symptoms while other conditions mask or hide symptoms. The following symptoms are associated with TMV infections:

- Stunting
- Mosaic pattern of light and dark green (or yellow and green) on the leaves
- Malformation of leaves or growing points
- Yellow streaking of leaves (especially monocots)
- Yellow spotting on leaves
- Distinct yellowing only of veins

Some of the above symptoms can also be caused by high temperature, insect feeding, growth regulators, herbicides, mineral deficiencies, and mineral excesses. TMV diseases cannot be diagnosed on the basis of symptoms alone.

Management

- No chemicals cure a virus-infected plant, nor do any protect plants from becoming infected.
- Purchase virus-free plants.
- Remove all weeds since they may harbor TMV.
- Remove all crop debris from benches and the greenhouse structure.
- Set aside plants with the above symptoms and obtain a diagnosis.
- Discard infected plants.
- Disinfest tools by placing them in a suitable disinfectant for at least 10 minutes.
- Disinfest door handles and other greenhouse structures that may have become contaminated by wiping thoroughly with one of these materials.
- Propagate plants via seed rather than vegetatively.
- Thoroughly wash hands after handling tobacco products or TMV-infected plants.
- Do not keep tobacco products in the pockets of clothing worn into the greenhouse. Launder greenhouse work clothes regularly.

Extremely few chemicals are registered for use on plants in the interior plantscape. However, most of the diseases noted elsewhere in this manual develop during production and do not begin after the plants have been placed in the interior plantscape. For these reasons, inspect plants very carefully and treat any existing diseases before the plants are placed. It is best, however, never to use plants that already have disease. The common causes of diseases that develop after plants are placed in the interior include overfertilization, phytotoxicity, improper watering practices, and lack of acclimatization. Phytotoxicity and overfertilization were previously covered on pages 13 and 14, respectively.

Lack of Acclimatization

Most plants placed indoors were grown in the field, in lathe houses, or in greenhouses where light intensities were relatively high, watering was done frequently, and high rates of fertilization were employed in order to maintain rapid growth. Most interiorscapes have relatively low light intensities and require less water and fertilizer. In fact, rapid growth of plants at most sites is not desired. If a plant is moved from the production area directly indoors, the light required by the plant will not be available. Plants usually respond to this by dropping leaves or, in some cases, dropping entire branches. Plants such as *Chlorophytum* cultivars with white- and green-striped leaves develop gray-brown streaks in the normally white tissue.

Plants must be slowly acclimatized to lower light conditions. While this is being done, excessive fertilizer must be leached from the root zone. The presence of high levels of fertilizer causes damage when the level of watering is reduced and results in root damage, leaf yellowing, defoliation, and death of the plant. If temperatures during production were much different than those that are present indoors, gradual acclimatization to new temperature conditions is required.

During the period of acclimatization, thoroughly inspect the plant for any signs or symptoms of disease.

Fungicides and Fungicide Resistance Management

The fungicides listed in this guide are registered for use on greenhouse-grown floricultural crops. Read the labels carefully to determine whether the crop you wish to treat is listed on the label or whether the label is written broadly enough (for example, "for use on greenhouse crops") to allow it to be used on your crop. Labels change frequently and the information presented here may not be up to date, even at the time of publication.

Certain fungicides, usually systemic fungicides that are taken up by the plant, have very specific ways of killing the fungus. That is, their mode of action is to disrupt a specific activity within the biochemical machinery of the fungus. If the fungus has an alternative biochemical pathway to achieve the same result but in a slightly different manner than the one disrupted by the fungicide, then that fungus is said to have resistance to the fungicide. There are naturally occurring variations within populations of fungi. Even before a fungicide is used, a few individuals in the population may have multiple biochemical pathways while others in the same population do not. When the fungicide comes into use, the many individuals surviving the treatment are those with the alternative biochemical pathways and only a few of the fungicide-sensitive ones survive. The result is that the next generation of fungus has even more members with resistance to the fungicide. As you continue to use that particular systemic fungicide, more and more of each generation of the population is resistant to the fungicide until the fungicide no longer effectively protects plants against the fungus. This is process is termed "selecting for resistance" and the fungicide is said to be "at risk." It is recommended that growers

1. know whether the chemical they plan to use is at risk to resistance development and minimize the use of high-risk chemicals;
2. strictly follow the manufacturer's recommendations concerning the amount of chemical to use and the frequency of use;
3. make applications before the disease becomes very severe and populations of the pathogen are high;
4. rotate or alternate chemicals with different modes of action so that the pathogen population is controlled in multiple ways (see below);
5. know exactly what pathogen you are trying to control and whether the chemical you plan to use can be expected to control that pathogen (some fungicides are very specific and only control one or two pathogens while others control a large number of different pathogens);
6. eliminate weed and other plants in the greenhouse that are not going to be kept under strict disease control in order to eliminate safe harbors for pathogens and the insects that may move them around the greenhouse.

One way to avoid selecting for resistance or at least slow down the process is to rotate or alternate chemicals. Rotation of chemicals means using a chemical with one mode of action at the first treatment and then using a chemical with a different mode of action in the subsequent treatment.

An organization of chemical companies has formed the Fungicide Resistance Action Committee (FRAC) to develop resistance-management strategies. It is recommended that when chemicals are used in rotation, chemicals with different modes of actions (ways of killing the fungus) be rotated rather than relying on just one chemical or class of chemicals. By simply choosing a chemical with a different group number than the one previously used, you know that the two chemicals act differently on the fungus. Many companies are voluntarily placing the FRAC number on the packaged product and on the label.

NOTE: Product labels change frequently, products go off market, and new products are added. New formulations of old active ingredients receive new trade names. The following information is just a guide for understanding the meaning of the FRAC classification and may not be complete or up to date even at the time of this publication because of the rapid changes in pesticides (see http://www.frac.info/frac/index.htm).

FRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
1	Benzimidazole (Methyl Benzimidazole Carbamates, MBCs)	thiophanate methyl	12	3336 (1001-69) OHP 6672 (51036-329-59807) Fungo Flo (51036-329-59807) Systec 1998 (48234-12)
2	Dicarboximide	iprodione	12	Chipco 26GT (100-1138) Chipco 26019 (264-481) Iprodione (51036-361) Sextant (51036-361-59807)
		vinclozolin	12	Curalan (7969-62-58185)
3	Imidazole	triflumizole	12	Terraguard (400-433)
	Pyrimidine	fenarimol		Rubigan (62719-134)
3	Piperazine	triforine	12	Triforine (241-355)
3	Triazole	propiconazole	24	Banner MAXX (100-741) Propiconazole (51036-403) Spectator (62719-346-10404) Kestrel (66222-41-81943) Strike (3125-436)
		triadimefon	12	Bayleton (432-1360)
		myclobutanil	24	Systhane (707-253)
4	Acylanine	mefenoxam	0	Subdue MAXX (100-796)
		metalaxyl	12	Subdue (100-619)
5	Piperidine	piperalin	24	Pipron (67690-1)
7	Anilide (Carboxamide)	flutolanil	12	Contrast (45639-208-58185)
		oxycarboxin	12	Plantvax (400-144)
11	Strobilurin	azoxystrobin	4	Heritage (10182-408)
		kresoxim-methyl	12	Cygnus (7969-124)
		pyraclostrobin	12	Insignia (7969-184)
		trifloxystrobin	12	Compass (432-1371)
12	Phenylpyrol	fludioxonil	12	Medallion (100-769)
14	Aromatic Hydrocarbon	PCNB	12	Revere (400-407-10404) Blocker (5481-211) Terraclor (400-399) Defend (5481-444-1001)
	Thiadiazole	etridiazole	12	Truban (58185-7) Terrazole (400-416) Banrot (58185-10)
17	Hydroxyanilide	fenhexamid	4	Decree (66330-35-67690)
25	Glucopyranosyl Antibiotic	streptomycin		Streptomycin (66222-121)
28	Carbamate	propamocarb	12	Banol (432-942) Previcur Flex
40	Cinnamic Acid Derivative	dimethomorph	12	Stature (241-419-67690)
M	Phthalimide	captan	96	Captan (66330-29)
	Chloronitrile	chlorothalonil	48 12 12 48 12 12	Daconil (50534-9) Echo (60063-7) PathGuard (60063-7-499) Exotherm Termil (70-223) Concorde (72167-24-1812) Pegasus (72167-24-1812)

(table continued on next page)

(table continued)

FRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
	Copper, Complex	copper sulfate	12 24	Camelot (1812-381) Phyton 27 (49538-3)
	Copper, Fixed	copper hydroxide	48	Kocide (352-656)
		cupric hydroxide	48	Champion (55146-1)
	Dithiocarbamate	mancozeb	24	Dithane (707-180) FORE (707-87) Junction (1812-360) Pentathlon (1818-251)
		manganese + zinc	24	Protect T/O (1001-65)
		ferbam	24	Ferbam (45728-7)
		ziram	48	Ziram (4581-140)
U	Phosphonate	fosetyl-Al	12	Aliette (432-890)
	Phosphite	phosphorus acid salts	4	Alude (71962-1-1001)
		potassium phosphate	4	Vital (42519-24)
NC		potassium bicarbonate	4	Armicarb (5905-541-AA) Milstop (70870-1-68539) Kaligreen (70231-1) Remedy (62719-70) Agricure (70870-1-1001)
		sodium hypochlorite		Clorox (5813-55) ZeroTol (70299-1)
		hydrogen dioxide		TerraClean (70299-5)
		neem oil	4	Trilogy (70051-2) Triact (70051-2-59807)
		paraffinic oil	4	JMS Stylet Oil (65564-1) Ultra-Fine Oil (862-23-499)
		potassium salts of fatty acids	12	M-Pede (62719-515)
		sulfur	24	Kumulus (51036-352)
Combined Products				
1 + M		thiophanate methyl + chlorothalonil		Spectro 90 (1001-72) Consyst (48234-7)
1 + M		thiophanate methyl + etridiazole		Banrot (58185-10)
1 + M		thiophanate methyl + mancozeb		Zyban (58185-31)

Group	Mode of Action
1	Inhibits tubulin formation
2	Inhibits RNA or DNA synthesis
3	DMI (demethylation inhibitor), inhibits sterol synthesis
4	Inhibits RNA synthesis
5	Inhibits isomease in sterol synthesis
7	Disrupts electron transport in mitochondria
10	Disrupts beta-tubulin assembly
11	Quinone outside inhibitors (QOI)
12	Disrupts osmotic signal transduction
14	Disrupts lipid peroxidation
15	Disrupts cell wall synthesis

Group	Mode of Action *(continued)*
17	Disrupts C4 demethylation in sterol biosynthesis
25	Disrupts protein synthesis
28	Affects membrane permeability
29	Uncouples oxidative phosphorylation
40	Disrupts phospholipids and cell wall deposition
41	Protein synthesis attachment of tRNA to ribosomal receptor
M	Multisite activity
P	Host plant defense induction
U	Unknown mode of action
NC	Not classified

Biological Control of Plant Pathogens

When one living organism is used to inhibit the activity of a living plant pathogen, it is said to be a biological control agent (BCA). There are several different fungi and bacteria commercially available that compete for space or nutrients with or produce antibiotic chemicals against certain plant pathogens. Some of these also trigger the plant's natural biochemical defense mechanisms. BCAs are registered for use by EPA and have labels very similar to those for chemical pesticides. BCAs can be hazardous to the applicator and all safety equipment recommended on the label should be used. BCAs may have to be applied more than once in order to maintain adequate protection. Follow the label recommendations for application intervals. BCAs can be used in a greenhouse with chemical pesticides. In general, a BCA should be applied 10 days before or for 10 days after applying a chemical.

Below is a partial list of biocontrol agents and the pathogens listed on their labels as being controlled:

Biological Control Agent Name (Type of Organism)	Trade Name (EPA Reg. No.)	Target Pathogens on One or More of the Product Labels
Agrobacterium radiobacter (Bacteria)	Galltrol A (strain 84) (40230-1)	*Agrobacterium tumefacians* (crown gall)
	Norbac 84C (strain K84) (38087-2)	
Ampelomyces quisqualis (Fungus)	AG10 (55638-16)	Powdery mildew
Bacillus subtilis (Bacteria)	Companion (GB03 strain) (71065-1)	*Pythium, Fusarium, Phytophthora, Rhizoctonia,* powdery mildew, *Colletotrichum, Erwinia, Pseudononas, Xanthomonas, Diplocarpon, Cercospora, Venturia*
	Serenade (69592-4)	
	Rhapsody (QST 713 strain) (69592-10)	
Candida oleophila (Yeast)	Aspire (55638-29)	
Streptomyces griseoviridis	Mycostop (64137-5)	*Botrytis, Alternaria, Phomopsis, Pythium, Fusarium, Phytophthora*
Streptomyces lydicus (Actinomycete [fungus-like] Bacteria)	Actinovate (73314-1)	*Pythium, Fusarium, Phytophthora, Rhizoctonia, Botrytis,* powdery mildew, downy mildew, *Sclerotinia, Verticillium*
Trichoderma harzianum (Fungus)	PlantShield, (68539-4)	*Pythium, Fusarium, Phytophthora, Rhizoctonia, Botrytis,* powdery mildew, downy mildew, *Sclerotinia*
Trichoderma virens	SoilGard (70051-3)	

Disease Identification and Management by Crop

African Violet

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Blight	Dark reddish-brown to black rotting areas form on roots and crown. Infected petioles have a greasy appearance.	*Erwinia chrysanthemi*	Pot and propagate in pasteurized media. Do not take cuttings from infected plants. Avoid high-temperature, high-humidity conditions. Keep plants separate from new plants, especially foliage plants of unknown health.
Botrytis Blight	Small, water-soaked lesions form on damaged petioles and spread to leaf blades. Infected flowers fade prematurely.	*Botrytis cinerea*	Space plants and provide ventilation to avoid excessively high humidity. Remove fading flowers and yellowing leaves. Apply mancozeb, chlorothalonil, or fenhexamid to protect healthy tissue.
Foliar Nematode	Small, tan, sunken areas form on lower surfaces of leaves. Spots become dry and dull black as they enlarge. Plants are stunted.	*Aphelenchoides ritzema-bosi*	Destroy infected plants. Water plants in a manner that keeps leaf surfaces dry and does not splash from plant to plant.
Phytophthora Crown Rot	Crowns and roots have a dark, water-soaked appearance, which spreads to petioles and leaf blades. Leaves remain firmly attached as the plant collapses.	*Phytophthora nicotianae, P. cryptogea*	Do not propagate from infected plants. Pot in pasteurized media Destroy infected plants. Apply etridiazole, etridiazole + thiophanate methyl, or mefenoxam to protect healthy plants.
Powdery Mildew	White, mealy fungal growth on the leaves and flowers causes them to dry and die.	*Oidium*	Apply myclobutanil, piperalin, or triadimefon to protect healthy plants.
Pythium Root Rot	Roots are dark brown. Plants are wilted and yellowed.	*Pythium*	Do not overwater plants. Pot in pasteurized media. Keep hose ends off the ground. To protect healthy plants, apply etridiazole, etridiazole + thiophanate methyl, or mefenoxam.
Rhizoctonia Crown Rot	Plants wilt, collapse, blacken, and die. A reddening of infected tissue may occur at soil line. Leaves readily detach from collapsing plants.	*Rhizoctonia*	Destroy infected plants. Pot in pasteurized media. To protect healthy plants, apply fludioxonil, etridiazole + thiophanate methyl or thiophanate methyl.
Ring Spot	Bright yellow or bleached ring patterns form on dark-green leaves.	Irrigation water much colder or warmer than the leaf surface causes cells to collapse.	Keep irrigation water off the foliage. Use water that is kept at room temperature

Aglaonema

Disease	Symptoms	Pathogen/Cause	Management
Anthracnose	Circular to oval, brown leaf spots have a yellow halo. Spots may become 2 inches in diameter and contain tiny, black, fungal fruiting structures.	*Colletotrichum*	Avoid overhead watering.
Bacterial Leaf Spot	Small, gray or dark-green leaf spots enlarge and become irregular in shape, tan, dark brown, or black.	*Pseudomonas cichorii, Erwinia chrysanthemi,* or *Xanthomonas campestris dieffenbachiae*	Purchase plants free of the disease. Remove infected leaves and water in a manner that keeps the surface of the leaves dry.
Copper Deficiency	New leaves are yellow, strap shaped, or distorted.	Lack of copper	Apply a micronutrient that contains copper. Damaged leaves will not recover. New foliage will form normally.
Myrothecium Leaf Spot	Large, gray-brown, oval leaf spots form at leaf tips or margins. Fungal structures form in concentric rings within the spots on the underside of the leaf.	*Myrothecium roridum*	Do not apply excessive amounts of nitrogen fertilizer.

Aster

Disease	Symptoms	Pathogen/Cause	Management
Aster Yellows	Leaves yellow. Abnormal branching occurs. Yellowed, leaf-like tissue forms instead of flower parts.	Phytoplasma	Destroy infected plants. Maintain good leafhopper control. Destroy any similarly affected weeds in the vicinity.
Botrytis Blight	Brown specks form on petals. The entire flower browns and dies.	*Botrytis cinerea*	Avoid sprinkler irrigation. Apply mancozeb, iprodione, or chlorothalonil.
Fusarium Wilt	Young seedlings are killed. Older plants are stunted and have yellowing and wilting up one side of the plant. Water-conducting tissue in the stems browns.	*Fusarium oxysporum*	Use potting soil that has been treated to eliminate pathogens, or use soilless potting mix.
Leaf Spots	Spots form on leaves. Leaves yellow, wilt, and die. Usually lower leaves are affected first and symptoms progress upward.	*Alternaria, Ascochyta, Cercospora, Septoria*	Avoid sprinkler irrigation. Apply mancozeb, iprodione, myclobutanil, thiophanate methyl + mancozeb, or chlorothalonil.
Powdery Mildew	White, felt-like growth develops on the surface of leaves. Leaves wither and die.	*Golovinomyces cichoracearum (formerly Erysiphe)*	Apply azoxystrobin, paraffin oil, mancozeb, triforine, triadimefon, thiophanate methyl + mancozeb, or sulfur.
Rust	Reddish-orange masses of spores form on the underside of leaves. Severely affected leaves yellow and die. On the alternate host (pines) blisters of spores form on needles in the spring.	*Coleosporium solidaginis*	No control is recommended.

Azalea

Disease	Symptoms	Pathogen/Cause	Management
Botrytis Blight	Small, water-soaked lesions form on petals. Gray fungal growth covers infected petals.	*Botrytis cinerea*	Space plants and provide ventilation to avoid excessively high humidity. Remove fading flowers and yellowing leaves. Apply mancozeb, trifloxystrobin, chlorothalonil, or iprodione to protect healthy tissue.
Cylindrocladium Blight	Plants die rapidly. Leaves turn brown to black and fall in 3 to 4 days. Stems have brown spots on which white masses of spores later form, or roots die and plants wilt without having leaf spots form.	*Cylindrocladium scoparium*	Pot and propagate in pasteurized media. Do not reuse propagation media. Use clean, disinfested tools. Discard infected plants. Remove all crop debris. Apply thiophanate methyl or iprodione as a soil drench.
Damping-Off	Cuttings defoliate and die after failing to root.	*Pythium*	Pot and propagate in pasteurized media. Use clean, disinfested tools. Discard infected plants. Do not leave cuttings in mist beds for excessive periods. Pot as soon as rooted.
Ovulinia Petal Blight	Pale white to rust-colored spots form on petals. Spots enlarge rapidly. Petals become slimy and fall apart easily.	*Ovulinia azalea*	Remove crop debris. Apply thiophanate methyl, propiconazole, chlorothalonil, triadimefon, PCNB, ziram, or triforine as blossoms open. Chlorothalonil is phytotoxic to some cultivars. Water in a manner that keeps plant surfaces dry. Space plants, heat, and ventilate to maintain low humidity.
Phytophthora Root Rot and Top Dieback	Plants stunted and wilted, and leaves yellow. Plants die. Roots, with few feeder roots, die. Stem wood at the soil level has red-brown discoloration. In top dieback phase, leaves have dark-brown spots. Shoots die from the tips back with dark-brown cankers forming.	*Phytophthora*	Pot and propagate in pasteurized media. Use clean, disinfested tools. Discard infected plants. To protect healthy plants, apply potassium salts of phosphorus acid, dimethomorph, etridiazole, etridiazole + thiophanate methyl, or mefenoxam. Use composted tree bark as the potting mix. Avoid overhead watering.
Powdery Mildew	Faint yellow areas form on expanded leaves. White fungal growth forms on the yellow areas of some cultivars while only small, dead spots with no fungal growth forms on other cultivars.	*Erysiphe polygoni* or *Microsphaera penicilata*	Apply thiophanate methyl, propiconazole, or triadimefon.
Rhizoctonia Web Blight	Small, tan to black spots form on leaves. Spots expand to entire leaf. Leaves fall. Webbing may develop. Small plants may die.	*Rhizoctonia solani*	Maintain good air circulation. Avoid late-afternoon watering. Apply PCNB, flutolanil, iprodione, or chlorothalonil.

Bedding Plants

The major losses of bedding plants are caused by damping-off, overfertilization, phytotoxicity, and *Botrytis*. See each of those topics elsewhere in this manual. Marigold, pansy, petunia, and zinnia are covered below.

Begonia

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Leaf Spot and Blight	Water-soaked areas surrounded by yellow halos develop on leaves. Plants slowly die one leaf at a time.	*Xanthomonas campestris* pv. *begoniae*	Purchase plants free of the disease. Discard infected plants, particularly Rieger-types, which are systemically infected. Remove infected leaves from Rex and tuberous types because they are not systemically infected. Do not wet leaves when irrigating. Do not propagate from infected plants. Destroy crop debris.
Botrytis Blight	Cuttings rot at their base. Tan spots develop on leaves. Established plants rot at the crown. Infected tissue is covered with dusty, gray fungal growth.	*Botrytis cinerea*	Maintain low humidity by spacing plants and venting to improve air circulation. Remove dead and dying flowers and leaves. Apply trifloxystrobin, mancozeb, or fludioxonil. Chlorothalonil may be used if plants are not flowering. Do not use one chemical exclusively.
Foliar Nematode	Plants are stunted. Excessive red pigment develops in infected leaves. Bronzed or water-soaked areas develop on leaves of some cultivars. Fibrous-rooted cultivars have small, brown leaf spots. Some cultivars exhibit no symptoms despite heavy infection.	*Aphelenchoides fragariae*	Purchase nematode-free plants. Avoid overhead irrigation and splashing. Discard infected plants.
Powdery Mildew	White, mealy fungal growth develops on leaves, flowers, and stems. Tissue beneath the fungus may die.	*Oidium*	Examine plants carefully and frequently to detect the onset of disease. Maintain a fungicide program to protect plants. Apply fenarimol, thiophanate methyl, trifloxystrobin, myclobutanil, piperalin, or triadimefon.
Pythium Rot	Seedlings die. Shiny, blackened areas develop on the stems and petioles of established plants at and just above the soil line as plants collapse and die.	*Pythium*	Plant in pasteurized potting media. Keep hose ends off the ground. Do not overwater Apply potassium salts of phosphorus acid, etridiazole, etridiazole + thiophanate methyl, fosetyl-Al, or mefenoxam.
Rhizoctonia Crown Rot	Stems rot at the soil line. Plants collapse and die. A fine webbing of fungal growth may be seen between the infected stems and nearby soil particles.	*Rhizoctonia*	Plant in pasteurized potting media. To protect healthy plants, apply thiophanate methyl or etridiazole + thiophanate methyl.
Viruses	Mosaic, malformed leaves, pale yellow ring spots, severe chlorotic mottling of leaves or plant stunting may occur.	Impatiens necrotic spot, tobacco ring spot, broadbean wilt, cucumber mosaic, tobacco necrosis virus	Purchase plants free of symptoms. Discard infected plants. Plant in pasteurized potting media. Maintain good aphid and thrips control to reduce spread.

Calceolaria

Disease	Symptoms	Pathogen/Cause	Management
Botrytis Blight	Leaves, especially those near the soil surface, rot and become covered with gray fungal growth as do fading flowers.	*Botrytis cinerea*	Heat and ventilate to maintain low humidity. Remove dead and dying tissue from the greenhouse. Apply chlorothalonil.
Phytophthora Root and Crown Rot	Crowns and roots have dark-brown spots at the soil level. This spreads up the stem as plants wilt and die. Roots are killed.	*Phytophthora* spp.	Plant in pasteurized potting mix. Discard infected plants. Apply etridiazole to protect healthy plants.

Carnation *(Dianthus)*

Disease	Symptoms	Pathogen/Cause	Management
Alternaria Leaf Spot	Small, purplish spots form on leaves. Their centers become brown while the leaf yellows.	*Alternaria dianthicola* or *Alternaria dianthi*	Apply chlorothalonil, propiconazole, fludioxonil, copper hydroxide, iprodione, mancozeb, or mancozeb + thiophanate methyl to protect healthy plants.
Bacterial Slow Wilt or Stunt	Wilting, twisting, curling, and stunting of lower leaves and side shoots followed by death of lower leaves. Wilted plants may recover only to wilt again. Stunted plants have narrow, yellow-green leaves. Symptoms require several weeks to develop.	*Erwinia chrysanthemi*	Grow in raised beds pasteurized between crops. Use culture-indexed cuttings free of the pathogen. Destroy infected plants.
Bacterial Wilt	Leaves turn gray-green then yellow and die. Roots rot. Vascular tissue browns. Cracks develop in internode tissue. Slime oozes from these cracks when humidity is high.	*Pseudomonas caryophylli*	Pot and propagate in pasteurized, raised beds. Use clean, disinfested tools. Use culture-indexed cuttings free of the pathogen. Destroy infected plants.
Botrytis Blight	Petals turn brown and are covered with gray fungal growth.	*Botrytis cinerea*	Space plants to ensure good air circulation. Maintain low humidity. Avoid watering late in the day. Remove crop debris. Apply chlorothalonil, cupric hydroxide, iprodione, mancozeb, or fludioxonil.
Fusarium Stem Rot	Reddish-brown spots at the base. No vascular discoloration occurs beyond the rotted area.	*Fusarium graminearum, F. avenaceum,* or *F. culmorum*	Plant only healthy, pathogen-free cuttings in pasteurized, raised beds.
Fusarium Wilt	Lower leaves yellow and wilt up one side of plant. Symptoms progress up plant. Top of main shoot grows at right angle to main stem. Late in the disease, root and stems rot.	*Fusarium oxysporum*	Pot and propagate in pasteurized, raised benches. Use culture-indexed plants free of the pathogen.
Greasy Blotch	Small, web-like patterns give leaves a greasy appearance. Leaves yellow and die.	*Zygophiala jamaicensis*	Maintain relative humidity below 85 percent.
Phialophora Wilt	Plants wilt, leaves yellow, and vascular tissue is discolored dark brown.	*Phialophora cinerescens*	Pot and propagate in pasteurized, raised benches. Use culture-indexed plants free of the pathogen.

(table continued on next page)

Carnation *(continued)*

Disease	Symptoms	Pathogen/Cause	Management
Rhizoctonia Stem Rot	Stems at the soil level have a lesion with a brown border. Stems have dry, shredded appearance.	*Rhizoctonia solani*	Plant in pasteurized, raised beds. Apply thiophanate methyl, PCNB, or iprodione as a soil drench to protect healthy plants.
Rust	Small blisters containing rust-red spores form on leaves.	*Uromyces dianthi*	Apply chlorothalonil, propiconazole, myclobutanil, ziram, mancozeb + thiophanate methyl, triadimefon, or triforine to protect healthy plants.
Viruses	Leaves may be mottled or have yellow spotting, dead flecks, line, or ring spot patterns. Plant may be distorted or have flower color breaking.	Fifteen different viruses are known.	Plant virus-indexed cuttings. Maintain good insect and mite control. Destroy infected plants.

Catharanthus (Vinca)

Disease	Symptoms	Pathogen/Cause	Management
Phytophthora Stem Rot	Plants yellow, wilt, and die.	*Phytophthora nicotianae*	Plant in pasteurized potting mix. Discard infected plants. Apply etridiazole or mefenoxam to protect healthy plants.

Christmas Cactus

Disease	Symptoms	Pathogen/Cause	Management
Basal Stem Rot	A brown spot forms at the soil line. As the tissue dies, it becomes tan and falls away, removing tissue from the edge to the heavy, center-vein tissue.	*Fusarium oxysporum*	Do not injure plants at the soil line. Apply thiophanate methyl or etridiazole + thiophanate methyl to protect healthy plants.
Botrytis Blight	Flowers die and become covered with gray fungal growth. Under very high humidity conditions, stems may be attacked.	*Botrytis cinerea*	Heat and vent the greenhouse to maintain low relative humidity. Apply iprodione or fludioxonil to protect flowers.
Phytophthora Root Rot	Roots rot and plants turn gray-green, wilt, and die.	*Phytophthora*	Plant in pasteurized potting mix. Discard infected plants. Apply potassium salts of phosphorus acid, mefenoxam, etridiazole, or etridiazole + thiophanate methyl to protect healthy plants.
Pythium Root Rot	Plants wilt and die.	*Pythium*	Plant in pasteurized potting mix. Discard infected plants. Apply potassium salts of phosphorus acid, mefenoxam, etridiazole, or etridiazole + thiophanate methyl to protect healthy plants.
Virus	Yellow spotting on branches. Infected plants may exhibit no symptoms.	Impatiens necrotic spot virus	Maintain good thrips control at all times. Discard infected plants

Chrysanthemum

Disease	Symptoms	Pathogen/Cause	Management
Alternaria or Stemphylium Ray Speck	Pinpoint-sized dead spots develop on petals. These spots may not enlarge. If enough spots are present, the entire flower dies.	*Alternaria* or *Stemphylium*	Avoid overhead irrigation. Maintain greenhouse humidity below 98 percent. Apply chlorothalonil, propiconazole, or iprodione as a foliar spray.
Ascochyta Ray Blight	Flower development is retarded on one side of the bud. Petals exhibit a brown discoloration. Browning and blackening extend down the stem, causing the flower to droop. Brown to black, irregularly shaped spots develop on leaves.	*Ascochyta (Mycosphaerella)*	Avoid overhead irrigation. Apply chlorothalonil, propiconazole, fludioxonil, copper hydroxide, iprodione, or thiophanate methyl + mancozeb as a foliar spray.
Bacterial Blight	Cuttings turn dark brown and collapse. Surviving cuttings may be infected but have no symptoms. Established plants wilt during the day when infected and recover at night.	*Erwinia chrysanthemi*	Purchase culture-indexed cuttings that are free of the pathogen. Disinfect propagation beds between crops. Destroy infected cuttings.
Bacterial Leaf Spot	Small, dark-brown to black spots on lower leaves enlarge and become irregular in shape. When infected leaves dry, the spots become brittle and crack. The disease often spreads up plants in one side of the pot, eventually to the flowers.	*Pseudomonas cichorii*	Do not plant infected cuttings. Avoid overhead irrigation. Water in a manner that keeps leaf surfaces dry at all times. Protect plants grown outdoors from splashing.
Botrytis Blight	Light-brown spots form on lower petals. Browning spreads to other petals. Infected tissues become covered with dusty, gray spores.	*Botrytis cinerea*	Maintain greenhouse humidity below 98 percent at all times. Apply chlorothalonil as a spray or fog, or apply iprodione, mancozeb, trifloxystrobin, or fludioxonil as a foliar spray.
Chlorotic Mottle	Leaves, at first mottled, become completely yellow. Infected plants grown under low light conditions and exhibit no symptoms when temperatures average less than 69°F (20°C).	Chrysanthemum chlorotic mottle viroid	Purchase virus-indexed plants that are free of the pathogen. Destroy infected plants and disinfest tools used to handle them. Do not handle healthy chrysanthemums after handling infected plants.
Fusarium Wilt	Symptoms vary with the cultivar infected. Yellowing of leaves and wilting and discoloration of the vascular tissue develops up one side of the plant.	*Fusarium oxysporum*	Purchase culture-indexed cuttings free of the pathogen. Plant in pasteurized soil or soilless mix free of the pathogen. Maintain soil pH between 6.5 and 7.0. Use nitrate rather than ammonium forms of fertilizer. Apply thiophanate methyl as a soil drench.
Powdery Mildew	Leaves have white, dry fungal growth on their surfaces.	*Golovinomyces cichoracearum* (formerly *Erysiphe*)	Apply *Ampelomyces*, myclobutanil, piperalin, fenarimol, trifloxystrobin, propiconazole, or triadimefon.
Pythium Root and Stem Rot	Stems turn dark brown to black at the soil line. Plants are stunted, wilt, and die.	*Pythium*	Plant in pasteurized soil or soilless mix free of the pathogen. Apply potassium salts of phosphorus acid, etridiazole, mefenoxam, or thiophanate methyl + etridiazole as a soil drench.

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Chrysanthemum *(continued)*

Disease	Symptoms	Pathogen/Cause	Management
Rhizoctonia Stem Rot	Young infected plants wilt during the day and recover at night. Reddish-brown dead areas develop at the soil line and girdle the plant.	*Rhizoctonia solani*	Plant in pasteurized soil or a soilless mix free of the pathogen. Apply flutolanil, PCNB, trifloxystrobin, iprodione, thiophanate methyl, or thiophanate methyl + etridiazole as a soil drench.
Stunt	Symptoms vary with the cultivar infected. Young leaves are light green and very upright. Plants are stunted to half their normal height at maturity. Infected plants flower prematurely and flower size is reduced. Some cultivars exhibit small dead spots or flecks on the leaves.	Chrysanthemum stunt viroid	Purchase virus-indexed plants that are free of the pathogen. Destroy infected plants and disinfest tools used to handle them. Do not handle healthy chrysanthemums after handling infected plants.
Verticillium Wilt	The margins of lower leaves wilt and die, or the entire leaf dies. Symptoms proceed up one side of the plant.	*Verticillium*	Plant in pasteurized soil or soilless mix free of the pathogen.

Cineraria

Disease	Symptoms	Pathogen/Cause	Management
Alternaria Leaf Spot	Dark-brown to black spots form on leaves. These enlarge to engulf large portions of the leaf. Spots on petioles may allow them to break.	*Alternaria sensecionis*	Remove infected leaves. Water in a manner that keeps leaf surfaces dry. Maintain low humidity. Apply iprodione to protect healthy plants.
Downy Mildew	Yellow spots on leaves become black. Sparse fungal growth may appear on the underside of infected leaves.	*Plasmopara halstedii*	Water in a manner that keeps leaf surfaces dry. Remove infected leaves.
Phytophthora Root and Collar Rot	Roots and stem at the soil line rot. Plants wilt and die.	*Phytophthora cinnamomi, P. cryptogea, P. megasperma,* and *P. drechsleri*	Plant in pasteurized potting mix. Apply etridiazole to protect healthy plants.
Powdery Mildew	White fungal growth forms on the leaf surface.	*Golovinomyces cichoracearum* (formerly *Erysiphe*) or *Sphaerotheca fusca*	Heat and ventilate to maintain low humidity at night. Apply triadimefon to protect leaves.
Viruses	Leaves may be mottled, have yellow spotting, dead flecks, or line or ring spot patterns. Plant may be distorted, have flower color breaking, or be stunted. Veins may be killed along with petioles and the entire plant.	Impatiens necrotic spot, streak and mosaic viruses	Destroy infected plants. Maintain good thrips and mite control.

Cordyline (Ti Plant)

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Leaf Spot and Stem Rot	Infected leaves and stems become wet and slimy. Cuttings rot. Roots of established plants turn black and die.	*Erwinia chrysanthemi, E. carotovora* pv. *carotovor*	Purchase plants free of the disease. Discard infected plants.
Fluoride Toxicity	Leaf tips and margins brown and die.	*Excessive fluoride*	Maintain a soil pH between 6.0 and 6.5. Do not use water containing more than 0.25 ppm fluoride. Do not use a potting mix with perlite or superphosphate fertilizer.
Fusarium Leaf Spot	Tan to red-brown, oval spots form on the tips of young leaves. Spots have a bright-yellow halo.	*Fusarium moniliforme*	Avoid overhead watering. Apply thiophanate methyl as a foliar spray to protect healthy leaves.
Fusarium Stem and Root Rot	Lower leaves yellow and wilt. Roots are brown. Tan spots form on the stem at the soil line and may be covered with powdery, yellowish spores.	*Fusarium*	Avoid overhead watering. Apply thiophanate methyl as a foliar spray or soil drench to protect healthy plants. Discard infected plants.
Phyllosticta Leaf Spot	Small, round to irregular spots form on older leaves. Spots have purple borders and yellow halos.	*Phyllosticta dracaenae*	Avoid overhead watering. Apply mancozeb to protect healthy foliage.
Phytophthora Leaf Spot	Leaves near the soil are water soaked and have brown, irregular, zonate dead areas.	*Phytophthora nicotianae*	Plant in pasteurized mix. Discard infected plants. Apply dimethomorph to protect healthy plants.
Poor Color	Plants appear dull, mostly dark purple to maroon and lack rose or pink tints.	Low or high light intensity, low fertilizer level, or high temperatures	Maintain moderate fertilizer level. Shade in the summer but add light in the winter if too low. Maintain moderate temperatures.
Tip Death	Very young leaves die but the plant recovers.	Damage from fertilizer or leaf-shining chemicals	Keep fertilizer off the growing point and young leaves. Use leaf shining chemicals carefully.

Crassula (Jade Plant)

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Soft Rot	Stems and branches collapse. The interior tissues are soft and mushy.	*Erwinia*	Discard affected plants.
Powdery Mildew	Scabby or corky areas develop on leaves.	*Sphaerotheca*	Apply thiophanate methyl or triadimefon.

Cyclamen

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Soft Rot	Yellowing plants wilt and die rapidly. Corms have a wet, soft rot.	*Erwinia carotovora* or *Erwinia chrysanthemi*	Plant only healthy, sound corms. Discard infected plants. Plant in pasteurized media.
Botrytis Blight	Leaf spots become tan in color. Flower petal spots are at first water soaked but become tan. Infected crowns, petioles, and developing flowers are covered with gray fungal growth.	*Botrytis cinerea*	Reduce the humidity in the greenhouse. Space plants to ensure good air circulation. Apply chlorothalonil, iprodione, azoxystrobin, or fludioxonil to protect healthy plants.
Fusarium Wilt	Infected plants become very yellow. Vascular tissue in the corm turns dark brown to black. Mature plants wilt and die.	*Fusarium oxysporum* f. sp. *cyclaminis*	Plant sound, disease-free corms in pasteurized media. Discard infected plants.
Leaf Spots	Yellow, brown, or gray, circular spots develop on leaves and may have a zonate pattern within them. Small, dark-brown dots can be seen within the spots.	*Septoria, Gloeosporium,* or *Phyllosticta*	Water plants in a manner that does not wet the leaves. Apply thiophanate methyl or chlorothalonil to protect plants.
Pythium Root Rot	Young plants die. Stunting and root rot occur on older plants.	*Pythium*	Plant in pasteurized media. Keep hose ends off the ground. Discard infected plants.
Thielaviopsis Root Rot	Stunted plants have blackened roots.	*Thielaviopsis basicola*	Plant in pasteurized media. Discard infected plants.
Viruses	Flowers may be abnormal in shape. Leaves are deformed and streaked with yellow or brown markings or have ring spots in a thumbprint-like pattern.	Tobacco mosaic, cucumber mosaic, tobacco rattle, tomato aspermy, potato virus X, impatiens necrotic spot	Discard infected plants. Maintain good aphid and thrips control. Wash hands thoroughly and frequently when handling plants to prevent mechanical spread.

Dahlia

Disease	Symptoms	Pathogen/Cause	Management
Aster Yellows	Leaf-like tissue forms where flower parts should be located. Flower-like parts remain green or light green.	Phytoplasma	Destroy infected plants. Control leafhoppers.
Bacterial Stem Rot	Blackened stems have a soft, wet interior and a foul odor.	*Erwinia carotovora*	Promptly destroy infected plants.
Gray Mold	In wet weather, masses of gray spores form on brown spots on buds, leaves, or stems.	*Botrytis cinerea*	Maintain low relative humidity. Apply fludioxonil, iprodione, or mancozeb to protect plants.
Powdery Mildew	Dry, white, mealy fungal growth occurs on the upper surface of leaves.	*Golovinomyces cichoracearum* (formerly *Erysiphe*)	Apply mancozeb, thiophanate methyl + mancozeb, fenarimol, piperalin, sulfur, triadimefon, myclobutanil, ziram, or triforine when the fungus is first observed.
Storage Rot	Tubers decay into a soft, smelly mass.	Various fungi and bacteria	Avoid wounding the tubers. Let the tuber surfaces dry and remove soil before storing. Store tubers in a cool, dry location.
Verticillium Wilt	Single branches or the entire plant wilts and dies. Vascular tissue in affected stems is black, dark brown, or greenish brown.	*Verticillium*	Plant in pathogen-free potting mix.
Virus	Conspicuous rings and line patterns may be present or a mosaic of light and dark green may occur on leaves.	Impatiens necrotic spot virus	Discard infected plants. Do not save tubers from affected plants. Control thrips since they vector the virus.

Delphinium

Disease	Symptoms	Pathogen/Cause	Management
Aster Yellows	Leaf-like tissue forms where flower parts should be located. Flower-like parts remain green or light green. Often flowers on only one side of the spoke show symptoms. Sepals may be very large or dwarfed.	Phytoplasma	Destroy infected plants. Control leafhoppers.
Bacterial Bud Rot, Crown Rot, and Stem Rot	Yellowed leaves and stunting occur. Blackened stem bases around cracks and wounds mark the point of entry. Smelly ooze forms under wet conditions. Infected stems topple.	*Erwinia carotovora* and *Erwinia chrysanthemi*	Promptly destroy infected plants. Avoid overhead irrigation.
Bacterial Leaf Spot	Black, irregularly shaped spots form on leaves. Seedlings are killed.	*Pseudomonas syringe*	Destroy infected plants.
Diaporthe Blight	As the plants flower, lower leaves brown and die. Brown spots form on the stems at the soil line and expand upward several inches. Small, black, pimple-like fungal fruiting structures develop on infected tissue.	*Diaporthe*	Destroy infected plants. Use seed known to be free of the fungus.

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Delphinium *(continued)*

Disease	Symptoms	Pathogen/Cause	Management
Fusarium Wilt and Canker	Small, brown spots form on stems and enlarge. Brown, sunken lesion may occur on petioles. Stem cankers may be dark brown and 12 inches long. As the canker tissue dies, masses of pink spores form in clumps. Wilting plants have vascular tissue that is browned.	*Fusarium oxysporum*	Destroy infected plants.
Powdery Mildew	Dry, white, mealy, fungal growth occurs on the upper surface of leaves. Leaves turn yellow and die from the base of the stem upward.	*Erysiphe polygoni*	Apply a sulfur, triadimefon, triforine, propiconazole, ziram, myclobutanil, or fenarimol when the fungus is first observed. Destroy plant debris at the end of the season.
Storage Rot	Tubers decay into a soft, smelly mass.	Various fungi and bacteria	Avoid wounding the tubers when digging them for storage. Let the tuber surfaces dry after digging, removing soil, and before storing. Store tubers in a cool, dry location.
Virus	Conspicuous rings and line patterns may be present and plants are stunted.	Cucumber and tobacco mosaic viruses	Destroy infected plants.

Dieffenbachia

Disease	Symptoms	Pathogen/Cause	Management
Anthracnose	Circular to oval, brown leaf spots have a yellow halo. Spots may become 2 inches in diameter and contain tiny, black fungal fruiting structures.	*Colletotrichum gloeosporioides*	Avoid overhead watering. Apply mancozeb to protect healthy leaves.
Bacterial Leaf Spot	Small, gray or dark green leaf spots enlarge and become irregularly shaped, tan, dark brown, or black.	*Erwinia carotovora* or *Erwinia chrysanthemi*	Purchase plants free of the disease. Remove infected leaves, and water in a manner that keeps the surface of the leaves dry.
Marginal Leaf Burn	Margins of leaves brown and die.	Overfertilization	Do no overfertilize. If no slow-release fertilizer is present, leach the potting medium.
Myrothecium Leaf Spot	Large, gray-brown, oval leaf spots form at leaf tips or margins. Fungal fruiting structures form in concentric rings within the spots on the underside of the leaf.	*Myrothecium roridum*	Do not apply excessive amounts of nitrogen fertilizer. Apply chlorothalonil, mancozeb, or thiophanate methyl + mancozeb.
Nitrogen Deficiency	Plants are yellowed with smaller-than-normal leaves and short internodes.	Lack of fertilization	Apply a balanced fertilizer solution.
Virus	Leaves have a mosaic of light green where they should be dark green. Plants may be stunted, and leaves deformed. Some cultivars die within a month of infection.	Dasheen mosaic virus	Discard infected plants. Maintain good aphid control. Disinfest tools used on the plants.
Wilt	Lower leaves yellow, wilt, and die.	Drought	Maintain even soil moisture.

Dracaena

Disease	Symptoms	Pathogen/Cause	Management
Flecking *(Dracaena marginata)*	New leaves have small, white to yellow spots near their tips.	Unknown	Maintain moderate temperature, moisture, and light conditions.
Fluoride Toxicity	Long, tan to dark-brown areas form in the white stripes of "Warneckii" leaves. Leaf tips are yellow or dead on "Janet Craig." Tan dead areas with bright-yellow borders form along the leaf margin of "Massangeana" leaves.	Excess fluoride	Maintain soil pH between 6 and 6.5. Avoid using perlite, superphosphate, and other fluoride-containing soil amendments. Do not irrigate with water containing 1 ppm fluoride.
Fusarium Leaf Spot	Young leaves have reddish to tan spots with wide, yellow halos. Spotting occurs close to the base of the leaves.	*Fusarium moniliforme*	Avoid overhead watering. Apply thiophanate methyl, iprodione, chlorothalonil, mancozeb, or thiophanate methyl + mancozeb.
Soft Rot	Rooted cuttings have a soft, brown rot and a foul odor. Lower leaves collapse.	*Erwinia carotovora* pv. *carotovora,* or *Erwinia chrysanthemi*	Purchase plants free of the disease. Discard infected plants.

Easter Lily

Disease	Symptoms	Pathogen/Cause	Management
Botrytis Blight	Oval to circular, reddish-brown spots form on leaves. Brown spots develop on flowers.	*Botrytis cinerea*	Maintain humidity below 85%. Avoid overhead irrigation. Apply iprodione, chlorothalonil, or copper hydroxide.
Bulb Basal Rot	The basal plate is dark brown and dead. Scales fall off.	*Fusarium* and *Cylindrocarpon*	Use pasteurized potting soil. Do not plant bulbs that have a rotted basal plate. Dip bulbs in thiophanate methyl before planting.
Bulb Storage Rot	Bulb scales have brown spots and a severe rot. Bulbs may be soft and covered with a blue-green mold or white fungal growth.	Bulbs harvested while still immature are attacked by *Penicillium* (blue mold) or *Rhizopus* (soft rot) fungi.	Do not plant affected bulbs.
Curl Stripe	Plants emerge later than normal. Soon after emerging, leaves twist and have white stripes. Tops are crooked. Mildly affected plants grow on and appear normal except for the lower leaves.	Lily symptomless virus (LSV)	No chemicals control a virus. Maintain greenhouse aphid free since LSV is carried by aphids from plant to plant.
Fleck	Short, white lines develop on the leaves. Entire plant and flowers are stunted.	Cucumber mosaic virus (CMV) in combination with LSV	No chemicals control a virus once disease has begun. Maintain aphid-free greenhouses since CMV and LSV are carried by aphids from plant to plant.
Leaf Scorch	Semicircular dead areas develop along leaf margins and may engulf leaf tips.	Uncertain. Fluoride toxicity, mineral deficiency induced by root rots, and low soil pH have been implicated in scorch.	Avoid the use of superphosphate and other fluoride-containing fertilizers. Control root rots. Maintain a soil pH between 6.0 and 7.0.

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Easter Lily *(continued)*

Disease	Symptoms	Pathogen/Cause	Management
Pythium Root Rot	Lower leaves yellow and die. Roots are limp and dark brown. Flowers abort.	*Pythium*	Use pasteurized potting soil. Drench potted bulbs with mefenoxam at planting and switch to other *Pythium*-controlling fungicides for later treatments. Or, apply etridiazole, or thiophanate methyl + etridiazole as a soil drench.
Rhizoctonia Stem Rot	Bulbs are yellow rather than the normal white. Stems and scales where the stem emerges develop a soft rot, causing the plant to topple.	*Rhizoctonia*	Use pasteurized potting soil. Drench potted bulbs with PCNB, iprodione, fludioxonil, or thiophanate methyl + etridiazole at planting. Repeat treatment as stated on the fungicide label.
Scale Tip Rot	The tips of scales turn tan or dark brown to black in color.	A complex interaction of *Pseudomonas* bacteria and the fungi *Fusarium* and *Cylindrocarpon* appears to be the cause.	Do not plant affected bulbs.
Twist	Leaves along the middle stem area twist while leaves above and below appear normal.	Uncertain. *Pseudomonas* may be involved.	None.

Exacum

Disease	Symptoms	Pathogen/Cause	Management
Basal Stem Rot and Branch Blight	At high temperatures, wounded stems are killed quickly.	*Nectria haematocca*	Maintain moderate temperatures. Avoid wounding plants.
Botrytis Blight	Stems of established plants rot at the soil line. This may occur just as plants flower, killing the entire plant.	*Botrytis cinerea*	Heat and ventilate to maintain low humidity. Remove dead and dying tissue from the greenhouse.
Pythium Root Rot	Plants wilt, collapse, and die. Roots appear water soaked, limp, and brown.	*Pythium*	Use pasteurized potting soil. Discard infected plants.

Fern

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Blight (*Asplenium*, Bird's-Nest Fern)	Translucent spots develop all over the leaves, enlarge quickly, and turn reddish-brown with purple halos.	*Pseudomonas cichorii* or *P. gladioli*	Purchase plants free of the disease. Avoid overhead watering. Discard infected plants.
Foliar Nematode (*Asplenium*)	Small, dark-green spots form at the base of fronds. Spots turn brown to black as they enlarge.	*Aphelenchoides fragariae*	Discard infected plants. Avoid wetting the fronds when watering.
Frond Lobing (*Asplenium*)	Fronds have many lobes and indentations. Frond tips may be crinkled or dead.	Overfertilization	Reduce the amount of fertilizer being used and leach the pots.
Graying (*Nephrolepsis*, Boston Fern)	Leaves have a gray color and plants have few runners.	Drought	Maintain even soil moisture at all times. Examine roots for nematode and root rot symptoms.
Leaf Tip Burn	Tips of fronds and leaflets brown and die.	Overfertilization	Reduce the amount of fertilizer being used and leach the pots.
Nematodes	Foliage grays, wilts, and dies. Roots are rotted.	*Pratylenchus*	Pot in pasteurized potting mix. Discard infected plants.
Pythium Root Rot	Plants have a gray color or are yellowed, stunted, and wilted. Roots are brown and rotted.	*Pythium*	Plant in pathogen-free pasteurized potting mix. Apply potassium salts of phosphorus acid, etridiazole + thiophanate methyl to protect plants.
Rhizoctonia Blight	Brown, irregularly shaped spots form on the foliage close to the crown or sometimes at the top. Spots spread very rapidly. Webbing of the fungus forms from frond to frond.	*Rhizoctonia solani*	Plant in pathogen-free pasteurized potting mix. Apply thiophanate methyl, fludioxonil, or flutolanil as a heavy, drenching foliar spray or chlorothalonil as a spray.

Ficus

Disease	Symptoms	Pathogen/Cause	Management
Anthracnose	Greasy-appearing spots yellow and then die and have a yellow halo.	*Glomerella (Colletotrichum)*	Avoid overhead watering. Apply mancozeb to protect healthy leaves.
Bacterial Leaf Spot (*Ficus benjamina*)	Angular yellow spots are limited in size by veins. Spots become brown and leaves fall.	*Xanthomonas campestris*	Purchase plants free of the disease. Avoid overhead watering.
Branch Dieback (*Ficus benjamina*)	Leaves wilt, die, and fall. Small and eventually large branches die. Wood under the bark is black.	*Phomopsis*	Maintain even soil moisture. Prune branches when they are small. Protect plants from injury.
Cold Injury (*Ficus elastica*)	Mature leaves have large, brown blotches. Young leaves appear puckered or distorted and brown.	Temperatures below 40°F	Do not place plants near air conditioners. Maintain temperatures above 40°F.
Foliar Nematode (*Ficus elastica*)	Areas between the leaf veins yellow and die.	*Aphelenchoides*	Discard infected plants. Remove infected leaves from plants not severely affected and avoid overhead watering.
Leaf Drop (*Ficus benjamina*)	Leaves yellow and fall.	Low soil moisture and low relative humidity	Maintain even soil moisture.

Fuchsia

Disease	Symptoms	Pathogen/Cause	Management
Rhizoctonia Root Rot	Plants are stunted. Stem bases become dry and shredded. Plants die.	*Rhizoctonia*	Plant in potting media treated to eliminate pathogens. Apply PCNB.
Rust	Yellowish-orange spore masses form on the underside of leaves.	*Pucciniastrum*	Apply mancozeb or myclobutanil.

Gazania

Disease	Symptoms	Pathogen/Cause	Management
Downy Mildew	Dense, white to grayish fungal growth develops on the undersides of leaves. This can be confused with powdery mildew and should be examined with a microscope.	*Plasmopara*	Discard infected plants. Apply azoxystrobin to the remaining plants.
Pythium Root Rot	Plants yellow, wilt, and die.	*Pythium*	Pot in sterile media. Keep hose ends off the ground. Discard infected plants.

Geranium

Disease	Symptoms	Pathogen/Cause	Management
Alternaria Leaf Spot	Water-soaked spots on underside of leaf enlarge to ¼ to ½ inch. Concentric rings of dark tissue form in spots.	*Alternaria alternata*	Avoid overhead watering. Remove and destroy crop debris from benches, pots, and walkways. Apply fludioxonil, iprodione, azoxystrobin, copper hydroxide, chlorothalonil, or mancozeb to protect plants.
Bacterial Blight	Two types of symptoms may develop: (1) Small spots (less than ¼ inch) develop on underside of the leaf and become sunken and well defined. The leaf wilts and dies as the bacterium spreads through water-conducting vessels of vein and petiole. V-shaped areas form with wide part of V on leaf margins and point of V on veins. (2) Lower leaves wilt at margins while the blade and petiole remain turgid. The vascular tissue of the main stem on the side of the affected portion of the plant is discolored gray-brown. Lower leaves die and fall.	*Xanthomonas campestris* pv. *pelargonii*	Purchase culture-indexed cuttings or grow plants from seed. Immediately discard infected plants after a positive diagnosis is made. Avoid overhead irrigation. Discard all unwanted geraniums at season's end. Do not take cuttings with knives. Wash hands frequently when breaking out cuttings. Or disinfest the cutting knife frequently and thoroughly.
Bacterial Fasciation	Short, thick, fleshy, aborted stems that form at base of main stem at or below soil level are pale green or green-yellow. The rest of the plant appears healthy.	*Rhodococcus fascians*	Purchase culture-indexed plants. Discard infected stock plants and cuttings and infested media.

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Geranium *(continued)*

Disease	Symptoms	Pathogen/Cause	Management
Blackleg	Cuttings first develop a brown, water-soaked rot at the base. The coal black rot proceeds 3 to 4 inches up stem and kills the cutting rapidly.	*Pythium*	Use sterile propagation media. Discard infected cuttings since affected rooted cuttings later develop root rot (see Pythium Root Rot). Keep hose ends off the ground.
Botrytis Blight	Flowers turn dark and fall prematurely. Where infected petals land on leaves, an irregular leaf spot forms. Cutting stubs have a brown rot that may extend down stem. Cuttings develop a dark-brown rot near the base.	*Botrytis cinerea*	Avoid damaging plants in any way. Do not leave large cutting stubs. Remove and destroy fading flowers and leaves. Heat, ventilate, and space plants to ensure good air circulation and low humidity. Apply chlorothalonil, trifloxystrobin, fludioxonil, copper hydroxide, iprodione, mancozeb, or fenhexamid. Exclusive use of one chemical can result in the development of populations resistant to the chemical. Do not rely on only one chemical.
Edema	Small, water-soaked pimples or blisters form on the underside of lower leaves. Blisters become corky brown. Severely affected leaves fall.	Physiological disorder favored by cool, cloudy weather	Space plants to provide good air circulation. Plant in well-drained mix. Avoid overwatering during cool, cloudy weather.
Pseudomonas Leaf Spot	Elliptical, water-soaked ¼- to ½-inch spots form on leaves. Spots become dark brown to black and irregularly shaped. A yellow halo may or may not surround each spot.	*Pseudomonas cichorii*	Purchase disease-free cuttings. Do not irrigate overhead. Keep leaf surfaces dry at all times.
Pythium Root Rot	Root tips appear translucent and water soaked. The outer layers of root tissue strip off when pulled from soil, leaving the central core of vascular tissue bare.	*Pythium*	Pot in sterile media. Keep hose ends off the ground. Discard blackleg-infected cuttings even if well rooted. Apply potassium salts of phosphorus acid, etridiazole, etridiazole + thiophanate methyl, fosetyl-Al, dimethomorph, or mefenoxam.
Rust	Chlorotic specks on upper leaf surface appear directly opposite pustules of rust-colored spores on underside of leaf. Spores erupt in concentric rings forming a "target" spot.	*Puccinia pelargonii-zonalis*	Purchase rust-free cuttings. Do not irrigate overhead. Discard unwanted geraniums at season's end. Apply chlorothalonil, myclobutanil, flutolanil, oxycarboxin, or triadimefon to protect plants.
Southern Bacterial Wilt	Lower leaves wilt, yellow, and fall. Vascular tissue of affected stems turns brown or black.	*Ralstonia solanacearum*	Purchase culture-indexed plants. Do not bring ground-planted geraniums into the production area or propagate from them. Destroy infected plants.
Verticillium Wilt	Middle and upper leaves collapse, dry, and fall. Vascular tissue of affected stems is browned. Symptoms are readily confused with those of bacterial blight.	*Verticillium albo-atrum* or *V. dahliae*	Purchase culture-indexed cuttings. Use sterile potting mix. Destroy infected plants.
Viruses	Symptoms vary with virus, cultivar, and growing conditions. Symptoms include mottling, ring spotting, leaf cupping, yellowing of veins, leaf malformation, leaf spotting, and loss of zonation.	Many viruses occur singly and in various combinations in plant tissue.	Purchase virus-indexed cuttings. Maintain strict insect and mite control.

Gerbera

Disease	Symptoms	Pathogen/Cause	Management
Alternaria Leaf Spot	Brown specks form on florets and the leaves. Centers become white on the leaf spots.	*Alternaria*	Maintain low relative humidity and do not wet leaves when watering. Apply azoxystrobin or fludioxonil.
Bacterial Leaf Spot	Small to large spots are circular at first, then become irregular and dark brown to black. May have a concentric ring pattern.	*Pseudomonas cichorii*	Maintain low relative humidity. Avoid overhead watering.
Botrytis Blight	Petioles have long brown spots. Leaves yellow and die. Petals have tan spots. Stems at soil level are killed. Infected tissues become covered with gray fungal growth.	*Botrytis cinerea*	Space plants to ensure good air circulation. Maintain low humidity. Avoid watering late in the day. Remove crop debris. Apply azoxystrobin or fludioxonil to protect healthy plants.
Phytophthora Crown Rot	Plants wilt suddenly. Leaves brown. Roots are rotted and a crown rot develops.	*Phytophthora cryptogea*	Plant in pasteurized potting media. Avoid overhead watering. Apply etridiazole or etridiazole + thiophanate methyl to protect healthy plants.
Powdery Mildew	White fungal growth develops on the surface of leaves.	*Golovinomyces cichoracearum* (formerly *Erysiphe*)	Apply triadimefon, kresoxim-methyl, azoxystrobin, or piperalin to protect plants.
Pythium Root Rot	Plants wilt and die as roots rot.	*Pythium*	Plant in pasteurized potting media. Apply etridiazole or etridiazole + thiophanate methyl to protect healthy plants.
Rhizoctonia Crown Rot	Stems at the soil level have a brown lesion. Plants wilt and die.	*Rhizoctonia solani*	Plant in pasteurized media. Apply azoxystrobin, PCNB, thiophanate methyl, or etridiazole + thiophanate methyl to protect healthy plants.
Thielaviopsis Root Rot	Plants yellow, wilt, and die. Roots are dark brown to black.	*Thielaviopsis basicola*	Plant in pasteurized media. Apply thiophanate methyl or etridiazole + thiophanate methyl to protect healthy plants.
Viruses	Leaves may be mottled, have yellow spotting, dead flecks, line or ring spot patterns. Plants may be distorted or have flower color breaking.	Tobacco rattle, gerbera mosaic, impatiens necrotic spot, and cucumber mosaic viruses	Maintain good insect and mite control. Plant in pasteurized media. Destroy infected plants.

Gladiolus

Disease	Symptoms	Pathogen/Cause	Management
Botrytis Blight	Brown spots that may have reddish margins develop on leaves. Spots can be very small to over ½ inch in diameter. Similar spots on stems become soft and rot in wet weather. Small, clear spots on petals become brown. A neck rot may occur at the soil line. Small, black granules (sclerotia) form on the surface of the infected corms.	*Botrytis gladiolorum*	Do not plant infected corms. Purchase corms that were treated with hot water and fungicides. Apply mancozeb, chlorothalonil, iprodione, or vinclozolin to protect growing plants.
Curvularia Leaf Spot	Long, rectangular spots on leaves are tan with a brown margin and yellow halo. Concentric rings form within the enlarging spots. Corms rot.	*Curvularia trifolli* f. sp. *gladioli*	Do not plant infected corms. Plant in pasteurized soil. Apply mancozeb or chlorothalonil to protect plants. Do not use thiophanate methyl on plants suspected of being infected with *Curvularia*.
Fusarium Yellows	Roots have brown spots or general rot. Older leaves yellow. Flower size, shape, and color may be abnormal. Flowers may not develop while stalks are curved in an S shape. Corms rot from the center outward. Oval, sunken spots on the corm surface are brown and may have concentric rings.	*Fusarium oxysporum* f. sp. *gladioli*	Do not plant infected corms. Maintain a soil pH of 6.6 to 7.0 and use nitrate as the nitrogen source when fertilizing.
Nematodes	Root system is small. Plants are stunted and flower late. Galls may form at nodes. Fusarium yellows may be severe.	*Meloidognye, Pratylenchus, Trichodorus, Belonolaimus, Ditylenchus, Hemicyliophora, Rotylenchus*	Plant in soil that has been steamed or chemically pasteurized. Maintain good weed control.
Scab	Brown, round, sunken areas with raised edges are on corms. A soft rot of the neck develops.	*Pseudomonas marginata*	Do not plant infected corms. Disinfest cutting knives frequently. Maintain good mite and insect control. Water in a manner that keeps leaf surfaces dry. Avoid working on wet plants.
Stemphylium Leaf Spot	Small, round, yellow spots have a distinct reddish center when held up to the light. Mature leaves have the most spotting.	*Stemphylium botryosum*	Apply mancozeb, ziram, or chlorothalonil before any disease begins.
Stromatinia Dry Rot	Corm scales are brown and may appear shredded. Small reddish-brown spots on the surface of the corm can be removed, leaving a clean, shallow, sunken area. Corms are dry, hard, and mummified. Clusters of plants are killed by neck rot.	*Stromatinia gladioli*	Do not plant infected corms. Purchase corms that have been treated with hot water and fungicides. Plant in soil that has been pasteurized with chemical fumigants or steam. If infection is noted after planting, apply maneb + zinc until flower production is complete. Then discard corms.
Viruses	Flowers are small, distorted, or have color breaking. Leaf tissue may be mottled or have white flecks or reddish blotches.	Bean yellow mosaic, cucumber mosaic, tomato ring spot, tobacco ring spot	Maintain good insect control. Plant in pasteurized soil free of nematodes and weeds. Destroy infected plants as soon as they are found.

Gloxinia

Disease	Symptoms	Pathogen/Cause	Management
Boron Deficiency	Small, dark-brown to black, irregularly shaped spots form at the leaf base of seedlings. Plants wilt and die as the browning spreads up the leaf blade. On older plants, flower stalks are short and wilted. Plants die.	Lack of boron	Apply boron.
Botrytis Blight	Small, water-soaked lesions form on damaged petioles and spread to leaf blades. Infected flowers fade prematurely.	*Botrytis cinerea*	Space plants and provide ventilation to avoid high humidity. Remove fading flowers and yellowing leaves. Apply chlorothalonil, iprodione, or vinclozolin to protect healthy tissue.
Foliar Nematode	Small, tan, sunken areas form on leaf tips and margins. Spots become dry and dull black.	*Aphelenchoides ritzema-bosi*	Destroy infected plants. Water plants in a manner that keeps leaf surfaces dry and does not splash from plant to plant.
Myrothecium Rot	Petioles of lower leaves develop darkened spots. Spots enlarge down stems and stems are easily broken.	*Myrothecium roridum*	Plant in pasteurized media. Apply iprodione to leaves and stems. Maintain moderate temperatures and low humidity.
Phytophthora Crown Rot	Crowns and roots have a dark, water-soaked appearance. This spreads to petioles and leaf blades. Young plants are quickly killed. Rhizomes of mature plants resprout but eventually succumb.	*Phytophthora nicotianae, P. cryptogea*	Do not propagate from infected plants. Pot in pasteurized media. Destroy infected plants. Apply potassium salts of phosphorus acid, etridiazole, etridiazole + thiophanate methyl, or mefenoxam to protect healthy plants.
Pythium Root Rot	Roots are dark brown. Plants wilt, yellow, and die.	*Pythium*	Do not overwater plants. Pot in pasteurized media. Keep hose ends off the ground. Apply potassium salts of phosphorus acid, etridiazole, etridiazole + thiophanate methyl, or mefenoxam.
Viruses	Leaves may be downwardly cupped, mottled, or strap shaped. Leaves may have line or ring spot patterns. Shoots may be elongated.	Tobacco mosaic, tomato ring spot, and impatiens necrotic spot virus	Maintain good thrips control. Do not take cuttings from infected plants. Destroy infected plants. Eliminate weeds within the production area. Use very fine mesh screen to keep thrips out. Do not use tobacco products when handling plants.

Gypsophila

Disease	Symptoms	Pathogen/Cause	Management
Alternaria Flower Blight	Flowers turn black.	*Alternaria*	Apply iprodione, mancozeb, or maneb + zinc.
Botrytis Blight	Bud scales and stems turn ash-gray and stems die.	*Botrytis cinerea*	Space plants to ensure good air circulation. Maintain low humidity. Avoid watering late in the day. Remove crop debris. Apply iprodione or mancozeb.
Phytophthora Crown Rot	Plants wilt. Stems at the soil level have a wet rot. Plants die and are easily pulled up.	*Phytophthora*	Plant in pasteurized soil. Apply mefenoxam, etridiazole, potassium salts of phosphorus acid, or etridiazole + thiophanate methyl to protect healthy plants.
Pythium Root and Stem Rot	A wet rot develops at the base of young plants. Leaves yellow, wilt, and die.	*Pythium* spp.	Plant in pasteurized soil. Do not overwater or overfertilize plants. Apply mefenoxam etridiazole, potassium salts of phosphorus acid, or etridiazole + thiophanate methyl to protect healthy plants.
Rhizoctonia Stem Rot	Stems rot at the soil level, split longitudinally, and have a dry, shredded appearance but are not easily pulled out.	*Rhizoctonia solani*	Plant in pasteurized raised beds. Apply PCNB, thiophanate methyl or iprodione as a soil drench to protect healthy plants.

Hydrangea

Disease	Symptoms	Pathogen/Cause	Management
Botrytis Blight	Petals turn brown and fall. Leaf spots form, especially where faded petals have fallen. Flower buds are killed before opening.	*Botrytis cinerea*	Space plants to ensure good air circulation. Maintain low humidity. Avoid watering late in the day. Remove crop debris. Apply chlorothalonil, iprodione, mancozeb, or vinclozolin.
Powdery Mildew	Yellow areas form on leaves. These may become purplish. White, cottony fungal growth forms on the lower surface of the leaf.	*Erysiphe polygoni*	Apply triadimefon, piperalin, thiophanate methyl, or fenarimol to protect leaves.
Virescence	Flowers are green and may be stunted. Leafy shoots grow from the flower parts. Plants decline and die.	Phytoplasma	Discard infected plants. Maintain good insect control.
Viruses	Leaves may be mottled, have yellow spotting, dead flecks, line or ring spot patterns. Plants may be distorted or have flower color breaking, or few flowers.	Hydrangea ring spot, tomato ring spot, impatiens necrotic spot	Plant virus-indexed cuttings. Maintain good insect and mite control. Destroy infected plants.

Impatiens

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Fasciation	Plants stunted and have many short shoots at the crown.	*Corynebacterium fascians*	Discard infected plants. Do not propagate from infected plants. Propagate and plant in pasteurized potting media.
Botrytis Blight	Flowers are spotted and stems rot.	*Botrytis cinerea*	Reduce humidity and maintain good air circulation. Do not space plants too closely. Remove fading flowers and yellowing leaves. Apply iprodione to protect plants. If plants are not flowering, chlorothalonil can be applied.
Damping-Off	Stems at the soil line die and plants collapse.	*Pythium* or *Rhizoctonia*	Plant in pasteurized potting media. Keep hose ends off the ground.
Powdery Mildew (New Guinea Impatiens)	White, mealy fungal growth develops on the top of leaves. Sometimes, heavy gray growth develops.	*Oidium*	Apply triflumizole to protect plants. If plants are not flowering, chlorothalonil can be applied.
Pythium Root Rot	Lower leave wilt, leaves fall, and the plant dies.	*Pythium* spp.	Pot in pasteurized, pathogen-free media. Keep hose ends off the ground. Apply potassium salts of phosphorus acid, dimethomorph, mefenoxam, or fosetyl-Al to protect healthy plants.
Thielaviopsis Root Rot	Roots become dark brown and rot. Lower stems have sunken lesions when infected.	*Thielaviopsis basicola*	Pot in pasteurized, pathogen-free media. Keep hose ends off the ground. Apply thiophanate methyl or etridiazole + thiophanate methyl to protect plants.
Verticillium Wilt	Lower leaves yellow and fall. Infected plants may recover.	*Verticillium dahliae*	Pot in pasteurized, pathogen-free media. Do not take cuttings from infected plants.
Virus	Ring spots on leaves. Death of growing tips. Severe stunting.	Impatiens necrotic spot virus	Discard infected plants. Control thrips that carry the virus. Do not propagate from infected plants.

Iris

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Leaf Blight	Faint, water-soaked spots on leaves enlarge along the leaf when weather is wet but cease activity when it is dry.	*Xanthomonas campestris* pv. *tardicrescens*	Remove infected leaves. Avoid overhead irrigation.
Botrytis Rhizome Rot	Few leaves emerge in the spring. Leaves are yellowed, turn brown, and die. Gray masses of fungal spores form on infected leaf tissue. Rhizomes have a dry, mealy rot. Large, shiny, black, granule-like structures (sclerotia) form on the surface of infected rhizomes.	*Botrytis convoluta*	Do not plant infected rhizomes. Destroy infected plants.
Crown Rot	Leaves die slowly from the tips. White fungal threads can be found at the leaf bases. Tan, spherical structures (sclerotia) form between rotting leaves.	*Corticium rolfsii*	Discard infected bulbs.
Ink Spot (Bulbous Iris)	Tiny spots and streaks on leaves enlarge and become dark reddish brown. Spots may become gray in the center. During wet weather, dark masses of spores form in the spots. The plants yellow and die prematurely. Heavily infected bulbs may rot before flowering occurs.	*Drechslera iridis*	Destroy leaf debris. Apply iprodione, chlorothalonil, triadimefon, or mancozeb when leaves are 6 to 8 inches long. Remove and destroy infected bulbs.
Leaf Spot	Small, brown spots with water-soaked margins turn yellow, enlarge, and develop reddish-brown borders. Leaves die. Dark fungal spores can be seen within the spots with a magnifying glass.	*Mycosphaerella macrospora (Didymellina)*	Remove and destroy infected leaves and leaf debris. Apply chlorothalonil, propiconazole, thiophanate methyl, triadimefon, or mancozeb when leaves are 6 to 8 inches long.
Nematodes	Black streaks develop along the veins of outer leaves of bulbs. The basal plate is gray and separated from the outer scales by a dark, sunken groove.	*Ditylenchus destructor*	Destroy infected bulbs. Plant in nematode-free soil.
Soft Rot	Leaves collapse suddenly or die gradually from the tips. The base of infected leaves and infected rhizomes have a foul-smelling soft rot.	*Erwinia carotovora* pv. *carotovora*	Destroy infected rhizomes. Control iris borers, which often cause the injury where the bacteria initially gain entry.
Virus	Mild mosaic on flower stalks and spathe (mild mosaic virus). Yellow-green stippling and stunting (severe mosaic virus). Flower color breaking and puckering can occur.	Iris mild mosaic, iris severe mosaic, cucumber mosaic (all aphid transmitted), broad bean wilt, tobacco ring spot, tobacco rattle, bean yellow mosaic, narcissus latent virus, bearded iris mosaic, beardless iris mosaic	Most iris cultivars tolerate viruses. Destroy severely affected plants.

Ivy (English, *Hedera*)

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Leaf Spot	Circular, dark-brown to black spots with yellow halos develop on leaves. Leaves yellow, die, and fall.	*Xanthomonas campestris* pv. *hederae*	Purchase plants free of the disease. Discard infected plants. Water in a manner that keeps the surface of the leaves dry. Apply potassium salts of phosphorus acid.
Fungal Leaf Spot	Large, irregularly shaped, tan to brown spots have numerous tiny, dark-brown dots (fruiting structures) within them.	*Colletotrichum trichellum*	Same as for bacterial leaf spot.

Ivy (Grape, *Cissus*)

Disease	Symptoms	Pathogen/Cause	Management
Powdery Mildew	Dry, white fungal growth develops on leaves.	*Oidium*	Apply piperalin, thiophanate methyl, or triadimefon.

Kalenchöe

Disease	Symptoms	Pathogen/Cause	Management
Phytophthora Root and Crown Rot	Crowns and roots have dark brown spots at the soil-level that spread up the stem. Plant wilts and dies. Roots are killed.	*Phytophthora*	Plant in pasteurized potting mix. Discard infected plants.
Powdery Mildew	Tan, scabby spots form on leaves. These may become covered with white fungal growth or remain scabby.	*Sphaerotheca humili*	Apply thiophanate methyl, mancozeb, triadimefon, triforine, or thiophanate methyl + mancozeb to protect leaves.
Virus	Leaves may be mottled and have yellow spotting, dead flecks, line or ring spot patterns. Plants may be stunted and not flower.	Top-spotting virus	Plant virus-indexed cuttings. Maintain good insect and mite control. Destroy infected plants. Do not take cuttings from infected plants.

Maranta

Disease	Symptoms	Pathogen/Cause	Management
Cucumber Mosaic Virus	Leaves are small and distorted. Bright-yellow line patterns form on the leaves.	Cucumber mosaic virus	Destroy affected plants. Propagate from plants free of the symptoms. Maintain good aphid control in the greenhouse.
Helminthosporium Leaf Spot	Small, water-soaked leaf spots yellow and die. Spots merge and become large, irregular, tan areas with yellow halos.	*Drechslera setariae* (formerly *Helminthosporium*)	Avoid overhead watering. Apply chlorothalonil to protect healthy foliage.
Root Knot Nematode	Plants are stunted. Normally tuberous roots appear beaded and galled.	*Meloidogyne*	Discard infected plants. Or, take top cutting and discard the roots and soil. Plant in pasteurized mix.
Tip Burn	Leaf tips and margins turn brown and die. There may be yellow between the dead and live tissue.	Phosphate fertilizer, fluoride toxicity, or high light intensity	Water and fertilize moderately. Avoid using superphosphate and perlite since they contain excessive fluoride.
Yellowing	Young leaves are yellowed.	Lack of fertilizer, iron deficiency	Maintain soil pH near 6. Use micronutrients or iron chelate to avoid iron deficiency.

Marigold

Disease	Symptoms	Pathogen/Cause	Management
Alternaria Leaf Spot	Purplish spots form on leaves and stems.	*Alternaria*	Avoid overhead irrigation. Apply chlorothalonil, propiconazole, iprodione, fludioxonil, azoxystrobin, neem oil, myclobutanil, copper hydroxide, mancozeb, or thiophanate methyl + mancozeb.
Bacterial Leaf Spot	Small (2 to 5 mm), circular dead spots form on leaves and petioles. Spots have purple margins.	*Pseudomonas tagetis*	Destroy infected plants. Avoid overhead irrigation.
Botrytis Flower Blight	Flower parts brown and die. Gray masses of spores form on the infected tissue when wet.	*Botrytis cinerea*	Avoid overhead irrigation. Apply chlorothalonil , fludioxonil, azoxystrobin, iprodione, mancozeb, thiophanate methyl + mancozeb, or ferbam.
Fusarium Wilt	Seedlings are killed. In older plants, black streaks darken the vascular tissue up one side of the plant. Plants wilt. Roots on the greatly reduced root system are rotted. During wet weather, salmon-colored spore masses form on infected stems.	*Fusarium oxysporum*	Plant in potting mix free of pathogens. Destroy infected plants.
Leaf Burn	The tips and margins of leaves yellow and die.	Excess boron, manganese, or molybdenum	Measure and apply micronutrient solutions carefully. Manganese should not be above 55 ppm, molybdenum above 24 ppm, or boron above 3 ppm.
Septoria Leaf Spot	Oval to irregular, gray to black spots with tiny dots peppering their surface (fungal fruiting structures) form first on lower leaves and then spread upward.	*Septoria tageticola*	Avoid overhead irrigation. Apply propiconazole, fludioxonil, or chlorothalonil.

Narcissus

Disease	Symptoms	Pathogen/Cause	Management
Basal Rot	Plants are stunted and foliage dies prematurely. The few roots present are brown and the basal plate is decayed. White or pink fungal growth develops between the bulb scales.	*Fusarium oxysporum* f. sp. *narcissii*	Do not plant bulbs that have white or pink fungus on them. Purchase and plant bulbs that were treated with hot water.
Fire	Flowers are spotted, turn brown, and die. Small, tan, oval spots form near leaf tips. Leaves have bright-yellow streaking near tips.	*Botryotinia polyblastis*	Discard infected plants. Apply thiophanate methyl, or chlorothalonil to protect healthy plants.
Lesion Nematode	Plants are stunted and the foliage dies prematurely.	*Pratylenchus penetrans*	Purchase and plant bulbs that were treated with hot water. Discard infected plants.
Scorch	Reddish-brown spots with yellow halos develop on leaf tips as they emerge. The spots enlarge, merge together, and the leaves die. Spots have small, brown dots (fruiting structures) within them.	*Stagnospora curtisii*	Purchase and plant bulbs that have been treated with hot water. Apply thiophanate methyl as new leaves emerge.
Stem and Bulb Nematode	Leaves from infected bulbs are small, distorted, and sometimes swollen. Infected bulbs are rotted and feel lighter than normal at planting.	*Ditylenchus dipsaci*	Purchase and plant bulbs that have been treated with hot water. Discard infected bulbs.
Viruses	Leaves may have a mosaic, have yellow to white stripes, or have dead tips, and die prematurely.	Many viruses are known including white streak, narcissus tip necrosis, cucumber mosaic, yellow stripe, tobacco ring spot, and tomato ring spot	Discard infected plants. Maintain good insect control.

Norfolk Island Pine

Disease	Symptoms	Pathogen/Cause	Management
Anthracnose	Small dead areas form on needles and the entire needle dies. Small, black fungal fruiting bodies are seen in the dead tissue. Large portions of branches brown and needles fall.	*Colletotrichum derridis*	Avoid overhead watering. Keeping the surface of the foliage dry will prevent this disease.
Branch Droop	Excessive drooping of branches although trunk is straight. Plants develop poorly.	Low light intensity	Provide at least 6,000 ft-c of light to plants more than 6 inches tall.
Root Rot	Plants grow slowly and wilt. Roots are small, brown to black, and soft and rotting.	*Cylindrocladium* or *Pythium*	Pot in pasteurize mix. Maintain even soil moisture. Etridiazole soil drench will protect against *Pythium.*
Yellowing	Branch tips and the main growing tip is yellow instead of dark green.	Micronutrient deficiency	Apply a micronutrient solution.

Palm

Disease	Symptoms	Pathogen/Cause	Management
Cold Injury	Reddish dead areas form on leaves within 5 days of exposure.	Temperatures below 40°F	Do not place plants near air conditioners. Maintain temperatures above 45°F.
Fluoride Injury	Chamaedorea palms' leaf tips turn dark brown and die. On areca palms, small dead spots form in chains between leaf veins.	Excessive fluoride in soil	Maintain soil pH between 6 and 6.5. Avoid using perlite and superphosphate. Do not irrigate with water containing 1 ppm fluoride.
Helminthosporium Leaf Spot	Reddish-brown to black oval spots less than ¼ inch in diameter merge to become irregular in shape.	*Drechslera setariae, Exerohilum rostratum, Phaeotrichoconis crotalariae*	Avoid overhead watering. Apply chlorothalonil or iprodione to protect healthy leaves.
Iron or Copper Toxicity	Oval dead leaf spots have yellow halos and may be confused with Helminthosporium leaf spot.	Excessive iron fertilization or copper fungicide use	Do not use copper fungicides. Do not use iron sequestrene under low-light, high-nutrient conditions.
Leaf Burn	Tips of lower leaves turn brown and die.	Excessive fertilization	Maintain moderate levels of fertilizer.

Pansy

Disease	Symptoms	Pathogen/Cause	Management
Anthracnose	Dead spots 1/8 to ¼ inch with dark-brown margins and gray centers form on leaves. Dark, concentric lines form within the spots. Sunken, brown to tan spots form on stems, girdle them, and kill the plant.	*Colletotrichum violae-tricoloris*	Apply mancozeb or thiophanate methyl + mancozeb.
Cercospora Leaf Spot	Small, black, circular spots form on the lower leaves under moist conditions.	*Cercospora*	Apply myclobutanil, mancozeb, triadimefon, chlorothalonil, or thiophanate methyl + mancozeb during wet weather.
Fusarium Wilt	Plants wilt and die quickly. Roots are rotted.	*Fusarium oxysporum*	Destroy infected plants.
Pythium Root Rot	Lower leave yellow as root rot. This is easily confused with Thielaviopsis root rot.	*Pythium*	Plant in pathogen-free potting mix. Avoid overwatering. Discard flats of infected plants. Fungicides effective for *Pythium* tend to stunt young pansies. Apply potassium salts of phosphorus acid, thiophanate methyl + etridiazole, mefenoxam, fosetyl-Al, or dimethomorph.
Scab	Round spots up to ¼ inch in diameter that are yellow or cream colored form on any part of the plant. Spots are slightly raised and appear scabby. Infected leaf tissue may fall out leaving holes in the leaf. Stems are girdled and plants die.	*Sphaceloma violae*	Apply mancozeb, or thiophanate methyl + mancozeb.
Stunt	Young plants are stunted and thick.	Lack of boron	Maintain a soil pH below 7. Have a water test done to be certain calcium and sodium are not too high.

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Pansy *(continued)*

Disease	Symptoms	Pathogen/Cause	Management
Thielaviopsis Root Rot	Roots have black spots. Many roots are killed. Lower leaves yellow. This is easily confused with Pythium root rot.	*Thielaviopsis basicola*	Plant in pathogen-free potting mix. Avoid water and heat stress, particularly on plugs. Discard flats of infected plants. Fungicides will not cure plants once infected.
Virus	Plants are stunted and rosetted. Plants may be completely yellow. Abnormal streaks of color form in the flowers. Flower parts may curl inward.	Curly top and cucumber mosaic viruses	Destroy infected plants.

Petunia

Disease	Symptoms	Pathogen/Cause	Management
Botrytis Blight	Flowers have small, translucent, or dead spots.	*Botrytis cinerea*	Maintain low relative humidity. Apply chlorothalonil, mancozeb, or fludioxonil to protect plants.
Phytophthora Crown Rot	Branches wilt and the plant rapidly dies at the crown. Young plants are quickly killed. Outdoors, if the weather is dry, the stem at the soil line may have a dry rot.	*Phytophthora nicotianae*	Use pasteurized potting mix or soilless mix known to be free of pathogens. Discard flats containing infected plants. Apply mefenoxam, dimethomorph, chlorothalonil, etridazole, etridiazole + thiophanate methyl, or propamocarb to protect remaining plants.
Stunt	Young plants are stunted and thick.	Lack of boron	Maintain a soil pH below 7. Have a water test done to be certain calcium and sodium are not too high.
Virus	Small etches on the leaf are surrounded by a dark halo.	Impatiens necrotic spot virus (INSV)	Destroy infected plants. Take steps to control western flower thrips. Examine other plants in the greenhouse for INSV symptoms and destroy them.

Philodendron

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Leaf Spot	Translucent spots on leaf margins become reddish brown with yellow halos. Large spots are tan and irregularly shaped.	*Xanthomonas campestris* pv. *dieffenbachiae*	Purchase plants free from the disease. Avoid overhead watering. Remove infected leaves.
Bacterial Blight (*Philodendron selloum*)	Small, very dark green spots on leaves expand rapidly and spread to petioles. Infected leaves collapse in a foul-smelling wet rot.	*Erwinia caratovora* pv. *carotovora, E. chrysanthemi*	Avoid overhead watering. Remove infected leaves of plants not severely affected. Water in a manner that keeps the surfaces of leaves and petioles dry at all times.
Cold Injury	Very dark green to brown blotches form between leaf veins.	Temperatures below 50°F	Do not place plants near air conditioners. Maintain temperatures above 55°F.
Magnesium Deficiency	V-shaped yellow areas form on leaves, especially in cool greenhouses.	Insufficient magnesium	Apply one teaspoon magnesium sulfate (Epsom salts) per gallon of water.
Tip Curl	Leaf tips curl downward and leaf margins brown. Roots die.	Overfertilization	Reduce fertilizer rate and leach the soil if slow-release fertilizer is not present. Repot if slow release is excessive.

Poinsettia

Disease	Symptoms	Pathogen/Cause	Management
Ammonium Toxicity	Root and top growth is restricted. Lower leaves yellow while leaf margins burn.	Favored by low light and low temperature in late fall, acidic potting mix, and exclusive use of ammonium nitrogen source	Do not use ammonium nitrogen sources exclusively. Do not overwater during periods of low light and low temperature.
Bacterial Canker	Longitudinal, water-soaked streaks on stems and spots on leaves. Defoliation and plant death follow.	*Curtobacterium poinsettia*	Destroy infected plants. Avoid overhead irrigation.
Bacterial Stem Rot	Cuttings develop a soft rot at the base that moves upward quickly and kills the cutting. Wounded stems of older plants develop soft rot and lodge.	*Erwinia carotovora*	Use sterile propagation media. Discard infected cuttings and infested media. Destroy infected plants and crop debris. Disinfest tools.
Botrytis Flower Blight	Brown spots form on flower, leaf, or stem tissue.	*Botrytis cinerea*	Avoid damaging plants. Remove damaged tissues. Space plants to provide good air circulation. Heat and vent to reduce humidity. If these practices are followed, then fungicides can help in management. Apply chlorothalonil (thermal smoke) to dry foliage not blossoms; or fenhexamid or iprodione to foliage.
Botrytis Stem Canker	Large, light-brown to tan, slightly sunken cankers form on older stems especially near large branches or crotches. Defoliation and death of branches occur above cankers that girdle stems.	*Botrytis cinerea*	Avoid damaging established, well-branched plants. Apply fludioxonil, trifloxystrobin, chlorothalonil, or iprodione to stems.

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Poinsettia *(continued)*

Disease	Symptoms	Pathogen/Cause	Management
Leaf Drop	Defoliation.	Root rot, overfertilization, low light intensity, or lack of moisture	Avoid root rots and overfertilization. Clean the greenhouse covering and space plants well. Maintain even soil moisture levels.
Magnesium Deficiency	Yellowing develops between the veins of middle and lower leaves.	Insufficient magnesium	Use of magnesium-containing limestone. Apply a magnesium-containing fertilizer.
Molybdenum Deficiency	Yellowing is followed by burning of lower leaf margins. Lower leaf margins are cupped downward.	Lack of molybdenum or acidic pH potting mixes (pH 4.5; 5.5 on some cultivars)	Lime to adjust the soil pH above 5.5. Use a molybdenum-containing fertilizer or a complete minor element supplement, or add sodium molybdate to soluble fertilizer.
Overfertilization	Plants are stunted. Lower leaves yellow and fall. Leaf margins yellow and burn.	The combined use of slow-release and soluble fertilizer or soluble fertilizer use with no leaching favors this. Conductivity readings at or above 1.0 mS for soil or 2.5 mS for soilless mixes (saturated paste extract) are excessive.	Do not combine the use of slow-release and soluble fertilizers. In continuous feed programs, 10% of the soluble fertilizer applied should leach out the bottom or clear tap water should be applied every second or third watering. If soluble salts become excessive, leach heavily, wait overnight, and leach again.
Phytophthora Root and Stem Rot	The base of infected stems appear soft and wet. Roots are brown and water soaked. Cuttings wilt and die rapidly. Under dry conditions, the pith of the lower stem is brown and the stem has a gray canker.	*Phytophthora nicotianae*	Immediately discard infected plants. Use pasteurized soil and clean pots and tools. Keep hose ends off the ground. Apply potassium salts of phosphorus acid, mefenoxam, dimethomorph, or etridiazole as a soil drench.
Powdery Mildew	Yellow spots form on the upper surface of leaves. White fungal growth in patches is seen on leaves and bracts.	*Oidium*	Scout stock plants frequently and inspect cuttings as soon as they arrive. Continue scouting throughout the season, especially as plants are being spaced. Apply thiophanate methyl, piperalin, or kresoxim methyl as soon as any mildew is found. Control must prevent disease before bracts form. Fungicides do not make the white fungus go away after it is dead.
Pythium Root Rot	Early in season, the rooted cuttings are stunted, yellow, and wilting. Roots are dark brown and the outer layers of root tissue strip off leaving a bare strand of inner vascular tissue exposed. Later in the season, plants defoliate and flower prematurely.	*Pythium*	Use only sterile soil and clean pots and tools. Keep hose ends off the ground. Do not overwater or overfertilize plants. Apply potassium salts of phosphorus acid, etridiazole, dimethomorph, mefenoxam, or etridiazole + thiophanate methyl.
Rhizoctonia Root Rot	Early in the season, cuttings wilt and yellow. Roots are rotted. Lower stems below ground may have a shredded appearance. Later, stunted plants defoliate, flower prematurely, and die. Sunken, dark-brown areas on stem may reach slightly above soil line.	*Rhizoctonia solani*	Use only sterile soil and clean tools, and hang us hose ends. Do not overfertilize. Apply PCNB, etridiazole + thiophanate methyl, fludioxonil, flutolanil, triflumizole, or iprodione at planting.

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Poinsettia *(continued)*

Disease	Symptoms	Pathogen/Cause	Management
Scab	Small, light-colored, round spots with yellow halos form on the leaf, particularly along the main vein. Infected stems stretch several inches above the normal crop.	*Sphaceloma poinsettiae*	Maintain low relative humidity in the crop canopy. Do not wet the foliage when irrigating. Apply azoxystrobin, trifloxistrobin, triflumizole, or triadimefon to protect plants.
Thielaviopsis Root Rot	Late in the season, roots turn black. Plant wilt. Longitudinal splits form at the stem base at and below soil line. Leaves yellow and fall.	*Thielaviopsis basicola*	Use only sterile soil and clean tools, and hang up hose ends. Apply thiophanate methyl or etridiazole + thiophanate methyl.

Pothos

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Leaf Spot	Water-soaked spots with yellow halos spread rapidly on leaves. Centers of the spots fall out under wet conditions.	*Pseudomonas cichorii*	Avoid overhead watering. Discard infected plants.
Pythium Root Rot	Cuttings have poor root systems and yellow leaves. Leaves of established plants yellow and die. Stems have a mushy black rot.	*Pythium*	Plant in a potting mix free of pathogens. Apply mefenoxam, potassium salts of phosphorus acid, dimethomorph, or etridiazole to protect healthy plants.
Rhizoctonia Stem Rot	Stems at the soil level are killed. Under wet conditions, a fine webbing of fungal growth can be observed on the soil surface near the infected stems.	*Rhizoctonia*	Plant in a potting mix free of pathogens. Apply iprodione as a spray directed at the base of the stems or PCNB as a drench.

Primula

Disease	Symptoms	Pathogen/Cause	Management
Aster Yellows	Plants are stunted with excessive branching and yellow, strap-shaped leaves.	Phytoplasma	Destroy infected plants. Maintain good insect and weed control in the greenhouse.
Botrytis Blight	Leaves, especially those near the soil surface, rot and become covered with gray fungal growth as do fading flowers.	*Botrytis cinerea*	Heat and ventilate to maintain low humidity. Remove dead and dying tissue from the greenhouse. Apply chlorothalonil, iprodione, or azoxystrobin.
Damping-Off	Seedlings wilt and die.	*Pythium* spp.	Plant in pasteurized potting mix. Discard infected plants. Apply mefenoxam to protect healthy plants.
Phytophthora Root Rot	Roots rot and plants wilt and die.	*Phytophthora primulae*	Plant in pasteurized potting mix. Discard infected plants. Apply potassium salts of phosphorus acid or mefenoxam to protect healthy plants.
Rhizoctonia Crown Rot and Bud Blight	Roots and stems brown. Plants wilt and die. Older plants may fail to flower or produce new leaves.	*Rhizoctonia solani*	Plant in pasteurized potting mix. Discard infected plants. Apply iprodione or PCNB to protect healthy plants.

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Primula *(continued)*

Disease	Symptoms	Pathogen/Cause	Management
Thielaviopsis Root Rot	Small, black spots form on roots. Gradually, the entire root system browns. Old leaves die while younger leaves yellow.	*Thielaviopsis basicola*	Plant in pasteurized potting mix. Discard infected plants. Apply thiophanate methyl as a soil drench to protect healthy plants.
Viruses	Leaves may be mottled, yellowed, curled, or have dead spots. Plants are stunted. Flower color may break. Entire plants may die.	Tobacco necrosis, primrose mosaic, cucumber mosaic, impatiens necrotic spot, tomato bushy stunt, alfalfa mosaic, or tobacco ring spot	Discard infected plants. Maintain good insect control, especially aphids and thrips.

Rose

Disease	Symptoms	Pathogen/Cause	Management
Anthracnose	Dark-purple to black spots are bordered by a narrow, dull-brown band. Centers of spots turn gray and fall out. Spots form on canes, similar to leaf spots.	*Sphaceloma rosarum*	Maintain good sanitation. Black spot control procedures (below) also control anthracnose.
Black Spot	Brown to black, round spots with feathery edges form on leaves. Leaves yellow and fall. Small, purplish spots form on canes.	*Diplocarpon rosae*	Remove infected canes. Remove and destroy fallen leaves. Water in a manner that keeps foliage surfaces dry. Apply one of the following to protect new foliage: chlorothalonil, propiconazole, neem oil, mancozeb, thiophanate methyl, thiophanate methyl + mancozeb, chlorothalonil + thiophanate methyl, copper hydroxide, ziram, captan, trifloxystrobin, or triforine. Triadimefon can stunt some cultivars.
Botrytis Blight	Small, water-soaked lesions form on petals. Gray fungal growth covers infected petals. Stubs left after harvest become infected. The fungus then moves down to girdle the cane.	*Botrytis cinerea*	Space plants and provide ventilation to avoid excessively high humidity. Remove fading flowers and yellowing leaves. Apply chlorothalonil, trifloxystrobin, fenhexamid, iprodione, or azoxystrobin to protect healthy tissue. Heat and ventilate to maintain low humidity.
Cankers	Reddish-brown spots on canes turn light to dark brown and become covered with tiny, black dots. Cankers girdle and kill the cane.	*Coniothyrium fuckelii, Cryptosporella umbrina, Coniothyrium wernsdorffiae, Cylindrocladium scoparium*	Do not plant stock with cankers. Remove infected canes, making the cut immediately above a bud. Apply a fungicide (see black spot) after pruning. Sterilize the shears with bromine disinfestant between cuts. Maintain even soil moisture and fertilization.
Crown Gall	Small, white to cream-colored galls form on stems. Galls may enlarge to 6 inches in diameter. Galls can form on roots or stems.	*Agrobacterium tumefaciens*	Do not plant infected material. Steam sterilized beds where infected plants were grown. Remove and destroy infected plants. Apply *Agrobacterium radiobacter* to protect healthy plants.

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Rose *(continued)*

Disease	Symptoms	Pathogen/Cause	Management
Damping-Off	Cuttings fail to root, defoliate, and die. Roots are killed.	*Pythium*	Pot and propagate in pasteurized media. Use clean, disinfested tools. Discard infected plants. Do not leave cuttings in mist beds for excessive periods. Pot as soon as rooted.
Downy Mildew	Purplish-brown spots form on leaves. Leaves yellow and fall. Small spots or long, purplish areas may form on canes and may kill twigs.	*Peronospora sparsa*	Heat and ventilate to maintain low humidity. Water in a manner that keeps leaf surfaces dry. Apply potassium phosphate, potassium salts of phosphorus acid, trifloxystrobin, mancozeb, azoxystrobin, dimethomorph, or mancozeb + thiophanate methyl.
Powdery Mildew	Spots on leaves, stems, and flower parts expand and become covered with white fungal growth. Small dead spots form on some cultivars.	*Sphaerotheca pannosa*	Apply chlorothalonil, propiconazole, piperalin, fenarimol, surfur, copper hydroxide, neem oil, azoxystrobin, kersoxim methyl, ziram, or triforine. Triadimefon can stunt many cultivars used in greenhouse production.
Viruses	Leaves may exhibit mosaic, mottling, yellow line or ring patterns. Veins may turn yellow.	Rose mosaic, mottle, yellow mosaic, ring pattern, tobacco streak, rose rosette, rose wilt, spring dwarf, color break, or strawberry latent ring spot virus	Destroy infected plants. Plant only healthy, virus-free plants. Maintain good insect and mite control.

Schefflera (*Brassaia*)

Disease	Symptoms	Pathogen/Cause	Management
Alternaria Leaf Spot	Large, dark-brown spots form on leaves and may have a yellow halo.	*Alternaria panax*	Avoid overhead watering. Apply iprodione or mancozeb to protect leaves.
Bacterial Leaf Spot	Small, tan to yellow, corky, irregularly shaped spots form on the lower surface of the leaf. Spots up to ¼ inch in diameter turn dark brown.	*Xanthomonas campestris* pv. *hederae*	Purchase plants free from the disease. Avoid overhead watering. Check nearby English ivy (*Hedera helix*) for bacterial leaf spot. Remove infected plants.
Cold Injury	Dead areas form on leaves up to several days after exposure.	Temperatures below 50°F	Do not place plants near air conditioners. Maintain temperatures above 50°F.
Leaf Yellowing	Leaves become light green or completely yellow. Stems are spindly and weak.	Low light intensity	Provide some and no more than 16 hours of light per day at 150 ft-c.

Snapdragon (*Antirrhinum*)

Disease	Symptoms	Pathogen/Cause	Management
Anthracnose	Definite yellow spots form on leaves and stems. These turn white and have a brown border. Leaves die as do entire plants if stems are girdled.	*Colletotrichum antirrhini*	Heat and ventilate to maintain low humidity. Water in a manner that keeps foliage surfaces dry. Apply mancozeb, ziram, or azoxystrobin to protect healthy plants.
Botrytis Blight	Petals turn brown and are covered with gray fungal growth.	*Botrytis cinerea*	Space plants to ensure good air circulation. Maintain low humidity. Avoid watering late in the day. Remove crop debris. Apply chlorothalonil, iprodione, mancozeb, captan, or fludioxonil.
Downy Mildew	Seedlings and cuttings are stunted and leaves curl downward. Gray to white fungus lightly covers the underside of leaves. Upper side of infected leaves have yellowed areas. The fungus causes a systemic infection of all leaves of seedlings. Older plants yellow, may be stunted, and die from the top down. Plants fail to flower.	*Peronospora antirrhini*	Heat and vent to maintain low humidity, especially when weather is cool and cloudy. Water in a manner that keeps leaf surfaces dry. Spray azoxystrobin, potassium salts of phosphorus acid, or trifloxystrobin to cover all leaf surfaces. Before replanting greenhouse beds, steam the soil because the fungus survives in debris.
Powdery Mildew	White fungal growth forms on either surface of lower leaves, as well as on stems of some cultivars.	*Oidium* spp.	Heat and ventilate, especially in the spring and fall, to reduce night humidity. Apply myclobutanil, propiconazole, thiophanate methyl, triforine, triadimefon, or thiophanate methyl + mancozeb.
Pythium Root Rot	Root tips turn brown and die. Plants are yellowed, stunted, wilt, and die. Older plants may survive if not placed under moisture stress.	*Pythium* spp.	Plant in pasteurized raised beds. Do not recontaminate beds. Apply mefenoxam, dimethomorph, potassium salts of phosphorus acid, etridiazole, or etridiazole + thiophanate methyl to protect healthy plants.
Rhizoctonia Stem Rot	Stems of seedlings or recent transplants collapse at the soil line. A red-brown lesion forms at the base of the stem. Older plants wilt and die with lesions at the base as noted above.	*Rhizoctonia solani*	Plant in pasteurized raised beds. Apply PCNB, flutolanil, or iprodione as a soil drench to protect healthy plants.
Rust	Small, yellow swellings form on leaves or stems and burst to release rusty colored spores. Concentric rings of spores form around the initial spot.	*Puccinia antirrhini*	Apply chlorothalonil, mancozeb + thiophanate methyl, triadimefon, mancozeb, maneb + zinc, or triforine to protect healthy plants.

Spathiphyllum

Disease	Symptoms	Pathogen/Cause	Management
Cylindrocladium Root and Petiole Rot	Lower leaves yellow and wilt. Dark-brown spots with halos form on leaves. Roots decay.	*Cylindrocladium spathiphylli*	Purchase plants free of pathogen. Discard infected plants. Apply thiophanate methyl as a soil drench to protect plants.
Magnesium Deficiency	Plants are stunted and vigor reduced. Tissue between leaf veins yellows and may be bronzed while veins remain green.	Lack of fertilization	Apply magnesium sulfate (Epsom salts) at ¼ pound per 10 gallons of water.
Marginal Leaf Burn	Leaf tips and margins yellow and die. Roots darken and die.	Overfertilization	Leach pots if no slow-release fertilizer is present. Maintain moderate levels of fertilizer.
Virus	A mild mosaic pattern of light and dark green appears on some leaves. Other leaves, while still infected, are symptomless.	Dasheen mosaic virus	Discard infected plants. Maintain good insect control in the greenhouse.

Statice

Disease	Symptoms	Pathogen/Cause	Management
Anthracnose and Crown Rot	Young plants wilt, yellow, and die. Tan to brown spots with yellow halos develop on flower stalks, wings, and flower parts. These enlarge and become reddish brown to brown or black on some cultivars.	*Colletotrichum gloeosporiodes*	Protect plants with thiophanate methyl or chlorothalonil, or a tank mix of the two.
Bacterial Rot	Yellow and dead leaves are found among healthy basal rosette leaves. Symptoms sometimes develop only on one side of the mid-vein. Veins may be red. Crowns and entire plant die. Rotting crowns smell foul.	*Pseudomonas*	Plant disease-free seedlings.
Botrytis Blight	Leaves on seedlings die and become covered with gray mold. Flowers discolor and collapse. When dried, infected flowers fall out of the head. Entire flower stalk may yellow and die.	*Botrytis cinerea*	Purchase decorticated seed that has been treated with hot water and fungicide. Avoid overhead irrigation. Water early in the day so that leaf surfaces dry. Space rows and maintain good weed control to ensure adequate air circulation. Apply chlorothalonil, mancozeb, or iprodione.
Cercospora Blight	Small, reddish spots form on leaves and flower stalks. Spots become brown and the entire leaf dies.	*Cercospora insulana*	Protect seedlings as well as older plants by applying chlorothalonil or a tank mix of the two before infection occurs.
Red Leaf	Leaves redden.	Cold weather or virus infection	Cold weather–injured plants recover. Virus-infected plants do not recover and should be destroyed.
Rhizoctonia Crown Rot	Gray spots develop on leaves near the soil. The crown and entire plant die.	*Rhizoctonia solani*	To protect healthy plants, apply PCNB, iprodione, etridiazole + thiophanate methyl.

(table continued on next page)

Statice *(continued)*

Disease	Symptoms	Pathogen/Cause	Management
Seedling Blight	Seedlings are killed.	*Alternaria, Botrytis, Stemphylium, Fusarium, Cercospora,* and *Colletotrichum.*	Produce seedlings from decorticated, hot water and fungicide-treated seeds.
Virus	Depending upon virus involved, stunting, deformed leaves, mosaic, red leaves, red or yellow line patterns and ring spots may develop.	Broadbean wilt, cucumber mosaic, statice Y, tobacco rattle, tomato bushy stunt, or turnip mosaic virus	Destroy infected plants. Maintain good aphid control to delay virus spread. Wash hands and disinfest tools thoroughly after handling infected plants to prevent mechanical spread.
Yellows	Small leaves, yellowing, stunting, and excessive branching occur. Mature plant leaves may redden. Flowers may fail to open, be reduced in size, or have abnormal color and shape.	Phytoplasma	Destroy infected plants. Maintain good leafhopper control to delay spread.

Syngonium

Disease	Symptoms	Pathogen/Cause	Management
Bacterial Blight and Stem Rot	Very dark green spots engulf the leaf in a foul-smelling soft rot. Infected tissue falls away, giving the leaf a tattered appearance. When stems are infected, lower leaves wilt and die.	*Erwinia*	Purchase plants free of the disease. Discard infected plants and water in a manner that keeps the surface of the plants dry at all times.
Bacterial Leaf Spot	Translucent spots on leaf margins become dull green with bright-yellow halos. Spot size and shape are limited by leaf veins.	*Erwinia, Pseudomonas, Xanthomonas*	Purchase plants free of the disease. Discard infected plants. Avoid overhead watering. Apply potassium salts of phosphorus acid.
Myrothecium Leaf Spot	Tan to dark-brown leaf spots have concentric rings and fungal fruiting structures.	*Myrothecium roridum*	Do not apply excessive amounts of nitrogen fertilizer. Protect leaves from wounding. Apply chlorothalonil or mancozeb to protect plants.
Phosphorus Deficiency	Plants are stunted. Lower leaves have dead spots.	Lack of fertilization	Apply a balanced fertilizer solution.

Tulip

Disease	Symptoms	Pathogen/Cause	Management
Basal Rot	Large spots on bulbs are dark brown. White or pink fungal growth forms on the bulbs. Flowers from infected bulbs are deformed. Foliage dies prematurely.	*Fusarium oxysporum* f. sp. *tulipae*	Do not plant bulbs that have white or pink fungus on them. Purchase and plant fungicide-treated bulbs.
Fire	Leaves may fail to emerge or may be stunted or deformed. The shoots may curl to one side. Dead spots are surrounded by dark green. Spots turn white or yellow and have small, black granules (sclerotia) in them.	*Botrytis tulipae*	Purchase fungicide-treated bulbs. Apply iprodione, thiophanate methyl, or chlorothalonil to protect healthy plants.
Pythium Root Rot	Bulbs have soft, gray spots with brown borders at the base of the bulb. Shoots fail to emerge.	*Pythium*	Plant in chemically or steam-pasteurized potting mix. Discard infected plants.
Stem and Bulb Nematode	Bulbs have gray to brown patches that feel spongy. Bulbs feel lighter than normal at planting and the interior of the bulb is mealy in texture.	*Ditylenchus dipsaci*	Purchase and plant bulbs that have been treated with hot water. Discard infected bulbs.
Viruses	Leaves may be mottled or have yellow flecks or stripes. Flower color may break or flowers may be distorted.	Many viruses are known, including tulip breaking, tobacco necrosis, tobacco rattle, tobacco mosaic, and cucumber mosaic virus.	Discard infected plants. Purchase virus-free plants.

Verbena

Disease	Symptoms	Pathogen/Cause	Management
Botrytis Blight	Tan spots develop on leaves. Established plants rot at the crown. Infected tissue is covered with dusty, gray fungal growth.	*Botrytis cinerea*	Maintain low humidity by spacing plants and venting to improve air circulation. Remove dead and dying flowers and leaves. To protect healthy plants, apply fenhexamid or fludioxonil.
Powdery Mildew	White fungal growth forms on the upper surface of leaves and may form on flower petals.	*Golovinomyces cichoracearum* (formerly *Erysiphe*) *or Podosphaera xanthii* (formerly *Sphaerotheca fuliginea*) *Note:* This powdery mildew can attack cucurbits and verbena.	Apply *Ampelomyces* , trifloxystrobin, or kresoxim methyl to protect plants.
Pythium Root Rot	Roots are dark brown. Plants are wilted and yellowed.	*Pythium* sp.	Do not overwater plants. Pot in pasteurized media. Keep hose ends off the ground. To protect healthy plants, apply etridiazole + thiophanate methyl or mefenoxam.

Vinca (*See* Catharanthus)

Zinnia

Disease	Symptoms	Pathogen/Cause	Management
Alternaria Leaf Spot	Large, reddish-brown or purple spots, at first round to oblong but becoming irregular in shape, have gray or tan centers that may drop out, leaving a hole. Severely affected leaves brown, dry, and become brittle.	*Alternaria zinniae*	Apply chlorothalonil, iprodione, mancozeb, fludioxonil, propiconazole, or thiophanate methyl + mancozeb Whenever possible, water in a manner that keeps the leaves dry to inhibit this seedborne disease.
Aster Yellows	Leaf-like tissue forms where flower parts should be located. Flower-like parts remain green or light green. Often flowers on only one side of the spoke show sympotms. Sepals may be very large or dwarfed.	Phytoplasma	Destroy infected plants. Control leafhoppers.
Bacterial Leaf Spot	Spots, reddish brown to dark brown, angular, and with a prominent yellow halo, form on leaves.	*Xanthomonas campestris* pv. *zinniae*	No sprays are effective. Whenever possible, water in a manner that keeps the leaves dry to inhibit this seedborne disease.
Powdery Mildew	White fungal growth forms on the upper surface of leaves and may form on flower petals.	*Golovinomyces cichoracearum* (formerly *Erysiphe*)	Apply myclobutanil, kresoxim methyl, fenarimol, mancozeb, piperalin, propiconazole, sulfur, thiophanate methyl + mancozeb, triadimefon, or triforine to protect plants.

General Considerations

Maintain a notebook of information on what insects and mites are problems in your greenhouse. Especially note the crops and varieties that have been affected by each arthropod. You will find that certain crops/varieties are repeatedly affected by certain arthropods. Use that information to guide variety selection and to plan grouping of susceptible plants for ease of scouting and for spot treating with chemicals if necessary. In the case of insects that are dispersed by air currents, highly susceptible plants should be grown in areas of the greenhouse away from doors and vents if possible.

Use yellow sticky cards to supplement thorough scouting to

1. detect the presence of aphids, whiteflies, thrips, fungus gnats, and shoreflies;
2. monitor whether insect populations are increasing or decreasing.

Change sticky cards on a weekly basis. They are *not* for insect control.

Chemicals for Arthropod Control

The chemicals and biocontrol agents listed here were registered for use on one or more floricultural crops or foliage crops in the greenhouse for arthropod control when this guide was being assembled. Because label information changes rapidly, this information may not be complete or up to date at the time of publication. Always read the product label and follow the directions. Do not rely entirely on the information printed here because it is only meant as a general guide. Many of the product labels state that the material can be used for greenhouse crops and do not list specific crops. Read the product label carefully for the following information:

- reentry interval (length of time after application that wearing safety equipment is required when entering the treated area)
- phytotoxicity or what crops can be damaged by the product
- resistance management strategies to follow
- interval between treatments
- the amount of product to use
- the best method of applying the product

Arthropod Resistance Management

Certain insecticides and acaricides have very specific ways of killing the insects or mites. That is, their mode of action is to disrupt a specific activity within the biochemical machinery of the arthropod. If the arthropod has an alternative biochemical pathway to achieve the same result but in a slightly different manner than the one disrupted by the chemical, then that individual insect or mite is said to have resistance to the chemical. There is naturally occurring variation within arthropod populations. A few individuals in the population may have multiple biochemical pathways while others in the same population do not. When the chemical comes into use, the many individuals surviving the treatment are those with the alternative biochemical pathways and only a few of the insecticide-sensitive ones survive. The result is that the next generation of arthropods has even more members with resistance to the chemical. As you continue to use that particular chemical, more and more of each generation of the population is resistant until the chemical no longer effectively protects plants against the arthropod. This is process is termed "selecting for resistance" and certain chemicals are said to be "at risk" to this process. In order to detect a resistance problem in your crop, you must note arthropod activity before and after treatment by scouting the plants and examining them directly or by comparing counts of captured arthropods on sticky cards before and after treatment.

Growers should

1. know whether the chemical you wish to use is "at risk" to resistance development and minimize its use;
2. strictly follow the manufacturer's recommendations concerning the amount of chemical to use and the frequency of use;
3. make applications before arthropod populations are high, if a chemical control measure is to be used;
4. rotate or alternate chemicals with different modes of action so that the arthropod population is controlled in multiple ways (see below);
5. eliminate weeds and other plants from the greenhouse that will not be treated with the chemical in order to eliminate safe harbors for the arthropods;
6. minimize the use of tank mixes of multiple insecticides/acaricides (note that some mixes are acceptible; Read pesticide labels carefully for information on beneficial tank mixes); and
7. know exactly which insect or mite you are trying to control.

One way to avoid selecting for resistance or at least slow down the process is to rotate or alternate chemicals. This means using a chemical with one mode of action on a crop the recommended number of times and then switching to a chemical with a different mode of action in the subsequent treatments.

In order to assist growers in making this complicated decision, the chemical industry has formed the Insecticide Resistance Action Committee (IRAC) to develop resistance management strategies and tools to assist growers in selecting chemicals for rotation in order to avoid selecting for insecticide/acaricide resistant populations of arthropods. It is recommended that when chemicals are used in rotation, chemicals with different modes of actions (ways of killing the arthropod) be rotated rather than relying on just one chemical or class of chemicals. By simply choosing a chemical with a different group number than the one previously used, you know that the two chemicals act differently on the insect or mite. Many companies are voluntarily placing the IRAC number on the packaged product and on the label.

NOTE: Produce labels change frequently, products go off market, and new products are added. New formulations of old active ingredients receive new trade names. The following information is just a guide for understanding the meaning of the IRAC classification and may not be complete or up to date, even at the time of this publication (see http://www.irac-online.org/).

IRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
1	Carbamates	methiocarb	24	† Mesurol (10163-228)
		acephate	24	Orthene (59639-91)
			24	Acephate (51036-238-34704)
		clorpyriphos		Duraplex (one active ingredient)
3	Pyrethroid	bifenthrin	12	Talstar (279-3105)
			12	Attain (499-472)
			12	Decathalon (432-1402-59807)
		cyfluthrin	12	Tempo (432-1363)
		lambda-cyhalothrin	24	† Scimitar (100-1088)
		fenproathrin	24	† Tame (59639-77)
		permethrin	12	Astro (279-3141)
			12	Permethrin G Pro (79676-2)
			12	Pyreth-It (1021-1091-499)
4	Neonicotinoid	acetamiprid	12	TriStar (8033-22-1001)
		clothianidin	12	Celero (66330-52)
		imidacloprid	12	Marathon (432-1329-59807)
		thiamethoxam	12	Flagship (100-955)
		dinotefuran	12	Safari (33657-16-59639)
5	Spinosyn	spinosad	4	Conserve (62719-291)
6	Avermectin	abamectin	12	Avid (100-896)
7	Juvenile hormone	kinoprene	4	Enstar II (2724-476)
		fenoxycarb	12	Preclude (499-437)
		pyriproxifen	12	Distance (59639-96)
8	Halide	methyl bromide		methyl bromide
9		pymetrozine	12	Endeavor (100-913)
		flonicamid	12	Aria (279-3287)

(table continued on next page)

(table continued)

IRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
10		hexythiazox	12	Hexagon (10163-251)
		clofentezine	12	Ovation (66222-53-58185)
		etoxazole	12	TetraSan (59639-108)
11	Midgut membrane disruptor	*Bacillus thuringiensis* sp. *israelensis*	4	Gnatrol (73049-11)
		Bacillus thuringiensis, sp. *kurstaki,* strain ABTS-351	4	Dipel (73049-39)
		Bacillus thuringiensis sp. *kurstaki* strain EG7841	4	Crymax (70051-86)
12	Organotin	fenbutatin	48	Promite (67690-40)
13		clorfenapyr	12	Pylon (241-374-59807)
15	Benzoylureas	diflubenzuron	12	Adept (400-477)
16		buprofezin	12	Talus (71711-15-67690)
17		cyromazine	12	Citation (100-667)
18	Azadirachtin	azadirachtin	4	Azatin (70051-27-598070)
			12	Ornazin (5481-476-67690)
20		acequinocyl	12	Shuttle (66330-38)
21		fenpyroximate	12	Akari (71711-4-67690)
		pyridaben	12	Sanmite (7969-106)
23	Tetronic acid derivatives	spiromesifen	12	Judo (432-1280-59807)
25		bifenazate	4	Florimite (400-481)
UNC		dicofol	48	Kelthane (62719-414)
Others		potassium salts of fatty acids	12	M-Pede (62719-515)
		paraffinic oil	4	JMS Stylet Oil (65564-1)
			4	Ultra-Fine Oil (862-23-499)
Combination Product				
3 + 4		imidacloprid + bifenthrin		Allectus (432-1415)
1 + 3		clorpyrifos + cyfluthrin	24	† Duraplex (499-405)

† = Restricted-use pesticide

Group	Primary Mode of Action/Target Site
1	Acetylcholine esterase inhibition
3	Sodium channel modulators
4	Nicotinic acetylcholine receptor antagonism
5	Nicotinic acetylcholine receptor antagonism other than group 4 type
6	Chloride channel activators
7	Juvenile hormone mimics
8	Mode of action unknown or nonspecific fumigants
9	Mode of action unknown or selective feeding blockers
10	Mode of action unknown or nonspecific fumigants (mite growth inhibitors)
11	Disruptors of insect midgut membranes
12	Oxidative phosphorylation disruptor

Group	Primary Mode of Action/Target Site *(continued)*
13	Oxidative phosphorylation uncoupler
15	Lepidopteran chitin biosynthesis inhibitor
16	Homopteran chitin biosynthesis inhibitor
17	Dipteran chitin biosynthesis inhibitor
18	Moulting disruptor
20	Electron transport inhibitor
21	Electron transport inhibitor-acaricides
23	Lipid synthesis inhibitor
25	Neuroactive (actual mode of action unknown)
27	Oxygenase inhibitors
UNC	Unknown mode of action

Aphids

Aphids are soft-bodied, teardrop-shaped insects that can be from 1 to 4 millimeters long. Depending upon their age and the nutrition provided by the host plant, they may or may not have wings. Aphids come in a wide variety of colors (light to dark green, yellow, black, or red) depending on the species present and the food source. On the fatter back end of the body, they characteristically have two cornicles or "tailpipes." The insect gives live birth to the young so that a variety of sized aphids may be present on a plant that is providing good nutrition to the insect. As they grow, they molt, leaving behind their cast skin. As they feed, their excrement (called honeydew) appears as clear, shiny droplets on the leaves. The "honeydew" contains a great deal of sugars, and black-colored sooty mold fungi grow on it.

Aphids are often first found on plants near doorways, vents, or other openings where they have gained access to the greenhouse. If winged forms are present, yellow sticky cards placed just above the crop canopy attract and capture them if they are in fairly high numbers. Generally, yellow sticky cards are not to be depended upon to detect first infestations.

Aphids are usually found on the undersides of leaves and on buds. Cast skins, sooty mold, and distorted or stunted plant growth are the indications of aphid activity. Once the live aphids are found, have your extension educator, Pennsylvania plant inspector, or other entomologist determine their identity because the different species vary in their sensitivity to insecticides and susceptibility to biological control agents.

Some species of aphids are highly efficient in moving viruses from plant to plant. For example, the green peach aphid is a good vector of cucumber mosaic virus.

General Management

- Eliminate weeds from areas close to greenhouse doors and vents.
- Eliminate weeds (including escaped crop plants) from under and between benches.
- Do not move plants that have been growing outdoors into clean areas of the greenhouse unless you are certain they do not harbor aphids.
- Use moderate nitrogen fertilization when possible because high nitrogen fertilization favors the buildup of aphids on the plants.
- Encourage the establishment of biological control agents in the greenhouse.
- Group highly aphid-susceptible plants for ease of scouting and so that spot-treating with an appropriate insecticide is simplified.

(table to follow on next page)

IRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
1	Organophosphate	acephate	24 24	Orthene (59639-91) Acephate (51036-238-34704)
3	Pyrethroid	bifenthrin	12 12	Talstar (279-3105) Attain (499-472)
		cyfluthrin	12 12	Decathalon (432-1402-59807) Tempo (432-1363)
		lambda-cyhalothrin	24	† Scimitar (100-1088)
		permethrin	12 12 12 12	Astro (279-3141) Permethrin G Pro (79676-2) Pyreth-It (1021-1091-499) Pyrethrum (499-479)
4	Neonicotinoid	acetamiprid	12	TriStar (8033-22-1001)
		clothianidin	12	Celero (66330-52)
		imidacloprid	12	Marathon (432-1329-59807)
		thiamethoxam	12	Flagship (100-955)
		dinotefuran	12	Safari (33657-16-59639)
6	Avermectin	abamectin	12	Avid (100-896)
7	Juvenile hormone	kinoprene	4	Enstar II (2724-476)
		fenoxycarb	12	Preclude (499-437)
		pyriproxifen	12	Distance (59639-96)
9		pymetrozine	12	Endeavor (100-913)
		flonicamid	12	Aria (279-3287)
18	Azadirachtin	azadirachtin	4 12	Azatin (70051-27-598070) Ornazin (5481-476-67690)
		potassium salts of fatty acids	12	M-Pede (62719-515)
		paraffinic oil	4 4	JMS Stylet Oil 65564-1) Ultra-Fine Oil (862-23-499)
1 + 3		clorpyrifos + cyfluthrin	24	† Duraplex (499-405)

† = Restricted-use pesticide

Fungus Gnats

Fungus gnats are 1-millimeter-long, black or dark-brown flying insects with long legs, long antennae, and clear wings. The wings have Y-shaped veins. Their larvae are up to 4 millimeters long, have white bodies with a black head, and are found in the top inch of soil. The larvae feed on the base of cuttings, often tunneling into the base and up the stem, and on roots. The feeding of the larvae opens the plant tissue to attack by opportunistic bacteria and fungi. The adult form does not feed on the plant but lays eggs in soils peat, wet soil, and in moist compost. It is known that the larvae will feed on *Pythium* spores in the soil and move that pathogen from plant to plant short distances in propagation beds.

The flying adult fungus gnats are attracted to and captured by yellow stick cards.

General Management

- Take steps to eliminate the pooling of water in the greenhouse.
- Repair plumbing so that there are not areas of wet soil maintained in the greenhouse.
- Keep compost piles away from the greenhouse, preferably downwind of the greenhouse.

IRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
3	Pyrethroid	bifenthrin	12 12	Talstar (279-3105) Attain (499-472)
		cyfluthrin	12 12	Decathalon (432-1402-59807) Tempo (432-1363)
		permethrin	12 12 12 12	Astro (279-3141) Permethrin G Pro (79676-2) Pyreth-It (1021-1091-499) Pyrethrum (499-479)
4	Neonicotinoid	acetamiprid	12	TriStar (8033-22-1001)
		imidacloprid	12	Marathon (432-1329-59807)
7	Juvenile hormone	kinoprene	4	Enstar II (2724-476)
		pyriproxifen	12	Distance (59639-96)
11	Midgut membrane disruptor	Bacillus thuringiensis sp. israelensis	4	Gnatrol (73049-11)
13		clorfenapyr	12	Pylon (241-374-59807)
15	Benzoylureas	diflubenzuron	12	Adept (400-477)
17		cyromazine	12	Citation (100-667)
18	Azadirachtin	azadirachtin	4 12	Azatin (70051-27-598070) Ornazin (5481-476-67690)
1 + 3		clorpyrifos + cyfluthrin	24	†Duraplex (499-405)

† = Restricted-use pesticide

Leafminers

The activity of leafminers is first seen as yellow or light-green spots or meandering lines on leaves. The flying adult females deposit eggs in leaf tissue and feed on the sap oozing from these wounds. The eggs hatch inside the tissue and the larvae feed on the tissue between the upper and lower epidermis of the leaf, leaving trails or tunnels of light-green color. When held up to the light, the larvae can sometimes be seen in the tunnel as can the dark fecal material in the tunnel. Larvae drop out of the tunnels to the soil where they pupate.

General Management

- Inspect all incoming plants for leafminer tunnels and discard infested plants.
- Some populations of leafminers are resistant to certain chemicals. Follow the manufacturer's use recommendations so that the buildup of resistance to chemicals in leafminer populations is avoided.
- If contact insecticides are used, repeat the spray every 3 to 4 days for 10 days to kill adults that emerged after the first spray.

IRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
3	Pyrethroid	bifenthrin	12 12	Talstar (279-3105) Attain (499-472)
		lambda-cyhalothrin	24	† Scimitar (100-1088)
		permethrin	12 12 12 12	Astro (279-3141) Permethrin G Pro (79676-2) Pyreth-It (1021-1091-499) Pyrethrum (499-479)
4	Neonicotinoid	imidacloprid	12	Marathon (432-1329-59807)
		dinotefuran	12	Safari (33657-16-59639)
5	Spinosyn	spinosad	4	Conserve (62719-291)
6	Avermectin	abamectin	12	Avid (100-896)
7	Juvenile hormone	fenoxycarb	12	Preclude (499-437)
17		cyromazine	12	Citation (100-667)
18	Azadirachtin	azadirachtin	4 12	Azatin (70051-27-598070 Ornazin (5481-476-67690)
		potassium salts of fatty acids	12	M-Pede (62719-515)

† = Restricted-use pesticide

Mealybugs

Mealybugs are 1- to 4-millimeter-long, soft-bodied insects whose bodies are covered with white, waxy material. These slow-moving insects can be found on any above-ground part of the plant, especially where the petiole meets the stem, along leaf midribs, and on the undersides of leaves. They produce abundant honeydew on which sooty mold fungi grow. Root mealybugs are found on the roots of some plants.

General Management

- Examine new, incoming plants, for mealybugs and sooty mold.
- Examine pot surfaces and greenhouse walls and benches where mealybugs can survive for 10 to 20 days in the absence of plants.
- Destroy infested plants.
- Apply spot treatments of an appropriate insecticide over a 5- to 6-week period, particularly to the nymph or crawler stage that is more sensitive to chemicals than other stages.

IRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
1	Organophosphate	acephate	24 24	Orthene (59639-91) Acephate (51036-238-34704)
3	Pyrethroid	bifenthrin	12 12	Talstar (279-3105) Attain (499-472)
		cyfluthrin	12 12	Decathalon (432-1402-59807) Tempo (432-1363)
		lambda-cyhalothrin	24	† Scimitar (100-1088)
		permethrin	12 12 12 12	Astro (279-3141) Permethrin G Pro (79676-2) Pyreth-It (1021-1091-499) Pyrethrum (499-479)
4	Neonicotinoid	acetamiprid	12	TriStar (8033-22-1001)
		clothianidin	12	Celero (66330-52)
		imidacloprid	12	Marathon (432-1329-59807)
		thiamethoxam	12	Flagship (100-955)
		dinotefuran	12	Safari (33657-16-59639)
7	Juvenile hormone	kinoprene	4	Enstar II (2724-476)
		fenoxycarb	12	Preclude (499-437)
9		flonicamid	12	Aria (279-3287)
16		buprofezin	12	Talus (71711-15-67690)
18	Azadirachtin	azadirachtin	4 12	Azatin (70051-27-598070 Ornazin (5481-476-67690)
		potassium salts of fatty acids	12	M-Pede (62719-515)
1 + 3		clorpyrifos + cyfluthrin	24	† Duraplex (499-405)

† = Restricted-use pesticide

Mites

Mites are small, spider-like arthropods usually found on the undersides of leaves. While several species of mites can seriously damage plants, some beneficial mites that are predatory on other mites are found in greenhouses. Some mites are beneficial because they consume harmful fungi on plants. Predatory mites move rapidly. Some mites are about the size of the dot in this letter "i." Others are even smaller.

Two-Spotted Spider Mites

These mites cause small, yellow flecks or stippling during their feeding on some plants. This is followed by leaf bronzing, tissue drying, and defoliation. When a very heavy infestation is underway, spider webbing is obvious. In geraniums, mite feeding contributes to the development of tan, scabby tissue on the undersides of leaves, termed edema (or oedema). Plants under high nitrogen fertilization support higher populations of mites than plants receiving lower levels of nitrogen. Hot, low humidity favors two-spotted spider mite development.

With a hand lens, inspect the plant buds and undersides of leaves. While holding a white piece of paper under the plant, sharply tap the plant. Mites falling onto the paper look like small spiders with two dark dots about half way down their bodies. They are yellowish in color (orange in cool weather). Although they move actively, they are not very fast. Do not confuse these mites with the very rapidly moving predatory mites that are usually slightly larger and more orange in color.

General Management

- Inspect plants in areas of the greenhouse that are generally under low-humidity conditions.
- Inspect incoming plants for mites using a hand lens and tapping the plant over a white sheet of paper.
- Apply an appropriate chemical (acaricide).

Cyclamen Mites

These mites are very small—a 20 to 40x hand lens is required to see them. They are more easily seen with a stationary dissecting scope because you are able to focus the scope and then peel the plant apart while examining it under high-power magnification. The symptoms typical of cyclamen mite feeding include stunting, twisting, and hardening of leaf, flower, and bud tissues. Young tissues turn black and die. Cyclamen mites thrive under cool (60ºF), moist conditions and can complete their life cycle in 2 weeks.

General Management

- Release predatory mites before cyclamen mites become a problem.
- Destroy infested plants.
- Treat remaining plants with an appropriate acaricide.

Broad Mites

The information on detecting cyclamen mites also applies to these extremely small mites. Broad mites usually cause a bronzing of the undersides of leaves or a blistered, silvery appearance in addition to stunting and twisting. Infested leaves become hard and brittle. This mite can complete its life cycle in 1 week under ideal conditions.

General Management

- Destroy infested plants.

Lewis Mites

This mite is not common but should be scouted for, particularly in poinsettias. It can be a major problem on poinsettias if not detected early. In addition to poinsettia, it also feeds on geranium, castor bean, and ceanothus and causes very small flecks or stipples to form on the leaves. Leaves will eventually yellow. The mites tend to move high on the plant, stay on the undersides of leaves, and make webs near the growing point. Usually the damage on poinsettia is obvious by October. This mite is smaller than the two-spotted mite and has several small greenish spots. This mite tends not to be attracted to sticky cards. To scout for this mite, you must use a magnifying glass to examine leaves and the growing point.

General Management

- Inspect plants in areas of the greenhouse that are generally under low humidity conditions.
- Inspect incoming plants for mites using a hand lens and tapping the plant over a white sheet of paper.
- Apply a chemical (acaricide) that has translaminar (will move from the upper side to the lower side of the leaf) or systemic activity.

IRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
3	Pyrethroid	bifenthrin	12 12	Talstar (279-3105) Attain (499-472)
		lambda-cyhalothrin	24	† Scimitar (100-1088)
5	Spinosyn	spinosad	4	Conserve (62719-291)
6	Avermectin	abamectin	12	Avid (100-896)
7	Juvenile hormone	fenoxycarb	12	Preclude (499-437)
10		hexythiazox	12	Hexagon (10163-251)
		etoxazole	12	TetraSan (59639-108)
		clofentezine	12	Ovation (66222-53-58185)
12	Organotin	fenbutatin	48	Promite (67690-40)
13		clorfenapyr	12	Pylon (241-374-59807)
18	Azadirachtin	azadirachtin	4 12	Azatin (70051-27-598070) Ornazin (5481-476-67690)
20		acequinocyl	12	Shuttle (66330-38)
21		fenpyroximate	12	Akari (71711-4-67690)
		pyridaben	12	Sanmite (7969-106)
23	Tetronic acid derivatives	spiromesifen	12	Judo (432-1280-59807)
25		bifenazate	4	Florimite (400-481)
		potassium salts of fatty acids	12	M-Pede (62719-515)
		paraffinic oil	4	JMS Stylet Oil (65564-1)
3 + 4		imidacloprid + bifenthrin		Allectus (432-1415)
1 + 3		clorpyrifos + cyfluthrin	24	† Duraplex (499-405)

† = Restricted-use pesticide

Scale Insects

Armored Scales

Several species of armored scales can occur on greenhouse plants. These circular to irregular insects resembling oyster shells vary in color from gray to white, red, brown or green. They secrete a hard, waxy shell over their bodies that can be detached. Armored scales produce brown to yellow spots or streaks on leaves as they encrust the tissue. They do *not* produce honeydew.

Armored scale females lay 20 to 400 eggs under the shell. Some give live birth to young rather than laying eggs. Those from eggs hatch into a crawler stage that is very sensitive to insecticides. Crawlers move a short distance, and settle down to feed. The insect goes through a nymph stage and matures into an adult. The time from egg to adult can vary from 60 to 120 days depending on the species of scale and temperature.

Soft Scales

Soft scales are generally oval or circular in shape, 2 to 5 millimeters long, and usually gray, brown, or black. The waxy shell they secrete cannot be detached from the body. Young plant tissues turn yellow, become distorted, and may die as the scales feed. Their excrement, honeydew, is rich in plant sugars and supports the growth of a black fungus commonly called sooty mold.

The female soft scale can produce up to 1,000 eggs. The crawlers hatch from the eggs and move around the plant for several days. Adult males are tiny, have wings, and live a few days. The time from egg to adult varies from 40 to 80 days depending on the species of soft scale and temperature.

General Management

- Examine new, incoming plants, for scales and sooty mold (in the case of soft scales only).
- Destroy infested plants.
- Apply spot treatments of an appropriate insecticide, particularly to the crawler stage.

IRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
1	Organophosphate	acephate	24 24	Orthene (59639-91) Acephate (51036-238-34704)
3	Pyrethroid	cyfluthrin	12 12	Decathalon (432-1402-59807) Tempo (432-1363)
		lambda-cyhalothrin	24	† Scimitar (100-1088)
		fenproathrin	24	Tame (59639-77)
		permethrin	12 12 12 12	Astro (279-3141) Permethrin G Pro (79676-2) Pyreth-It (1021-1091-499) Pyrethrum (499-479)
4	Neonicotinoid	acetamiprid	12	TriStar (8033-22-1001)
		imidacloprid	12	Marathon (432-1329-59807)
		thiamethoxam	12	Flagship (100-955)
		dinotefuran	12	Safari (33657-16-59639)
7	Juvenile hormone	kinoprene	4	Enstar II (2724-476)
		fenoxycarb	12	Preclude (499-437)
		pyriproxifen	12	Distance (59639-96)
16		buprofezin	12	Talus (71711-15-67690)
18	Azadirachtin	azadirachtin	4 12	Azatin (70051-27-598070) Ornazin (5481-476-67690)
		potassium salts of fatty acids	12	M-Pede (62719-515)
3 + 4		imidacloprid + bifenthrin		Allectus (432-1415)
1 + 3		clorpyrifos + cyfluthrin	24	† Duraplex (499-405)

† = Restricted-use pesticide

Shoreflies

Shoreflies look like tiny house flies with short antennae. Their larvae are clear to white, maggot-like, with no head capsule. Each gray wing has five light spots. It is known that adult shoreflies will feed on *Pythium*, ingest the *Pythium* spores, and the deposit *Pythium* in fecal material on plants elsewhere in the greenhouse. They tend to thrive under wet soil conditions where algae grow and on which the shoreflies feed. *Pythium* can grow along with the algae.

General Management

- Examine yellow sticky cards for the presence of shoreflies.
- Take steps to eliminate the pooling of water in the greenhouse.
- Repair plumbing so that there are not areas of wet soil maintained in the greenhouse.
- Keep algae under control in walkways and under benches.

IRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
5	Spinosyn	spinosad	4	Conserve (62719-291)
7	Juvenile hormone	pyriproxifen	12	Distance (59639-96)
		fenoxycarb	12	Preclude (499-437)
15	Benzoylureas	diflubenzuron	12	Adept (400-477)
17		cyromazine	12	Citation (100-667)
18	Azadirachtin	azadirachtin	4 12	Azatin (70051-27-598070 Ornazin (5481-476-67690)
1 + 3		clorpyrifos + cyfluthrin	24	† Duraplex (499-405)

† = Restricted-use pesticide

Thrips

Thrips (singular and plural) are 2- to 4-millimeter-long (1-millimeter-wide) insects that feed on a wide range of plants and, in some cases, carry impatiens necrotic spot and tomato spotted wilt viruses from plant to plant.

Winged adults insert eggs into the plant. The larvae hatch and feed on the undersides of leaves and in bud tissues. Sharply tapping a plant held over a white sheet of paper will dislodge these actively moving insects. On yellow sticky cards, thrips can be confused with small bits of peat moss. They are best seen with a stationary dissecting scope because you are able to use needles to peel apart buds while examining them under magnification. Gently breathing on the tissue increases the carbon dioxide level and encourages the thrips to move out of protected areas. Thrips feeding causes the young growth to be distorted and stunted. White feeding scars, when examined with a hand lens, look like something scraped the green tissue away.

The larvae fall to the soil, where they pupate and later emerge as adults. Adults are attracted to open flowers but quickly move to buds. Especially examine plants near doors and vents because thrips are easily moved by air currents. Place yellow sticky cards slightly above the crop canopy, change them regularly, and keep them above the canopy as the plants grow. One or two cards per 1,000 square feet is recommended.

Thrips are known to be resistant to some insecticides. Follow insecticide label directions carefully to avoid the buildup of resistant populations of thrips. See the "Resistance Management" section of this guide.

General Management

- Carefully inspect incoming plants for thrips.
- Discard heavily infested plants.
- Place yellow sticky cards just above the crop canopy, especially among plants near vents and doors.
- Apply an insecticide three times, 7 days apart to kill emerging adults (possibly 5 days apart during warm weather). Follow the label direction be certain you are following the recommended interval. Switch to a different class of insecticide and repeat the application.
- Eliminate weeds from the area immediately outside greenhouse doors and vents.
- Eliminate escaped plants under and between benches.
- Keep all plants, including those being held over for sale at a future time under strict insect control. Holiday cacti can support large numbers of thrips and can be infected with impatiens necrotic spot virus without exhibiting symptoms.

IRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
1	Organophosphate	acephate	24 24	Orthene (59639-91) Acephate (51036-238-34704)
3	Pyrethroid	bifenthrin	12 12	Talstar (279-3105) Attain (499-472)
		cyfluthrin	12 12	Decathalon (432-1402-59807) Tempo (432-1363)
		lambda-cyhalothrin	24	† Scimitar (100-1088)
		fenproathrin	24	† Tame (59639-77)
4	Neonicotinoid	acetamiprid	12	TriStar (8033-22-1001)
		imidacloprid	12	Marathon (432-1329-59807)
		dinotefuran	12	Safari (33657-16-59639)
6	Avermectin	abamectin	12	Avid (100-896)
7	Juvenile hormone	fenoxycarb	12	Preclude (499-437)
9		flonicamid	12	Aria (279-3287)
15	Benzoylureas	diflubenzuron	12	Adept (400-477)
18	Azadirachtin	azadirachtin	4 12	Azatin (70051-27-598070) Ornazin (5481-476-67690)
3 + 4		imidacloprid + bifenthrin		Allectus (432-1415)
1 + 3		clorpyrifos + cyfluthrin	24	† Duraplex (499-405)

† = Restricted-use pesticide

Whiteflies

Whiteflies are exactly that—small, white insects that are found on the undersides of leaves. Certain plants, such as poinsettias, are particularly susceptible to attack. They produce honeydew excrement, which is then colonized by black-colored sooty mold fungi. The flying adult stage is attracted to yellow sticky cards. The pupae are small, oval, white or light-colored, 2- to 3-millimeter-long structures on the plant tissue. While the silverleaf (B-biotype) or sweet potato whitefly (Q-biotype) pupa has an irregular outline and lacks hairs and sides that slope down to the leaf, the greenhouse whitefly and the banded-winged whitefly have a smooth outline, hairs, and in side view do not slope but look like a tiny rectangle sitting on the leaf.

Whitefly populations in some greenhouses are resistant to some insecticides.

General Management

- Carefully inspect incoming plants for thrips.
- Place yellow sticky cards just above the crop canopy and check them regularly to detect the insect.
- Eliminate weeds from the area immediately outside greenhouse doors and vents.
- Eliminate escaped plants from under and between benches.
- Keep all plants, including those being held over for sale at a future time (like fuchsias) under strict insect control and monitoring.
- Eggs and pupae are not sensitive to most insecticides. Apply an appropriate insecticide to eliminate the nymph stage and flying adults.

The following information is based on the product label listings of arthropods controlled by the chemical. The product labels for most chemicals used for arthropod management do not list the names of specific crops for which they can be used. Instead, they state that they are for ornamentals or for greenhouse use, or employ other words indicating that they can be used in the greenhouse. Read the product label carefully to determine whether the chemical may be phytotoxic (damaging) to a particular plant.

(table to follow on next page)

IRAC Group	Class	Active Ingredient	Restricted-Entry Interval (REI)	Trade Names (EPA Reg. No.)
1	Organophosphate	acephate	24 24	Orthene (59639-91) Acephate (51036-238-34704)
3	Pyrethroid	bifenthrin	12 12	Talstar (279-3105) Attain (499-472)
		cyfluthrin	12 12	Decathalon (432-1402-59807) Tempo (432-1363)
		lambda-cyhalothrin	24	† Scimitar (100-1088)
		fenproathrin	24	† Tame (59639-77)
		permethrin	12 12 12 12	Astro (279-3141) Permethrin G Pro (79676-2) Pyreth-It (1021-1091-499) Pyrethrum (499-479)
4	Neonicotinoid	acetamiprid	12	TriStar (8033-22-1001)
		clothianidin	12	Celero (66330-52)
		imidacloprid	12	Marathon (432-1329-59807)
		thiamethoxam	12	Flagship (100-955)
		dinotefuran	12	Safari (33657-16-59639)
5	Spinosyn	spinosad	4	Conserve (62719-291)
7	Juvenile hormone	kinoprene	4	Enstar II (2724-476)
		fenoxycarb	12	Preclude (499-437)
		pyriproxifen	12	Distance (59639-96)
9		pymetrozine	12	Endeavor (100-913)
		flonicamid	12	Aria (279-3287)
15	Benzoylureas	diflubenzuron	12	Adept (400-477)
16		buprofezin	12	Talus (71711-15-67690)
18	Azadirachtin	azadirachtin	4 12	Azatin (70051-27-598070 Ornazin (5481-476-67690)
21		pyridaben	12	Sanmite (7969-106)
23	Tetronic acid derivatives	spiromesifen	12	Judo (432-1280-59807)
		potassium salts of fatty acids	12	M-Pede (62719-515)
3 + 4		imidacloprid + bifenthrin		Allectus (432-1415)
1 + 3		clorpyrifos + cyfluthrin	24	† Duraplex (499-405)

† = Restricted-use pesticide

Guide to Evaluating the Total Greenhouse Operation

The following is a guide to assessing the various procedures and equipment used in a greenhouse, keeping in mind the threat of pathogen, mite, and insect population development in the crops being grown in a particular greenhouse. There is a blank form at the end of this guide for you to use in your particular operation. No detail is too minor to disregard. Although you believe you know all the details, it is suggested you talk to employees to be certain you know exactly how they do various tasks. For example, in a greenhouse where trowels or dibble boards are used, where does the employee put them when not in use? If placed on the floor, they may become contaminated with pathogen-infested soil. If they are hung on the wall or always left on pathogen-free potting mix, they are not likely to become contaminated. Even these small details are important.

I. Potting Mix

A. Grower-Prepared

Components

- What components are used to make the potting mix? Sand, soil, and peat are likely to carry pathogens while vermiculite, hydrogels, and perlite are, by virtue of their manufacturing, free of pathogens and insects.
- Fertilizer used to amend the potting mix, if stored too near herbicides, could absorb herbicides.
- Potting mix–incorporated pesticides, if not incorporated in the proper amount and manner, may be toxic. These should be incorporated after steaming, fumigation, or other treatments and prior to potting.

Treatment to Eliminate Pathogens and Other Pests

- If components are used that may carry pathogens, is the mix treated to eliminate those pathogens?
- Heat can eliminate all pathogens if applied properly.
- Chemical fumigation generally kills most but not all organisms.
- All chemicals leave some residue to which certain plants are very sensitive.

Storage of the Potting Mix

- Is the potting mix stored in a location and under conditions where pathogen-contaminated soil is not likely to get into the mix?

B. Commercial, Soilless Mix

Treatment

- Since some brands appear to harbor pathogens, the mix used for stock plants should be steamed or fumigated.

Storage

- Is the potting mix stored in a location and under conditions where pathogen-contaminated soil is not likely to get into the mix?
- Are bags or plastic-covered bails kept intact without tears?

C. Moving the Mix from Storage to Potting Area

- Is all the equipment used to move potting mix used only for that purpose? Or, are all the tools and equipment, including the buckets of a front-end loaders, cleaned and disinfested prior to moving the mix if also used for other purposes?

II. Potting Area

- Are potting benches and floors cleaned and disinfested periodically?

(outline continued on next page)

III. Pots and Flats

- Are pots, flats, and other containers new? Or, if used, are they thoroughly washed to remove all lumps of soil and then disinfested?

Storage of Pots and Flats

- Are pots and flats stored in the original boxes (closed) or in a covered area so that pathogen-contaminated soil is not likely to get onto them?

IV. Planting

- Do workers wear clean clothes not contaminated with soil or plant sap that may harbor pathogens? They should not have been handling plants elsewhere in the facility prior to planting.
- Is any machinery used in planting periodically disinfested prior to use?
- Are dibble boards or other tools used to make holes in the potting mix disinfested periodically and kept off the floor?

V. Benches, Floors, or Surface on Which Pots Are Placed

- Are benches raised at least 24 inches above the floor?
- Are solid-topped benches thoroughly cleaned and then disinfested prior to plant placement?
- Are expanded metal bench tops, wooden slats, or lath bench tops thoroughly cleaned and then disinfested between crops?
- Are porous cement floors or other paved surfaces on which pots are placed thoroughly cleaned and disinfested between crops?
- Does water stand on floors or walkways for an extended periods or are there areas under or between benches that remain wet for long periods and foster the growth of algae and provide havens for fungus gnats and shoreflies?

VI. Plant Material

- List all the plants that are grown.
- Do you inspect new plants coming into the greenhouse for arthropods and pathogens?
- Do you keep plants from a particular supplier grouped, at least until you are satisfied that they are healthy?
- Do the pathogens and pests of some of the crops readily infect or infest the next crop to be grown in that space or nearby crops?

A. Seedling Production

- If starting plants from seed, were the seeds fungicide, hot water, or chlorine treated by the seller to eliminate pathogens?
- If seedling plugs are purchased, is the supplier reliable?
- Have there been disease problems on plants from this supplier in previous years soon after receiving plants?

B. Vegetatively Propagated Material

Stock Plants

- Are new stock plants established every 12 months or more often? Is the stock plant material culture indexed and virus indexed?
- Are stock plants always under a strict arthropod and disease management regime and monitored regularly?

Propagation

- Are cuttings removed by breaking out the branch by hand? Or, if knives are used, are they disinfested when moving from one stock plant to another?

- Are cutting ends dusted with the hormone and not dipped in a common container? If a common container becomes contaminated with a pathogen, all cuttings subsequently dipped may be inoculated with the pathogen.
- Is the cutting bed divided or are flats, rooting cubes, pellets or similar products separated so that if it is later discovered that a few cuttings carried a pathogen, not all the cuttings will have been exposed? Do not place the entire crop at risk by rooting everything in a common bed.

VII. Spacing of Plants

- Are stock plants in rows parallel to air flow with space between rows?
- Are seedlings and plants spaced to allow adequate air circulation during growth?
- Good air circulation that fosters a reduction in relative humidity inhibits gray mold (*Botrytis*) activity.

VIII. Handling of Plants during Production

- Are stock plants handled only by one or two of the most trusted employees early in the day before they handle any other plants?
- While disbudding, harvesting cuttings, cleaning the potting soil surface, and removing the fading lower leaves are important tasks, they can spread pathogens. Do each of these tasks separately. Or, assign one person to each task so that the rest of the plant is not touched.
- Do workers always handle plants known to be healthy first and work toward areas where arthropods or diseases are known to occur so that they minimize their spreading of pathogens on hands and clothing?
- Do workers use snuff, chewing tobacco, or other tobacco products in a location away from the plants and then wash their hands thoroughly before going back to work? Do they store the tobacco products in a location where their work clothes and tools will not become contaminated? Tobacco products can contain tobacco mosaic virus, which is easily spread on hand and tools to healthy plants.

IX. Greenhouse Structure

- Is the stock plant greenhouse completely separate from all other parts of the operation?
- Is condensation drip onto plants minimized?
- Are heat and venting systems set up and actually used to maintain low humidity and good air circulation?
- Are shoe dip stations located at each entry? Are workers told that it is important to always pass through the shoe dip in order to minimize their spread of pathogens into the greenhouse? Is the dipping solution replaced each day?
- Are handwashing stations readily accessible and close to where work is being done?
- Are the greenhouse vents, cooling pads, and other open areas screened with a mesh size that will prevent the entry of aphids, whiteflies, and larger insects? Is air movement within the greenhouse designed to keep insects out?

X. Watering Practices

- Is well water or municipal water used? Or, is water from a surface water supply used? Surface water may carry *Pythium*, *Phytophthora*, and *Erwinia*.
- Is overhead irrigation, which readily splashes pathogens from plant to plant, employed? Or, is capillary mat, drip, ebb and flow, or trickle irrigation watering, which tend not to spread pathogens and keeps the plant surfaces dry, used?
- Are hose ends hung and not left on the ground? Are hose ends disinfested periodically and especially immediately if they fall on the ground?
- Is watering done early in the day so that relative humidity decreases before night?
- Are ebb and flow tanks covered or protected from contamination by stray soil or runoff?

(outline continued on next page)

XI. Cultural Practices

- Do fertilization practices avoid overfertilization, nutrient deficiencies, and nutrient toxicities?
- Are plant growth regulators, if used, applied in the manner defined by the product label only to plants listed on the product label?

XII. Worker Training and Practices

- Are workers trained to recognize symptoms and signs of disease and arthropod activity?
- Do workers understand the most common places where pathogens and arthropods are harbored?
- Are new workers trained to recognize what is normal and what is abnormal for each crop?

XIII. Misc. Greenhouse Practices

- Is debris disposed of promptly in appropriate covered containers outside the greenhouse, away from intake vents, until removed from the area?
- Are weeds, including escaped crop plants, removed from under benches? Are weeds immediately outside greenhouse vents cut or removed on a regular basis? These may harbor pathogens, mites, and insects.

XIV. Chemical Treatments

- Is there a specific reason for using each chemical being applied? What is the rationale for the timing of their use?
- Are records kept on each lot of plants treated so that it is known what specifically has been used on particular plants, when it was applied, and what environmental conditions prevailed during and soon after application?

XV. IPM Methods

- Does someone have the responsibility of regularly scouting the greenhouse?
- Is that person trained and updated frequently? Is the person given the necessary amount of time needed to thoroughly scout each week?
- What is the established scouting schedule?
- Are records kept on findings?
- Are soil or tissue tests run regularly?
- Where does the scout go for backup on diagnoses when it is needed?

XVI. Problems Encountered by Grower

- Are records kept on the occurrence of disease and arthropod outbreaks including when they occurred, crops affected, and how the problem was resolved? Do particular problems recur each growing season? What is the likely source of these problems?
- Are records kept on what actions were taken and how effective they were in solving the problem?
- Are disease, insect, and mite diagnoses and soil/water test results kept on file for future reference?

Appendix A: Greenhouse Assessment Worksheet

I. Potting Mix

A. Grower-Prepared

Components:

Treatment to Eliminate Pathogens and Other Pests:

Storage of the Potting Mix:

B. Commercial, Soilless Mix

Treatment:

Storage:

C. Moving the Mix from Storage to Potting Area:

II. Potting Area:

III. Pots and Flats:

Storage of Pots and Flats:

(worksheet continued on next page)

IV. Planting:

V. Benches, Floors, or Surface on Which Pots Are Placed:

VI. Plant Material:

A. Seedling Production:

B. Vegetatively Propagated Material:

Stock plants:

Propagation:

VII. Spacing of Plants:

VIII. Handling of Plants during Production:

IX. Greenhouse Structure:

X. Watering Practices:

XI. Cultural Practices:

(worksheet continued on next page)

XII. Worker Training and Practices:

XIII. Miscellaneous Greenhouse Practices:

XIV. Chemical Treatments:

XV. IPM Methods:

XVI. Problems Encountered by Grower:

Appendix B: Specimen Information Form

Lab Specimen No. _____ *(Clinic will assign.)*

Specimen Information Form

Please Complete All Sections of This Form

CLIENT INFORMATION

Name _____

Address _____

City _____ State _____ Zip _____ County _____

Phone _____ Fax_____ E-Mail _____

SPECIMEN INFORMATION

Plant _____ Variety _____ Date Collected _____

Describe the problem and explain what concerns you:

_____

_____

_____

Plant Part Affected

☐ Leaves
☐ Roots
☐ Stems, Branches
☐ Flowers

Symptoms

☐ Yellowing: ☐ Interveinal ☐ General ☐ Marginal
☐ Browning: ☐ Interveinal ☐ General ☐ Marginal
☐ Wilting ☐ Distortion ☐ Mottling ☐ Leaf Spots
☐ Other _____

Type of Planting

☐ Greenhouse
☐ Garden Center
☐ Shade House
☐ Nursery

Disease Distribution

☐ General
☐ Scattered Plants
☐ Dry Areas
☐ Wet Areas
☐ Near Vents/Fans
☐ End of Planting
☐ Other _____

Potting mix: _____

When did the symptoms first appear? _____

Has the problem occurred before? _____ **When?**_____

Size of Planting _____ Acres
_____ Square Feet
_____ Number of Plants

Extent of Problem

_____ Percentage of Plants Affected *or*
_____ Number of Plants Affected

(Specimen information continued on next page)

Specimen Information Form *(continued)*

SPECIMEN INFORMATION ***(continued)***

Chemicals Applied This Season and Previous Year (include materials, rates, and dates):

	MATERIALS	RATES	DATES
☐ Fungicide			
☐ Insecticide			
☐ Herbicide			
☐ Nematicide			
☐ Growth Regulators			

Type of Irrigation

☐ Hose
☐ Drip or Trickle
☐ Mist System
☐ Overhead Boom
☐ Trough
☐ Ebb and Flow—Benches
☐ Ebb and Flow—Floors

Other: _____

Source of Water

☐ Well
☐ Municipal Supply
☐ Pond or Lake
☐ Stream or River
☐ Runoff from Roof

Treatment of Water

☐ None
☐ Chlorine
☐ Ozone
☐ Ultraviolet Light
☐ Sand Filter
☐ Cloth Filter
☐ Screen Filter

Other: _____

Other Practices

☐ Raised Beds
☐ Ground Beds
☐ Pots or Containers

Heating System: _____

Temperature in Production Area: Days:_____ To_____°F Nights:_____ To_____°F

Additional Comments:

_____

_____

_____

_____

_____

_____

_____

Notes

Notes

Measurement Conversions for Mixing Pesticides

Pesticides are often purchased in large containers that do not include instructions on the label for mixing small amounts of spray. The following conversions may be helpful in mixing small units of spray.

3 teaspoons	= 1 tablespoon		
2 tablespoons	= 1 fluid ounce	= 6 teaspoons	
16 tablespoons	= 1 cup	= 8 fluid ounces	= ½ pint
2 cups	= 1 pint	= 16 fluid ounces	= 96 teaspoons
2 pints	= 1 quart	= 4 cups	
4 quarts	= 1 gallon	= 8 pints	= 16 cups

Spray Conversion from 100 Gallons to 1 Gallon

For Dry Formulations

When directions are to mix 1 pound of wettable powder formulation in 100 gallons of water, an approximate equal dosage is 1 tablespoon in 1 gallon of water. However, this can be very inaccurate. Purchase a scale and weigh small quantities rather than using volume measures. A postage scale is adequate.

For Emulsifiable, Flowable, and Liquid Formulations

When directions are to mix 1 pint of a liquid pesticide in 100 gallons of water, an approximate equal dosage is 1 teaspoon in 1 gallon of water.

NATIONAL POISON CENTER

1-800-222-1222

Calling the toll-free National Poison Center hotline above will connect you to the nearest poison center. Pennsylvania residents are served by the Pittsburgh Poison Center and the Poison Control Center in Philadelphia.