An Pocket Guide for IPM Scouting in Herbaceous Perennials
Michigan State University Extension Service
Jan Byrne, Diagnostic Service, Michigan State University; Raymond A. Cloyd, Department of Entomology, Kansas State University
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by:
Jan Byrne and
Raymond A. Cloyd

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Written by:

- Jan Byrne, Diagnostic Services, Michigan State University.
- Raymond Cloyd, Department of Entomology, Kansas State University.

Reviewed and edited by:

- Willie Kirk, Department of Plant Pathology, Michigan State University.

Graphic design by:

- Joy Landis, Integrated Pest Management Program, Michigan State University.

Development team members

The concept for this pocket guide was developed and funding secured by a collaborative group of specialists at Michigan State University, North Carolina State University and Kansas State University:

- Jan M. Byrne and Steven A. Gower, Diagnostic Services, Michigan State University.
- Raymond A. Cloyd, Department of Entomology, Kansas State University.
- William W. Kirk and Diane E. Brown-Rytlewski, Department of Plant Pathology, Michigan State University.
- Robert J. Richardson, Department of Crop Science, North Carolina State University.
- David R. Smitley, Department of Entomology, Michigan State University.
- Bernard H. Zandstra, Department of Horticulture, Michigan State University.
- Michael J. Brewer, Joy N. Landis and Rebecca J. Lamb, Integrated Pest Management Program, Michigan State University.

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- Robert L. Anderson; USDA Forest Service
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- Diane Brown-Rytlewski, Michigan State University
- Mike Bryan, Michigan Department of Agriculture
- Jan Byrne, Michigan State University
- David Cappaert, Michigan State University
- Raymond A. Cloyd, Kansas State University
- Tom Creswell, North Carolina State University
- Paula Flynn, Iowa State University
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- Brian Olson, Oklahoma State University
- Jackie Smith, Michigan State University
- Joe Svoboda, Michigan State University
- James Taulbee, Michigan State University

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Introduction

Herbaceous perennials, whether grown in greenhouse, nursery or landscape settings, may encounter multiple problems caused by insect and mite pests and pathogens. These pests are best managed using an integrated pest management (IPM) approach. Pest management starts with identifying the particular pest causing a problem. This pocket guide was developed for use in the field, where growers and landscape managers often first notice a pest problem. It provides quick problem identification to facilitate a fast response before pest problems cause significant plant damage. The guide is not a replacement for other more extensive references or services provided by a diagnostic laboratory.

Pest management strategies may vary, depending on the setting within which the crop is growing. This diversity of settings was considered during the process of developing the management information, and as a result, all the management information for a particular pest may not pertain to all settings.

Specific pesticides are not listed in this guide because recommendations change frequently as

new products become available and older ones are removed from the market. We suggest that you contact your local Extension office for pesticide recommendations.

Lastly, we would like to acknowledge Diane Brown-Rytlewski for initiating the partnership between the authors that resulted in this publication.

Suggested reading

Integrated Pest Management Handbook for Herbaceous Perennials. L. Pundt and T. Smith. 2003. University of Connecticut.

Disease Control in the Landscape. C.W. Ellett, M.A. Ellis, S.T. Nameth, H.A.J. Hoitink, N.J. Taylor, J.W. Rimelspach, J.A. Chatfield, M.A. Rose and D.J. Shetlar. 1996. Bulletin 614. The Ohio State University Extension.

Pests and Diseases of Herbaceous Perennials. S. Gill, R.A. Cloyd, J.R. Baker, D.L. Clement and E. Dutky. Batavia, IL; Ball Publishing.

Identifying Natural Enemies in Crops and Landscapes. M. Gardiner, C. DiFonzo, M. Brewer and T. Noma. Reprinted 2007. Bulletin E-2949. Michigan State University Extension.

Chewing pests

Black vine weevil

Black vine weevil adults do not possess wings, so they cannot fly. The adults are active primarily at night and hide during the day in debris or under plant containers. Adults feed on a wide variety of herbaceous perennials. The larvae, which are located in the growing medium, are white and grub-like and feed on plant roots.

10 mm

The adult is black with patches of fine yellow hairs covering its body. It has a short, snout-shaped mouth that creates characteristic notches on plant leaves during feeding (see below).

Management: Remove plant and growing medium debris from the area. Contact insecticides with residual activity can be applied to the foliage in the evening. Beneficial nematodes such as *Heterorhabditis bacteriophora* may be applied as a drench to individual containers. The nematodes attack and kill the larval stage.

Blister beetle

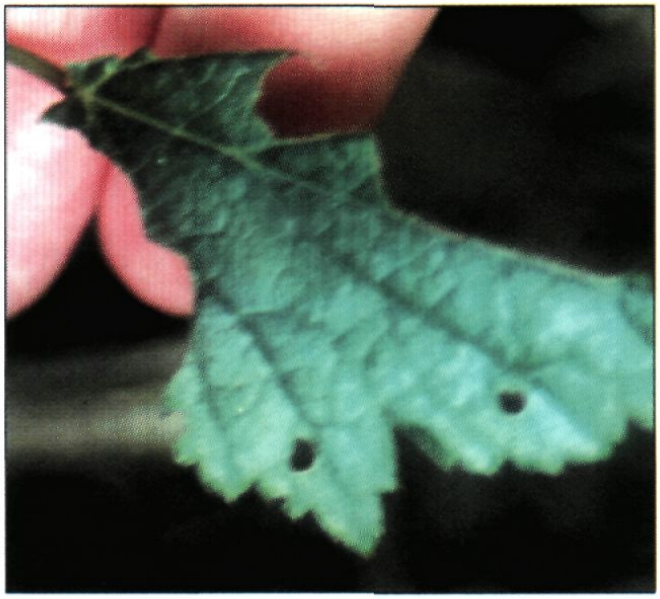
Blister beetle adults are 19 mm long and elongated. They vary in color from black and blue to brown, with or without stripes. They possess a characteristic constricted neck. These beetles overwinter as larvae in the soil.

19 mm

Adult beetles with stripes.

Color variations include black like these adult beetles.

Blister beetle – *continued*



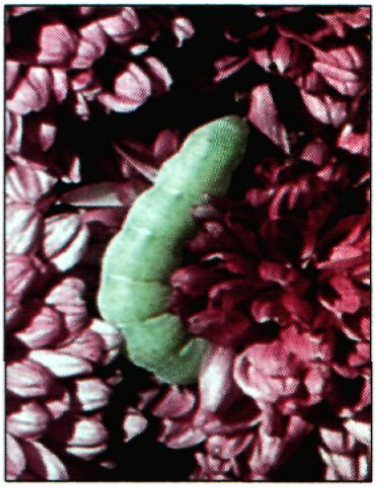
Adults feed on flowers and leaves, creating small rounded or irregularly shaped holes.

Management:
Adults can be hand picked, but it is important to wear gloves because these insects release a caustic substance when crushed that can cause blisters and welts on the skin. Contact insecticides may be used to control the adults.

Chewing pests
Caterpillars

Caterpillars are the larval stages of moths and butterflies. They cause damage by feeding on plant leaves. The adults feed on pollen and nectar. Color and size will vary, depending on the species.

Caterpillars – *continued*



Many types of caterpillars feed on herbaceous perennials, including cutworms, corn earworms, imported cabbageworms, diamondback moths, cabbage loopers, saddleback caterpillars and American lady caterpillars.

Caterpillars remove plant parts during feeding, creating irregular or rounded holes in leaves and flower buds. Frass (fecal deposits) are typically present near damaged tissues. Herbaceous perennials are susceptible to a variety of caterpillar types.

Management: Remove weeds and plant debris from adjacent areas. Applying an insecticide derived from the soil bacterium *Bacillus thuringiensis* var. *kurstaki* is effective on young larvae feeding on plant leaves. Contact insecticides are also effective. Scout regularly using yellow sticky cards, which attract the adults.

Earwig

Earwigs are active at night, hiding during the day in mulch, under rocks and underneath wood lying on the soil surface. They prefer moist habitats. Earwigs feed on leaves and flowers, creating small, irregularly shaped holes and giving plants a ragged appearance. They overwinter as adults and eggs.

Earwig adults are 6 to 25 mm long and pale brown to reddish black, and the body appears flattened. Their large, pincers (cerci) extend from the back of the abdomen.

Management:

Remove plant debris, organic mulch and scrap wood from the area, as these are potential hiding places for earwigs. Moistened rolled-up newspapers left overnight on the soil may be retrieved in the morning, and any earwigs present can be shaken into a container of soapy water.

Chewing pests

Flea beetle

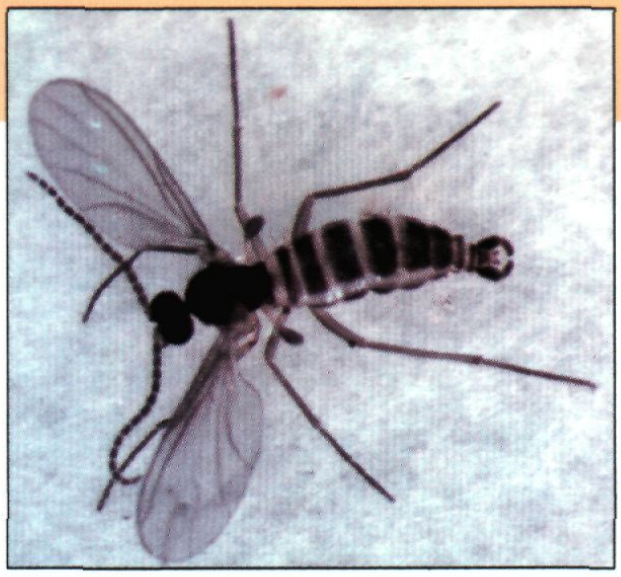
Flea beetle adults are 1.5 mm long and vary in color from black to blue. ■ 1.5 mm

Adult flea beetles chew multiple small holes in leaves and flowers. They tend to feed in large groupings and possess enlarged hind legs that allow them to jump off plants when disturbed. Flea beetle larvae are located in the soil and feed on plant roots. Flea beetles overwinter as adults in weeds and plant debris.

Management: Remove overwintering sites such as weeds and plant debris. Place a covering over plants until adults are no longer present. Contact insecticides may be useful in controlling adults.

Chewing pests

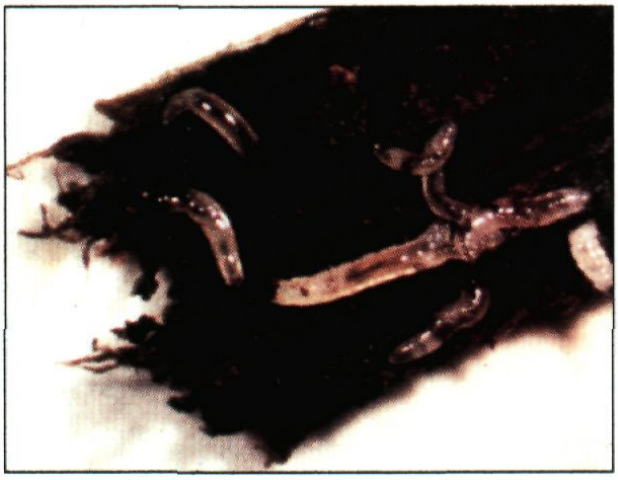
Fungus gnat



Fungus gnat adults are black and winged, with long legs and antennae. Each front wing has a characteristic Y-shaped vein.

3 mm

Fungus gnat adults are located primarily near the surface of growing media. Each female can lay up to 200 eggs in the cracks and crevices of the growing medium. They are highly attracted to growing media that contain high amounts of organic matter. The larvae feed on plant roots, reducing the plant's ability to take up water and nutrients. In addition, larvae may tunnel into plant stems near the growing medium surface, causing stunting, wilting and even death.



Fungus gnat larvae are white, translucent and legless. They possess a distinct black head capsule.

6 mm

Fungus gnats – *continued*

Management: Avoid overwatering plants – allow the top 1 to 3 inches of growing medium to dry. Insecticides, particularly insect growth regulators, can be applied as a drench to the growing medium to control larvae. Applications of the beneficial nematode *Steinernema feltiae* to the growing medium are effective in controlling the larvae. Rove beetles, *Atheta coriaria*, are predators that may be effective against fungus gnat larvae. Both the larvae and adults are predaceous.

Chewing pests
Grasshoppers

Grasshoppers have long hind legs that are adapted for jumping. They tend to feed during the day, creating large, ragged holes in plant leaves.

Adult grasshoppers are typically 2 to 5 cm long, and they vary in color from brown, green and red to yellow, depending on the species.

Grasshoppers – *continued*

High numbers of grasshoppers can cause extensive plant damage within a short period of time. They overwinter as eggs in the growing medium.

Management: Grasshoppers are difficult to control with spray applications of contact insecticides because they are strong fliers and highly mobile. One option is to place a covering over plants until adults are no longer present. Remove weeds from adjacent areas.

Chewing pests

Harlequin bug

10 mm

Harlequin bug adults are 10 mm long, robust and shield-shaped. Adults are brightly colored in black and red-orange with distinct yellow markings. There is a black X on the thorax.

Harlequin bug – *continued*

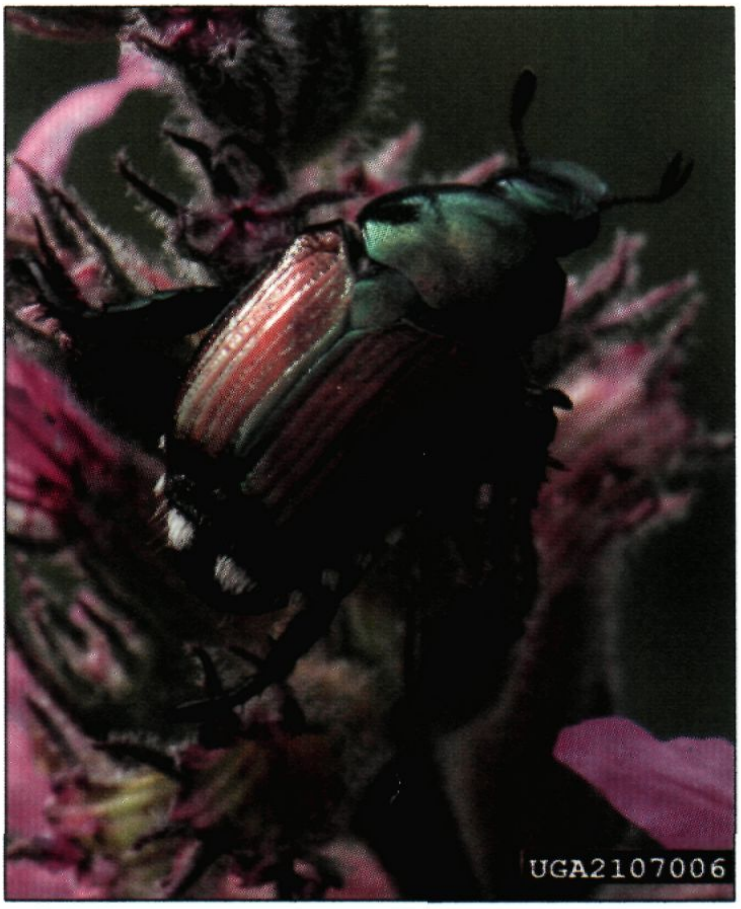
Harlequin bug adults and nymphs use their piercing-sucking mouthparts to withdraw plant fluids, causing plants to wilt, turn brown and possibly die. Nymphs resemble adults but are smaller and lack wings.

Eggs are laid on leaf undersides and are very distinctive, resembling tiny white kegs standing on end in a double row. Each egg has two dark bands, one near the top and one near the bottom. Harlequin bug overwinters as an adult.

Management: Remove weeds and plant debris from adjacent areas that may serve as over-wintering sites. Keep grassy areas mowed during the spring and summer. Contact insecticides may be effective in controlling harlequin bug adults and nymphs.

Japanese beetle

Look for adults in late June through September. Timing may vary, depending on geographic location. Adults tend to congregate on plants, feeding between the leaf veins and causing leaves to appear lace-like or skeletonized. Japanese beetle adults feed on a wide variety of herbaceous perennials.



Japanese beetle adults are 9 to 12 mm long, metallic green with coppery wing covers. White tufts of hair at the rear end of the abdomen are a distinguishing characteristic for identification.

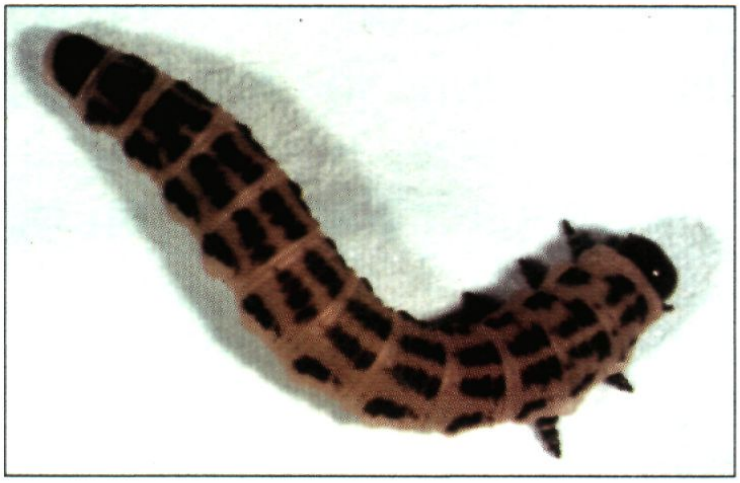
Japanese beetle – *continued*

D. Brown-Rytlewski, MSU

Damage from beetle feeding.

Management: Japanese beetles are attracted to plants that have been previously damaged, so it is important to control beetles early. The use of pheromone and bait traps is not recommended because this will attract more beetles from surrounding areas and result in greater damage to plants. Small numbers of Japanese beetle adults can be hand picked. Contact insecticides may be applied as soon as adults are apparent. Note that many contact insecticides are harmful to bees, beneficial insects and mites.

Sawflies



Sawfly larvae, which resemble caterpillars, vary in color from green, red, yellow and tan to black. Larvae tend to feed in groups during the evening.

Young sawfly larvae skeletonize leaves initially and consume the entire leaf except for the midvein as they mature. Adults are large, robust insects that resemble bees or wasps with a dark body and long antennae. Females lay eggs on the undersides of leaves.

Management: Hand pick small numbers of sawfly larvae. Contact insecticides, applied early, are effective in controlling the young larvae. Although sawfly larvae resemble caterpillars, they are in the insect order Hymenoptera, not Lepidoptera, so they are not susceptible to the bacterial insecticide *Bacillus thuringiensis* var. *kurstaki*, which is used to control young caterpillars.

Slugs

Slugs have chewing mouthparts and create large irregular, ragged holes on leaves with tattered edges.

Slugs are worm-like, legless organisms that are often referred to as snails without shells. They vary in length from 1 to 15 cm when full grown, depending on the species. Slugs prefer to reside in moist areas and are active at night. They leave a silvery slime trail, which is most noticeable on sunny days. Slugs vary in color from black, brown, lavender, purple and white to yellow. Several have brown specks or mottled areas.

Management: Remove any hiding places including plant debris, weeds, rocks and wood lying on the soil surface. Avoid overwatering herbaceous perennials to minimize creating moist habitats ideal for slug breeding. Commercial molluscicides can be applied in the evening. It is important to irrigate the area before application.

Chewing pests

Spotted cucumber beetle

Adults are 6 mm long and yellow-green with a small black head. There are typically 12 black spots on the hard wing covers. 6 mm

Adult spotted cucumber beetles chew holes in plant leaves and flowers. They commonly feed on pollen. Although adults typically cause minimal damage, large populations may significantly damage plants, particularly those in the sun-flower family, including chrysanthemum, coreopsis and dahlia. The adults overwinter in plant debris.

Management: In early spring, cover plants with a row cover until blooming starts. Remove and discard any plant debris. Contact insecticides may be used to control the adults.

Sucking pests

Aphids

Aphids are 1 to 3 mm long and pear-shaped, with two tubes (cornicles) projecting from the back of the abdomen. They vary in color, depending on the host plant fed upon, from black, brown, green, orange and red to yellow. 3 mm

Aphids use their piercing-sucking mouthparts to withdraw fluids from terminal growth and leaf undersides. This results in leaf curling or distortion. Aphids produce honeydew, a clear, sticky liquid. Aphids feeding on plants outdoors are susceptible to many beneficial insects (natural enemies), including parasitic wasps, ladybird beetles, green lacewings and hover flies. Many species of aphids feed on a wide variety of herbaceous perennials.

Management: A hard water spray will quickly remove aphids from plants and minimally affect any beneficial insects. Avoid overfertilizing and overwatering plants. Remove weeds from adjacent

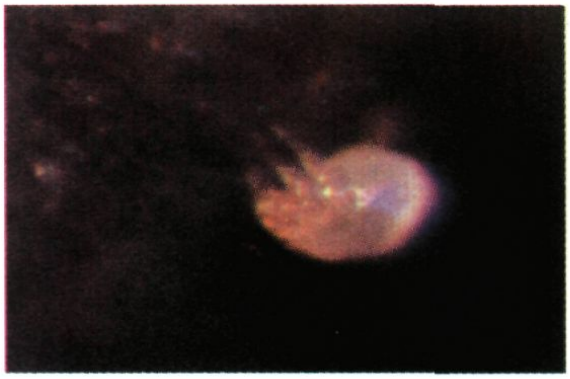
Aphids – *continued*

areas – many weeds serve as a reservoir for aphids. Contact and systemic insecticides may be effective in controlling aphids.

Aphids tend to feed on plants in large numbers.

Sucking pests
Broad mite

Broad mite resembles cyclamen mite (see page 19) in size and appearance. The primary difference is that broad mite eggs have noticeable bumps on the surface and cyclamen mite eggs are smooth.



Broad mite adults are 0.25 mm long and invisible to the naked eye. They are oval to elongated and white or amber-colored.

Broad mite – *continued*

Broad mite feeding results in curled, distorted and cupped or puckered leaves. In addition, infected leaves may appear glossy or silvery and are harder than normal. Newly emerging leaves may also look shiny and brittle.

Management: Dispose of all plants exhibiting symptoms of broad mite damage. Also, remove all plants within 1 foot of damaged plants. Broad mite control with miticides is difficult because they tend to be located in hidden, hard-to-reach areas.

Sucking pests

Cyclamen mite

Cyclamen mites cannot be seen with the naked eye because the adults are about 0.25 mm long. They are oval or elongated and white or amber-colored. Cyclamen mites require high relative humidity – 80 to 90% – and temperatures around 60°F for development. These mites do not produce webbing.

Cyclamen mite feeding causes flower curling, twisting and distortion. In addition, leaves may appear brittle.

Management: Dispose of all plants exhibiting symptoms of cyclamen mite damage. Also, remove all plants within 1 foot of damaged plants. Cyclamen mite control with miticides is difficult because they tend to be located in hidden, hard-to-reach areas.

Eriophyid mite

Eriophyid mites are microscopic (less than 0.25 mm long), and spindle-shaped with elongated bodies. They resemble cigars with the head and legs on one end.

Eriophyid mites feed deep within plant tissues, withdrawing plant fluids with their stylet-like mouthparts and injecting a toxin that deforms plant growth. Once eriophyid mite damage is evident, it is too late to save plants because the mites are already established in the plants. They tend to congregate in large numbers, feeding on all plant parts – buds, flowers and leaves.

Management: Dispose of all plants exhibiting symptoms of eriophyid mite damage. Also, remove all plants within 1 foot of damaged plants. Eriophyid mite control with miticides may be difficult because they tend to be located in hidden, hard-to-reach areas.

Eriophyid mite – *continued*

Eriophyid mite feeding results in distorted, roughened growth on both leaves and flowers. Eriophyid mites may also cause swollen or thickened growth, leaf blistering and bronzing of infected leaves.

Sucking pests

Four-lined plant bug

6 mm

Four-lined plant bug nymphs and adults move very rapidly when disturbed. Young nymphs are red-orange with black markings on the thorax.

Four-lined plant bug adults are slender, 6 mm long, green or yellow and oval-shaped with four distinct black stripes on the wings.

Four-lined plant bug – *continued*

Four-lined plant bug feeding results in pale, round, depressed spots 1 to 3 mm long on leaves. These spots turn brown and may coalesce, forming large brown blotches.

Four-lined plant bug feeds on a wide variety of herbaceous perennials. It overwinters in the egg stage.

Management: Remove weeds and plant debris from adjacent areas. Contact insecticides may be applied when nymphs and adults are present.

Sucking pests

Lacebug

Lacebug nymphs are black and covered with spines.

Lacebug adults are 3 to 6 mm long, flat and white with transparent, lace-like wings covering the body.

Lacebug – *continued*

Lacebugs cause a characteristic stippling of leaves, similar to twospotted spider mite damage. Black fecal deposits may be present on the undersides of leaves.

All the life stages – eggs, nymphs and adults – are located on leaf undersides. Eggs are typically laid in groups. Lacebug overwinters as either an egg or an adult.

Management: A hard water spray will quickly remove lacebugs from plants. Contact insecticides may be applied when lacebug nymphs and adults are present. Lacebug numbers may not be high enough to warrant control,however.

D. Brown-Rytlewski, MSU

Leafhoppers

3 mm

Leafhoppers are 3 mm long, slender and wedge-shaped. They are usually yellow to light green, depending on the species. They hold their wings roof-like over their body.

Leafhopper feeding causes stippling of plant leaves that is similar to damage caused by twospotted spider mite. Leafhopper feeding can result in leaf distortion, chlorosis, plant stunting, leaf curling, leaf yellowing and necrosis. Extensive feeding damage gives plants a scorched appearance. Both the adults and nymphs are active, typically moving sideways when disturbed.

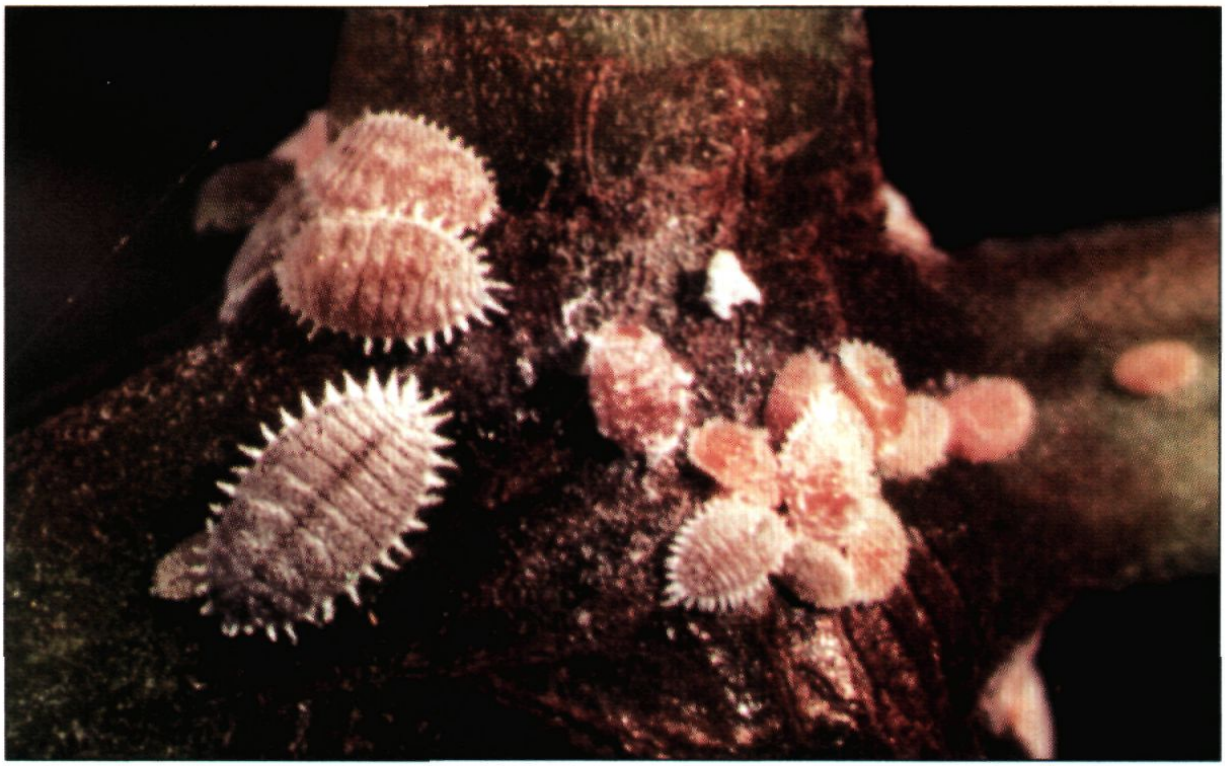
Leafhoppers feed on a wide variety of herbaceous perennials. The aster leafhopper transmits aster yellows disease.

Management: Remove weeds from adjacent areas – many weeds serve as a reservoir for leafhoppers. Contact insecticides may be used against leafhoppers, but control can be difficult because leafhoppers are very mobile.

Sucking pests

Mealybugs

Mealybugs feed on plant sap with their piercing-sucking mouthparts. Heavy infestations of mealybugs on plants can result in leaf yellowing, leaf drop, plant wilting and stunting. Mealybugs also produce large quantities of honeydew, a clear, sticky liquid, which serves as an ideal growing medium for black sooty mold fungi.



Mealybugs are 3 to 6 mm long, orange-pink when young. Mature adults look like cottony white flecks with fringe of waxy filaments surrounding the body.

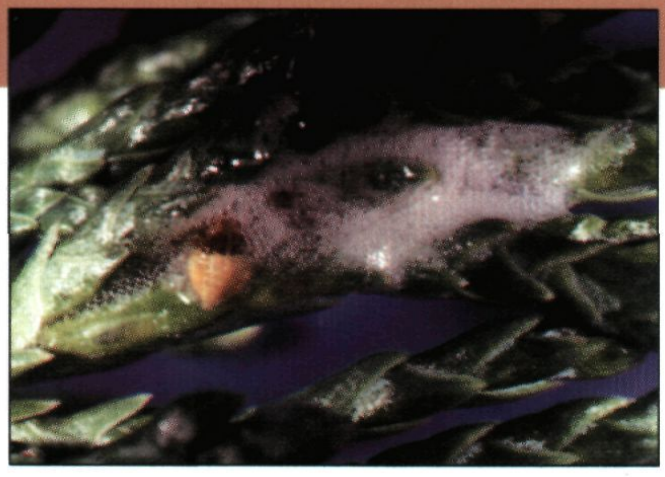
Mealybugs – *continued*

Management: Dispose of heavily infested plants immediately. Contact insecticides may be used, but sprays must be applied when crawlers are present because once the later instars have developed the waxy coating, contact insecticides are less effective. Systemic insecticides typically need to be applied before mealybugs are present.

Mealybugs usually feed in leaf and stem axils and along leaf veins.

Sucking pests

Spittlebugs



6 mm 8 mm

Spittlebug nymphs produce a frothy white mass or "spittle" in the center of stems or leaf axils. This covering protects spittlebugs from predators and environmental conditions.

Adult spittlebugs are 6 to 8 mm long and black, brown or yellow with distinct red eyes. The adults may possess orange bands on the wings, depending on the species. Nymphs are cream-colored with brown heads and red eyes. Generally, spittlebugs don't cause significant plant damage, although they may stipple leaves.

Management: A hard water spray will quickly remove spittlebugs from plants. Contact insecticides may be used, although their effectiveness is often reduced by the frothy covering, which prevents the insecticide from making contact with spittlebug nymphs or adults.

Tarnished plant bug

Feeding by tarnished plant bug adults and nymphs causes yellowing of terminal growth, which becomes twisted and distorted. In addition, leaves may appear ragged and discolored. Flowers may fail to develop, or the flower buds may abort. Tarnished plant bug overwinters as an adult.

Tarnished plant bug adults are 3 to 6 mm long, oval-shaped, and mottled brown with several small black, brown, red or yellow markings on the body. A white or black triangle is typically visible on the front of the abdomen. The antennae and legs are relatively long.

Management: Remove weeds and plant debris from adjacent areas. Contact insecticides may be applied when nymphs and adults are present.

Sucking pests

Thrips

Both adult and nymphal stages of thrips feed on leaves and flowers. Adults tend to be located in terminal flower buds or open flowers; nymphs are usually found on plant leaves.

Thrips typically feed on leaf buds before they open, which results in leaf abortion or flower deformation. Numerous species of thrips feed on herbaceous perennials. Several thrips species transmit viruses, including impatiens necrotic spot and tomato spotted wilt virus.

Adult thrips, depending on the species, are less than 1.5 mm long and slender with wings that contain hairs. Nymphs resemble adults except that they lack wings.

Thrips – *continued*

Thrips feeding causes scarring, stunting or distortion of leaves or flowers. Additionally, leaf tissue may appear sunken or indented. Black fecal deposits may be present on leaf undersides.

Management: Remove weeds from adjacent areas – many weeds serve as a reservoir for thrips and the viruses they transmit. Placing yellow sticky cards among plants, just above the canopy, will trap adults. Thrips control with contact insecticides may be difficult because they tend to reside in unopened terminal and flower buds. Sprays need to be applied when plants are young.

Sucking pests

Twospotted spider mite

Twospotted spider mite has piercing-sucking mouthparts and is usually found feeding on leaf undersides. Leaves heavily infested with twospotted spider mites may appear yellow to bronze, turn brown, dry up and fall off. Webbing may be present on leaf undersides and plant stems when populations are large. This spider mite prefers hot, dry conditions.

Twospotted spider mites are 2 mm long, oval-shaped, and green, yellow or reddish orange. Adults have two dark spots on both sides of the body.

2 mm

Management: A hard water spray directed at leaf undersides will quickly remove two-spotted spider mites from plants and minimally affect any

Twospotted spider mite – *continued*

Twospotted spider mite damage appears as small, white to yellow specks on plant leaves. This damage is often referred to as stippling.

beneficial insects and mites. Avoid overfertilizing and overwatering plants. Remove weeds from adjacent areas – weeds serve as overwintering sites for twospotted spider mite. Contact miticides and those with translaminar properties may be effective in controlling twospotted spider mites.

Sucking pests

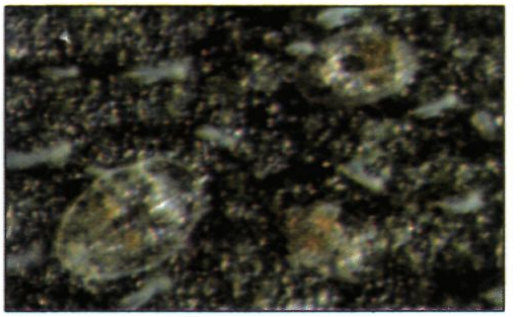
Whiteflies

Whiteflies – primarily the nymphs – remove plant fluids with their piercing-sucking mouthparts resulting in leaf yellowing. Like aphids, whiteflies produce honeydew – a clear,

Whiteflies – *continued*

3 mm

Whitefly adults are 3 mm long with two pairs of wings covered with powdery white wax. Adults tend to be located on the undersides of leaves.



2 to 3 mm

Whitefly nymphs are elliptical, 2 to 3 mm long and pale yellow ,and they reside on leaf undersides. Some species have setae or hairs protruding from the body.

sticky liquid. Large whitefly populations may cause plant stunting, wilting and possibly death. Eggs, nymphs and pupae are typically located on the undersides of leaves.

Management: Remove weeds from adjacent areas – many weeds serve as a reservoir for whiteflies. Placing yellow sticky cards among plants, just above the canopy, will trap adults. Dispose of plants heavily infested with whiteflies. Prune out or remove plant parts with whiteflies and dispose of everything in plastic containers. Contact and systemic insecticides may be effective in controlling whiteflies.

Leafminers

Many leafminer types, such as wasps, caterpillars and flies, may attack herbaceous perennials. Adult leafminer flies are 2 to 3 mm long and black to yellow, with yellow bands or markings on the abdomen. They resemble houseflies. Larvae are approximately 3 mm long, shiny and yellow to white. Leafminers usually pupate in growing medium or soil. Leafminers that attack herbaceous perennials include columbine, verbena and larkspur leafminers.

Leafminer larvae feed between the leaf tissues, creating winding or serpentine tunnels or, in some instances, blotches.

Leafminers – *continued*

Although leafminers don't usually kill plants, the damage may reduce the aesthetic appearance of infected plants.

Management: Remove and dispose of infested plant parts such as leaves and stems. Remove weeds from adjacent areas – many weeds serve as a reservoir for leafminers. Avoid overfertilizing plants with nitrogen-based fertilizers – this may enhance the attractiveness of herbaceous perennials to adult females and increase the number of eggs laid per plant. Insecticides with systemic or translaminar properties may be used to control leafminers.

European corn borer

European corn borer larvae initially chew round holes in leaves and then tunnel into plant stems. European corn borer will attack a wide variety of herbaceous perennials grown outdoors. They are more problematic in areas adjacent to cornfields.

2 cm

European corn borer larvae are 2 to 2.5 cm in length. They are gray to pink with a distinct black head. Dark brown spots are present on each segment of the abdomen.

Management: Remove volunteer corn from adjacent areas. Applications of an insecticide derived from the soil bacterium *Bacillus thuringensis* var. *kurstaki* are effective on young larvae feeding on plant leaves but less effective on larvae that bore into plant tissues. Scout regularly using yellow sticky cards, which are attractive to the adults.

Boring pests
Iris borer

The mature larvae of iris borer are 2 to 5 cm long, fleshy, smooth and pink with black spots on the side.

Iris borer larvae initially feed at the tops of plants, chewing holes in leaves and giving leaves a ragged appearance. They eventually create dark-streaked areas that appear watery. Larvae migrate down the plant, and then mature larvae bore into leaves a few inches above the growing medium surface. Mature larvae then feed within the rhizome, creating large tunnels. The tunneling causes plants to wilt severely and eventually rot. The adult iris borer is

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Iris borer – *continued*

a nocturnal moth with dark purple front wings and yellow-brown hind wings. Females lay eggs in plant debris. Iris borer overwinters in the egg stage.

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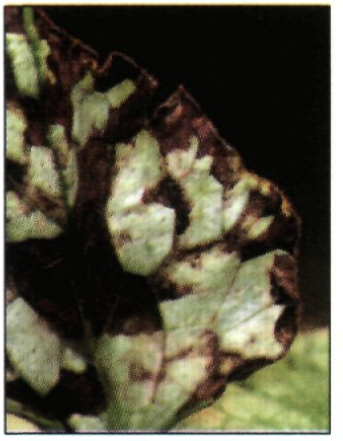
Management: Remove debris from adjacent areas. Clip and remove dead iris leaves and stems to eliminate any overwintering eggs. Contact insecticides need to be applied before the larvae enter leaves. Frequent applications may be necessary in the spring.

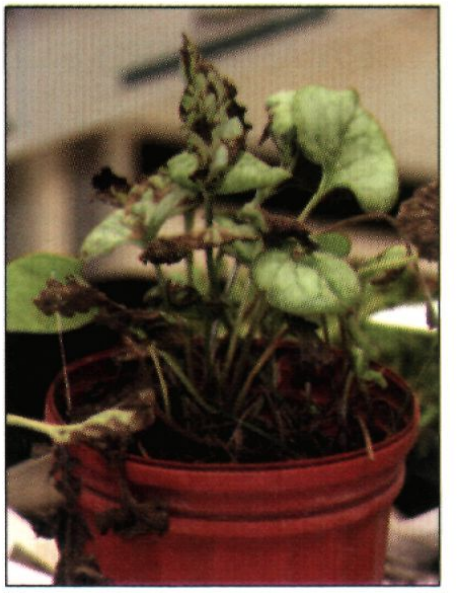
Pest nematodes
Foliar nematodes

Foliar nematodes are extremely small – approximately 0.8 mm long – colorless roundworms. They need a film of moisture to move around.

Foliar nematodes – *continued*

Foliar nematodes enter leaf tissue through the stomates, feeding on new growth and leaf tissues and causing plant stunting, leaf twisting, curling or spotting. They also create blotched or blighted areas on leaves.





Foliar nematodes feed within the plant's spongy mesophyll and spend most of the growing season in leaves. The nematodes cannot move across main leaf veins while inside the leaf, so infected areas of leaves are bounded by the veins. Foliar nematodes may overwinter on debris and in the crown of plant buds. They may infect a number of herbaceous perennials, including hosta, astilbe and delphinium.

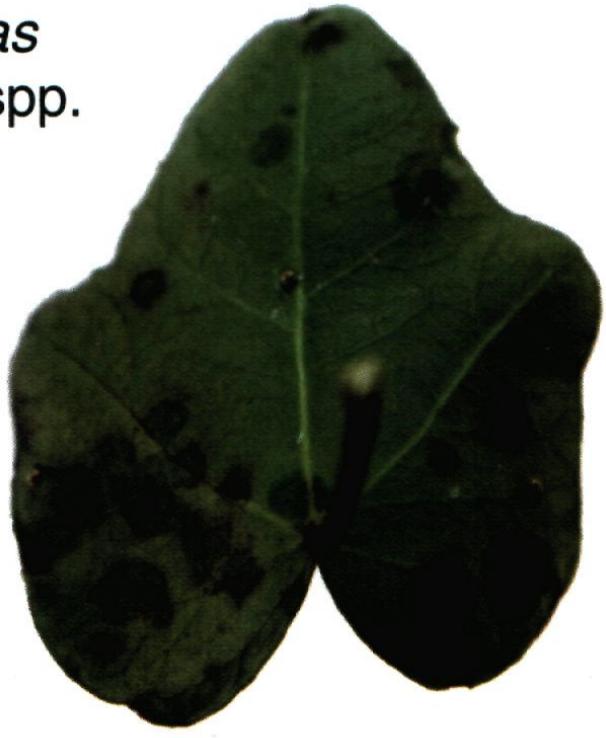
Management: Dispose of all infected plants and plant material. Avoid splashing water on susceptible plants. Selectively remove leaves from plants just expressing symptoms of foliar nematode damage. Insecticides with translaminar properties may be useful in controlling foliar nematodes.

Bacterial leaf spot

Pathogen: *Pseudomonas* spp. and *Xanthomonas* spp.

Hosts include: *Astilbe, Chrysanthemum, Delphinium, Echinacea, Heuchera, Hypericum* and *Rudbeckia.*

Symptoms: Disease symptoms include water-soaked lesions on foliage that darken with age. Lesions may be bordered by the leaf venation.



Xanthomonas leaf spot of ivy. Note the water-soaked halos around leaf spots.

Spread: Bacteria on the plant surface are easily spread to nearby plants by splashing water from rain and irrigation. Asymptomatic plants can serve as a source of inoculum.

Management: Bacterial pathogens can survive and reproduce on the surface of

Bacterial leaf spot – *continued*

Bacterial leaf spots on *Heuchera*.

asymptomatic plant tissues. Disease symptoms develop once the pathogen reaches high population levels on the plant surface. Sanitation is especially important. Workers should wash their hands after handling diseased plants. Foliage should not be handled when it is wet. Symptomatic plants should be destroyed. Avoid overhead irrigation or time irrigation to minimize leaf wetness. Succulent tissue is especially susceptible to infection. Most fungicides are not effective against bacteria. Copper-based products are helpful in limiting populations of surface-borne populations of bacterial pathogens.

Crown gall

Pathogen: *Agrobacterium tumifaciens.*

A large gall on a dead stem of *Achillea.*

Hosts include: *Achillea, Anemone, Artemisia, Aster, Campanula, Coreopsis, Delphinium, Dianthus, Gaillardia, Geranium, Gypsophilia, Helianthus, Heuchera, Lathyrus, Nepeta, Oenothera, Penstemon, Phlox, Platycodon, Primula, Rudbeckia, Salvia, Scabiosa, Sedum* and *Stachys.*

Symptoms: Galls form on stems and roots, restricting shoot or root growth.

Spread: This bacterium persists in soil; use of infested field soil can spread the disease. Moving infested plants also spreads disease. Cuttings taken from infected plants are likely to become infected.

Crown gall – *continued*

Management: Plants with galls should be removed and destroyed: they cannot be successfully treated. Infection usually occurs through wounds. Good sanitation is important during vegetative propagation. Effective biological control products are available and can be used to protect especially susceptible plants.

Fungal leaf spots
Alternaria leaf spot

Pathogen: *Alternaria* spp.

Hosts: Several species are pathogenic on perennials. Together, they have a wide host range, including *Aster, Calendula, Coreopsis, Dianthus, Gypsophila, Helianthus, Iris, Ligularia, Pelargonium, Platycodon, Shasta* and *Stokesia*.

Symptoms: Dark-colored leaf spots. Lesions may have

Severe leaf spotting on *Chelone* sp.

Alternaria leaf spot – *continued*

concentric rings within them. Spots may coalesce, resulting in blighting of foliage. Petals of some plants may be infected. *Dianthus* flower buds can be rotted.

T. Creswell, NCSU

Lesions on *Ligularia*.

Spread: Spores are produced on the plant surface and are spread by splashing water or air movement or by moving infected plant material.

Management: Maintain adequate plant spacing to allow for good aeration to reduce humidity levels around plants. *Alternaria* spp. require leaf wetness for germination and infection; reduce durations of leaf wetness with good timing of overhead irrigation. Regular fungicide applications will likely be necessary to reduce losses on especially susceptible hosts.

Dark, multicelled spores produced on the surface of infected plant material by *Alternaria* spp. Spores may be visible with a hand lens.

Anthracnose

Severe leaf spotting on a young hollyhock leaf.

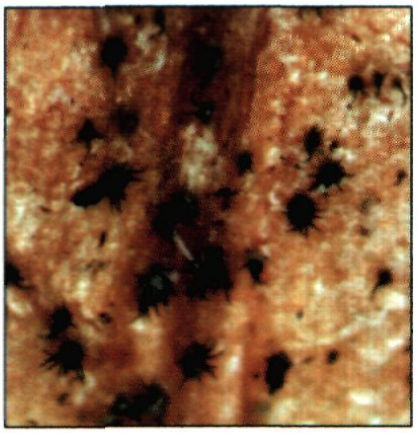
Pathogen: *Colletotrichum* spp.

Hosts include: *Althaea, Bergenia, Heuchera, Hosta, Limonium, Sedum* and *Lupinus*.

Symptoms: Symptoms vary, depending on the host. *Althaea* seedlings and young plants are especially susceptible to infection: leaf spotting and stem lesions can be severe. Lupine seedlings are especially vulnerable: infected plants wilt and have necrotic lesions on stems. Leaf spots, shepherd's crooks and crown rot develop on more mature lupine plants (see photo). Anthracnose causes severe stem girdling and crown rot on sedum. Susceptibility varies with cultivar. Infection on

Anthracnose – *continued*

hosta causes leaf spots with bleached out centers and reproductive structures (black dots) are often visible in these lesions.



Setae, produced in clumps on the surface of dead plant material, are a diagnostic structure.

Spread: Disease can be seed-borne in some perennial crops. The pathogen persists on infested material. Spores are splash-dispersed by rain and irrigation.

Management: Space plants to promote air circulation around them. Remove diseased plant material – *Colletotrichum.* spp. will sporulate readily on dead plant material in the production area. Fungicide applications may be needed. Lupine seedlings can be infected by seed-borne inoculum. Disease management must rely heavily on the use of disease-free seed and fungicide applications to seedlings.

Foliar dieback symptoms on a larger, more mature lupine plant.

Botrytis blight

Pathogen: *Botrytis cinerea.*

Severe leaf spotting. Infections developed during prolonged, wet weather.

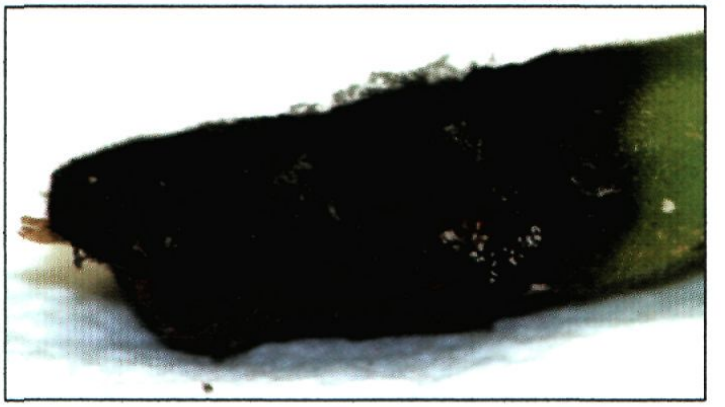
Hosts: Very large host range, some of the most susceptible include *Delphinium, Hosta, Iris, Lilium, Primula, Rudbeckia* and *Viola*. Blossoms are especially susceptible.

Symptoms: Seedling blight, leaf spots and blight, distortion of young leaves, crown rot and blossom blight.

Severe leaf spotting on *Lilium*, a very susceptible host.

Botrytis blight – *continued*

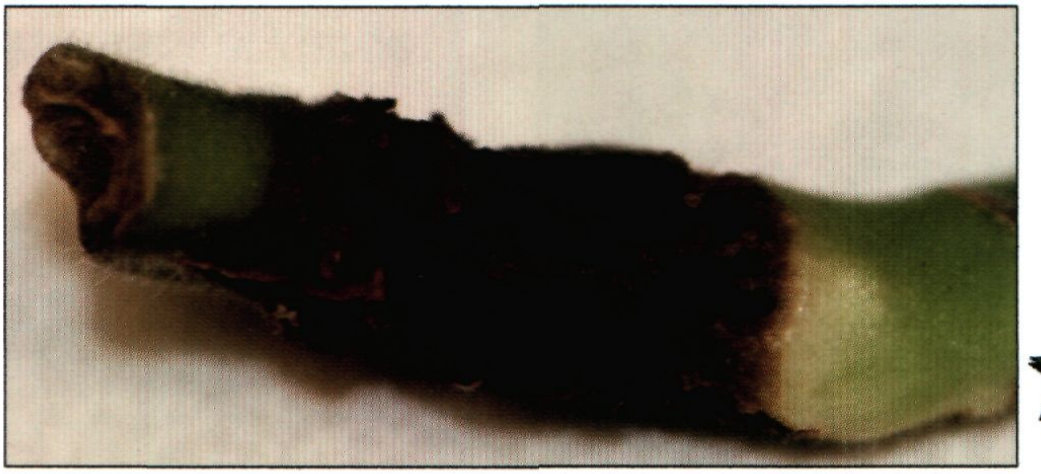
Signs: In high relative humidity, grayish, fuzzy mold on the surface of the affected tissue is visible with the naked eye.



Basal ends of cuttings can be infected during propagation. The gray, fuzzy mold is characteristic of *B. cinerea* sporulation.

Spread: Spores are produced in mass under humid conditions and are readily released and moved by air currents. Additionally, overwintering structures (sclerotia) are formed and can persist in soil and plant debris. Sclerotia are found on the surface of heavily diseased plant material.

Sclerotia, the overwintering structure, on dead stem tissue.



Botrytis blight – *continued*

Management: Sanitation and aeration procedures that reduce humidity levels around plants and appropriate fungicide applications are recommended for disease control. *Botrytis cinerea* can sporulate on dead plant material; fallen leaves and petals should be carefully removed from production areas. Trash cans used for dead plant tissue should not be kept in production areas. Regular fungicide applications will likely be necessary to reduce losses on especially susceptible hosts grown in humid environments.

Foliar blighting of *Rudbeckia*.

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Fungal leaf spots

Daylily leaf streak

Pathogen: *Collecephalus hemerocalli.*

Hosts: *Hemerocallis.*

The disease was named for these streak symptoms along the leaf's midrib.

Symptoms: Elongated brown lesions, which are lengthwise on the foliage, surrounded by a chlorotic halo. Lesions that affect the midrib of a leaf cause the leaf to senesce from the lesion to the leaf tip. Tissue in the center of the leaf becomes necrotic, creating a dead streak down the middle of the infected leaf. Flower production may be decreased.

Initial symptoms are tan leaf spots surrounded by chlorotic halos.

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Severely infected leaf.

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Daylily leaf streak – *continued*

Spread: Diseased plant material can introduce the pathogen into a production area. *C. hemerocalli* produces wind-borne spores on infected leaves. Sclerotia, an overwintering structure, are produced on dead or dying foliage.

Management: Cultivars vary in their susceptibility. Remove dead foliage from the preceding year. Poorly managed plants in overcrowded growing situations are more likely to become diseased. The disease is more severe early in the growing season. Temperatures above 90°F limit disease development.

Leaf streak symptoms are readily visible in a planting bed.

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Didymellina leaf spot

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Severe blighting of foliage. Most infections occur on the upper portion of the foliage.

Pathogen: *Didymellina poecilospora*.

Hosts: *Iris*; most severe on rhizomatous iris.

Symptoms: The first symptoms are tiny, brown spots with water-soaked borders. As disease progresses, the water-soaked areas develop into irregular spots with grayish centers and dark borders. Foliage is killed, weakening the rhizomes. Disease severity worsens after bloom.

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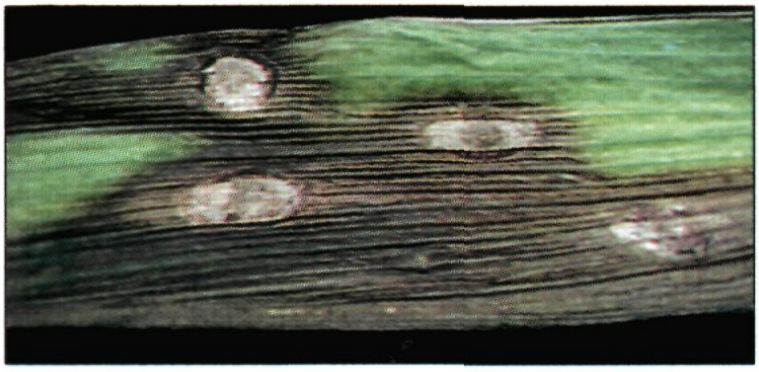
Individual spots with grayish centers and darker borders surrounded by yellow halos.

Didymellina leaf spot – *continued*

Necrotic tissue coalesces around the leaf spots.



Spread: Rain and splashing water disseminate spores to adjacent plants. The disease can easily be introduced on infected plant material.

Management: Good sanitation is important. Leaf debris should be removed in the fall to reduce inoculum, which overwinters on the dead foliage. If infected debris is left in the area in the spring, the pathogen can sporulate and reinfect developing foliage.

Fungal leaf spots
Myrothecium leaf spot

Pathogen: *Myrothecium roridum*.

Hosts: *Lamium, Molucella, Rudbeckia* and *Salvia*.

Symptoms: This disease causes leaf spots. Concentric rings may develop in the

Myrothecium leaf spot – *continued*

lesions. Raised, black sporodochia develop on diseased tissue. In high humidity, the sporodochia are encircled by a tuft of white growth.

Black, raised sporodochia on diseased tissue. Note that many are surrounded by a white tuft of spores.

Spread: Spores are splash-dispersed by irrigation water and rainfall.

Management: Avoid injuries to plants. Young or injured tissue is most susceptible. One common cause of wounding is packaging for shipping; disease readily develops following shipping. Avoid excessive fertilization – high fertilizer rates that favor lush foliage growth have also been associated with disease outbreaks. Reduce periods of leaf wetness by carefully timing irrigation. Fungicide applications may be needed to control severe disease problems.

Fungal leaf spots

Red spot, measles

P. Flynn, ISU

Pathogen: *Cladosporium paeoniae*.

Hosts: *Paeonia*.

Symptoms: Initial symptoms typically develop after bloom. Small, reddish, circular spots form on the foliage. Lesions may coalesce, making blotchy patches. The upper surfaces of infected leaves become dark purple; the lower surface is brown. Foliage that is infected before it is fully expanded may become slightly distorted. Infection of stems causes reddish streaks.

Spread: This fungus survives on dead plant debris and in soil. Spores are spread by rain or wind.

Management: Remove and destroy infected plant material. Avoid overhead irrigation or carefully time irrigation to limit the duration of leaf wetness.

Septoria leaf spot

Pathogen: *Septoria* spp.

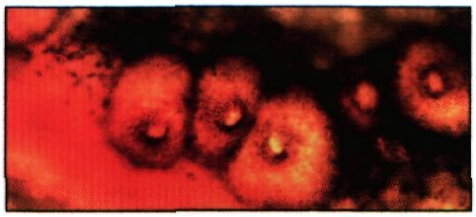
Hosts include: *Artemisia, Baptisia, Campanula, Chrysanthemum, Coreopsis, Delphinium, Dianthus, Echinacea, Gaillardia, Heuchera, Lamium, Lathyrus, Lupinus, Lychnis, Monarda, Potentilla, Ratibida, Rudbeckia, Stachys, Veronica* and *Viola*.

Lesions on *Heuchera*.

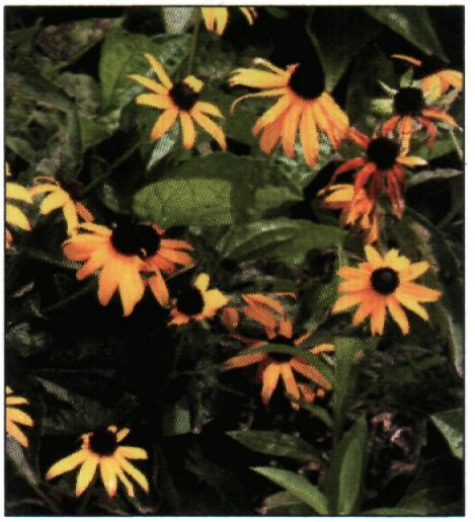
Symptoms: Tan to brown leaf spots. Small, black fruiting bodies (pycnidia) may be visible in the lesions. Lesions on *Rudbeckia* and *Echinacea*

Septoria pycnidia are visible in lesions.

Microscopic view of pycnidia on leaf surface. Spores are released through the central opening in these volcanolike structures.



Septoria leaf spot – *continued*



Purple leaf lesions caused by *Septoria rudbeckiae*. *Rudbeckia* and *Ratibida* are the only hosts of this particular species of *Septoria*. At right, a closer look at severe purpling on rudbeckia foliage.

are purple. Lesions may be more severe on older foliage.

Spread: The disease may be introduced on infected material. Spores are splash-dispersed to nearby foliage. Disease can also be spread by workers moving through wet foliage.

Management: There are many species of *Septoria*. Each is relatively host-specific, affecting only a few plant genera. Remove and destroy infected plant material. Avoid overhead irrigation or carefully time it to limit the duration of leaf wetness. Protectant fungicides can be used to manage *Septoria* leaf spot.

Downy mildew

Pathogen: *Peronospora* spp. and *Plasmopara* spp.

Hosts: Many fungi cause downy mildew. Each has a fairly limited host range. Common hosts include: *Buddleia, Delphinium, Dianthus, Dicentra, Geum, Helianthus, Iberis, Lamium, Lathyrus, Oenothera, Papaver, Potentilla, Primula, Rudbeckia, Veronica* and *Viola*.

Symptoms: Fuzzy, gray to black mold develops on the undersides of infected leaves. Chlorotic or necrotic lesions appear on the upper surfaces of

Downy mildew on the underside of *Rudbeckia* foliage produces a thick, whitish, fuzzy growth. At right, lesions on the upper surface. Note the angular edges of lesions that are bordered by the leaf venation.

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Downy mildew – *continued*

infected leaves. Lesions may have angular edges; some lesions are bordered by veins. Infected foliage may be cupped, and new growth may become distorted. Severely affected plants are stunted. Some seedlings can be infected systemically, causing new growth to be stunted and severely distorted.

Lesion on *Potentilla* foliage.

Spread: Spores are readily released and carried by air currents. Peak spore release often occurs when relative humidity rapidly decreases, which typically occurs in the morning. Some downy

Mottling symptoms. Note the angular edges of the lesions.

Downy mildew – *continued*

mildews are spread by contaminated seed; others are effectively spread on vegetative cuttings and seedlings.

Management: Scout susceptible incoming plant material carefully for signs of downy mildew paying careful attention to leaf undersides. Remove and destroy infected plants. Do not compost the plant debris. Warm days and cool nights with high humidity are favorable conditions for downy mildew spore production. Maintain good air circulation and increase night temperatures in greenhouses. Fungicides should be used preventively on especially susceptible crops. Downy mildews are capable of developing resistance to several effective systemic fungicides. Rotate use of systemic fungicides with protectants to slow resistance development.

Downward curling and yellowing of *Veronica* leaves caused by downy mildew.

Powdery mildew

Pathogen: Multiple including *Erysiphe* spp., and *Microsphaera* spp.

Heavily infected *Salvia* foliage.

Hosts: *Achillea, Aquilegia, Aster, Coreopsis, Clematis, Delphinium, Helianthus, Lupinus, Monarda, Phlox, Pulmonaria, Rudbeckia, Salvia, Scabiosa, Solidago, Sedum, Veronica* and *Viola*.

Symptoms: White, talcumlike colonies on the leaf surface. Chlorotic spots may be present on the leaf surface opposite the colony. Under favorable conditions, colonies enlarge and coalesce, blighting larger sections of foliage. Severe infections on some hosts cause defoliation. Infection on sedum causes slightly raised scabby lesions; powdery colonies may not be readily visible.

Spread: Powdery mildew spores are air-disseminated and subsequently infect leaves and stems of plants under humid conditions.

Powdery mildew – *continued*

Necrotic lesions caused by powdery mildew on *Sedum*. Symptoms are similar on other succulents.

Management: Scout plantings for signs of disease. Timely fungicide applications made early in the disease epidemic are more effective at control. Reduce the relative humidity, if possible – high levels are conducive to powdery mildew development. Increase plant spacing to promote air movement around plants. Fungicide applications may be necessary. Use both systemic and protectant products. Powdery mildew fungi can develop resistance to systemic fungicides. To delay the development of fungicide resistance, these products should not be used exclusively.

Note: Although many plants are affected by powdery mildew, each powdery mildew fungus has a specific host range, usually affecting closely related plants. For example, *Phlox* infected with powdery mildew will not serve as a source of inoculum infecting *Aquilegia*.

Aster yellows

Pathogen: Aster yellows phytoplasm.

Hosts include: *Anemone, Bellis, Campanula, Chrysanthemum, Coreopsis, Delphinium, Gaillardia, Rudbeckia, Salvia* and *Scabiosa*.

Symptoms: Symptoms vary, depending on the host. Possibilities include stunting, yellowing, twisting, distortion of flowers or flower petals, and bushy, broomlike growth. Infected plants have stunted and, possibly, malformed roots. Infected

Witches' brooming symptom on *Limonium* caused by aster yellows.

W. Cranshaw, CSU

Aster yellows – *continued*

W. Cranshaw, CSU

Echinacea and *Rudbeckia* may have deformed, yellowish flower heads.

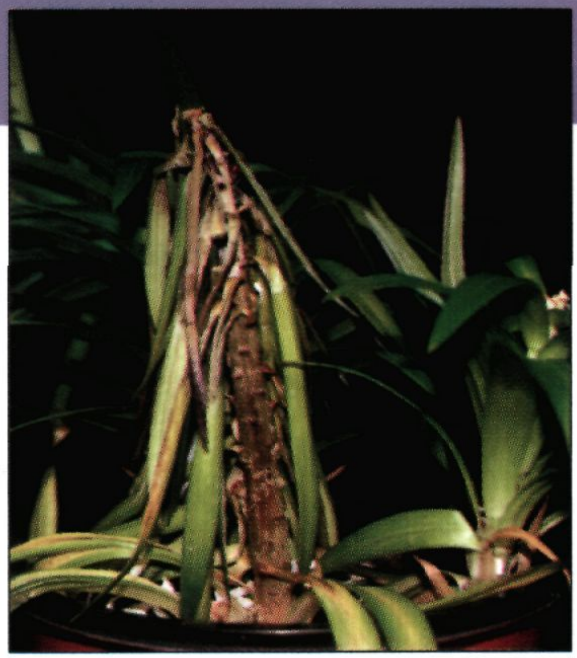
Spread: The pathogen is vectored by aster leafhoppers (*Macrosteles fascifron)*, as well as a few other leafhopper species. Aster leafhoppers can migrate into production areas on air currents, bringing the pathogen with them.

Management: Infected plants cannot be treated and should be removed and destroyed. Susceptible field-grown perennials should be scouted regularly for leafhoppers. Good control of leafhoppers in the growing area is important to limit spread of the disease. Weeds can be infected; many are symptomless hosts. Maintain good weed control, especially of overwintering weeds, to reduce sources of inoculum.

Phytophthora

Pathogen:
Phytophthora spp.
(*P. cactorum, P. drechsleri, P. nicotianae*, etc.)

Hosts include: *Achillea, Clematis, Euphorbia, Fragaria, Heuchera, Leucanthemum, Lilium, Phlox, Platycodon, Sedum, Sempervivum, Scabiosa* and *Viola.*



Aerial *Phytophthora* infection caused water-soaked lesions and stem collapse of lily.

Symptoms: Stem and crown rot, root rot, stunting, wilting, yellowing. Infection of aboveground plant parts causes foliar dieback. Plants with low levels of infection may not have obvious symptoms.

Spread: *Phytophthora* is a soil-borne pathogen; spores can also be disseminated short distances through the air. Moving infested plant material can spread the disease. *Phytophthora* has several different spore types, including chlamydospores,

Phytophthora – *continued*

sporangia, zoospores and oospores. (Refer to *Pythium* root rot for a description of these spore types.)

Management: Management strategies for *Pythium* spp. also apply to *Phytophthora*. Symptomatic plants should be removed and destroyed. Fungicides are often used to prevent losses. It is important to get good coverage of the affected plant parts. Fungicides have limited scope and should not be expected to cure heavily infected plants. Systemic fungicides should be used in rotation with protectant fungicides to delay resistance development. Applications at the high end of the labeled rate are required for *Phytophthora* control.

Discolored roots caused by *Phytophthora* infection.

Pythium

Pathogen: *Pythium* spp. (*P. aphanidermatum, P. debaryanum, P. ultimum,* etc.).

Hosts include: *Berberis, Calendula, Chrysanthemum, Delphinium, Dianthus, Gaillardia, Gypsophila, Lathyrus, Lavandula, Lilium, Lupinus, Pelargonium, Phlox, Salvia, Sempervivum* and *Viola*.

Symptoms: Wilting, stunting, uneven plant growth, crown rot and plant death. Roots are discolored. The cortex may slough off, leaving the vascular cylinder.

Spread: *Pythium* spp. are soil-borne pathogens, so movement of infested soil or plant material can spread disease.

Small discolored lesions caused by *Pythium* sp. on the roots of a hosta.

Pythium – *continued*

This pathogen produces several types of spores, each with a slightly different function. Sporangia can either germinate and infect plants directly or produce many zoospores. Sporangia may be produced on both above- and below- ground plant parts. Zoospores are motile spores, which allow the fungus to spread in saturated soils or standing water. Each zoospore can cause a new infection. Oospores are thick-walled spores, which allow the fungus to survive on equipment or in soils for long periods of time. Disease can be quickly spread through recirculated irrigation water.

Infected roots are discolored. Note that the root cortex has sloughed off some of the roots.

Pythium – *continued*

Management: Roots of incoming plant material should be checked for root rot symptoms. Use media with good drainage and avoid overwatering; do not use field soil in growing media for particularly susceptible crops. Maintain good sanitation practices with equipment and keep hose ends off the ground. *Pythium* spp. can develop resistance to mefenoxam, the active ingredient in several fungicides commonly used for *Pythium* spp. control. If *Pythium* spp. problems persist, diagnostic testing should be done to assess the sensitivity of the pathogen to mefenoxam.

Stunting and plant death caused by *Pythium* spp. in a plug sheet of *Sempervivum*.

Rhizoctonia

Stem lesions can develop in the canopy of closely spaced plants.

Pathogen: *Rhizoctonia solani.*

Hosts include: *Achillea, Aconitum, Aquilegia, Aster, Campanula, Chrysanthemum, Coreopsis, Delphinium, Dianthus, Digitalis, Gaillardia, Gypsophila, Helianthus, Hemerocallis, Hosta, Iberis, Lathyrus, Lilium, Limonium, Lysimachia, Nepeta, Oenothera, Papaver, Phlox, Platycodon, Potentilla, Primula, Salvia, Sedum, Veronica* and *Viola.*

Symptoms: *Rhizoctonia* causes a variety of symptoms, including damping-off, stem lesions, stem rot, root rot, crown rot and aerial web blighting. Infection causes wilting, stunting and possibly plant death. Some

Girdling lesions on plugs caused by *Rhizoctonia* that infected plants at the soil line.

Rhizoctonia – *continued*

vegetatively propagated plants are susceptible to rot at the base of the cutting.

Spread: This is a soil-borne pathogen. It persists in soil as mycelium and sclerotia (small, brown, long-term survival structures). The disease is spread when contaminated soil, plant material, tools and equipment are moved.

Management: Good sanitation practices are important to minimize disease introduction and spread. *Rhizoctonia* spp. tend to be more prevalent on stressed or wounded plants. Stress factors such as an excess or deficiency of water and fertilizer are important considerations in preventing *Rhizoctonia* diseases. Avoid periods of wet conditions followed by dry conditions. The fungus is favored by warm, moist conditions. Severely affected plants should be removed promptly. Research on efficacy of biological control through soil amendments is ongoing.

Discrete brown lesions on roots of *Echinacea*.

Sclerotinia

Pathogen: *Sclerotinia sclerotiorum.*

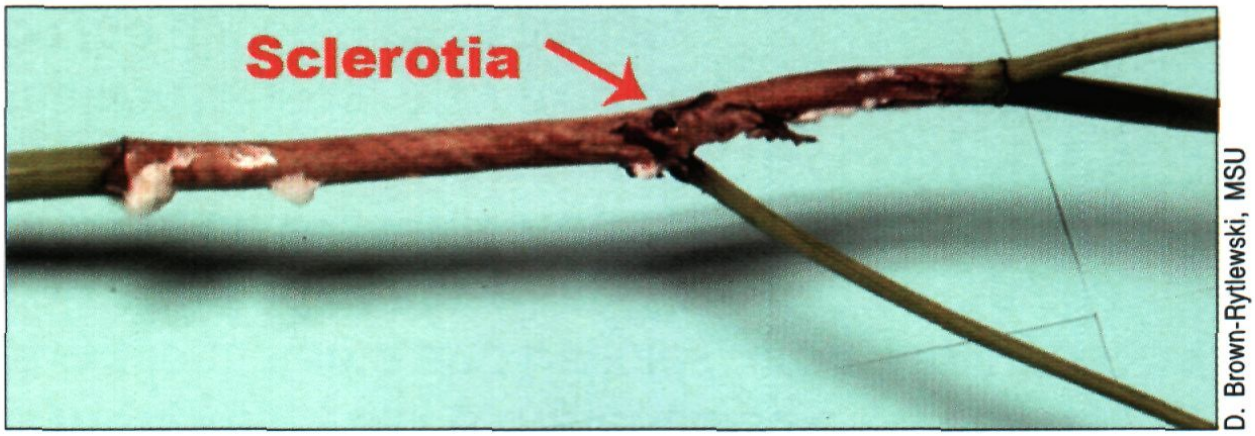
Hosts Include: *Anemone, Aquilegia, Aster, Bellis, Campanula, Coreopsis, Delphinium, Digitalis, Helianthus, Hosta, Iris, Liatris, Lupinus, Papaver, Platycodon, Rudbeckia* and *Scabiosa.*

Symptoms: Pre- and postemergent damping-off, crown rot, and blighting of foliage and petioles. Small, hard, irregular, black structures called sclerotia may be present on or in plant tissue (especially inside stem and petiole tissue). White, fluffy growth on affected plant parts is most readily visible in high humidity.

D. Brown-Rytlewski, MSU

Dieback of a flower stalk of *Baptisia* caused by *Sclerotinia sclerotiorum.*

Sclerotinia – *continued*



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Canker caused *by Sclerotinia sclerotiorum*. Note the white growth and the small sclerotia.

Spread: Sclerotia, long-term survival structures, are found in soil and on plant debris. The disease is primarily spread when these structures are moved. Disease can also be spread when infected plant material is moved.Under certain environmental conditions, mushroomlike structures (apothecia) are produced. These release airborne spores.

Management: Field soil should be sterilized before use in growing media. Susceptible crops should not be grown in areas with a history of white mold problems. Additionally, good sanitation is important to limit spread. Control weeds in production areas – some weeds are hosts to *S. sclerotiorum*. Fungicide drenches can protect plants from infection.

Sclerotium or southern blight

Pathogen: *Sclerotium rolfsii.*

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Collapse of lower leaves.

Hosts include: *Ajuga, Anemone, Aquilegia, Campanula, Coreopsis, Delphinium, Dianthus, Digitalis, Helianthus, Hosta, Lathyrus, Liatris, Lilium, Limonium, Lupinus, Monarda, Penstemon, Phlox, Rudbeckia, Salvia, Scabiosa, Sedum and Veronica.*

Symptoms: Wilting, water-soaked lesions on succulent stems and petioles, crown rot, plant collapse and death. Fluffy fungal mats may be present on the soil surface or on affected plant tissues. Light brown sclerotia, about the size of mustard seeds, may also be present in clumps on the affected plant tissue.

Sclerotium/southern blight – *continued*

Typical chlorosis caused by *Sclerotium rolfsii* infection on *Hosta*. Chlorosis develops as the petioles are degraded by the fungal pathogen.

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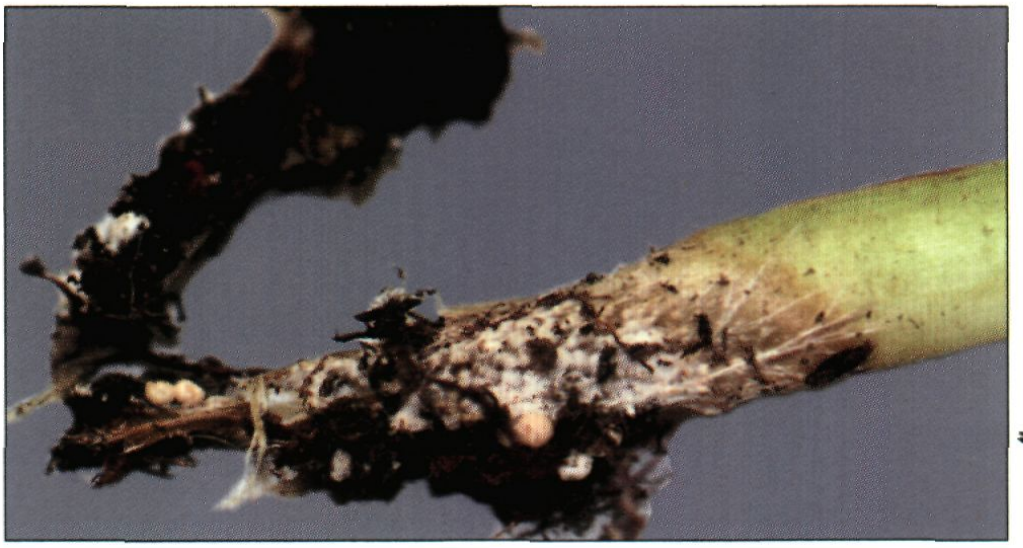
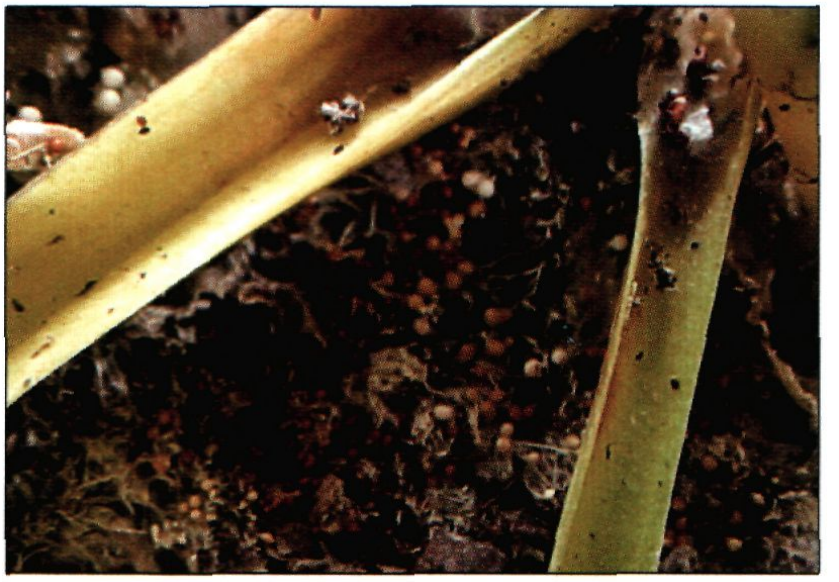
Spread: This is a soil-borne pathogen. Moving soil or diseased plant material spreads the disease. The pathogen can persist for an extended time in soil as sclerotia. During hot, humid conditions, sclerotia germinate, producing fungal mats that can infect susceptible hosts. *Sclerotium rolfsii* rarely produces spores, so dispersal by air movement is not significant.

Hyphae and sclerotia are visible on this rotted hosta petiole.



Sclerotium/southern blight – *continued*



Sclerotia look like mustard seeds on the soil surface surrounding the crown of a rotted plant.

Management: Good sanitation and pathogen exclusion are important steps in limiting disease. Carefully inspect incoming plant material for signs of disease. Remove and destroy affected plants, and avoid spreading soil from infected areas. Mulch used around field-grown plants or plants in the landscape may favor growth of *S. rolfsii*. Limit use of mulch in sites with a history of *S. rolfsii*. Fungicide applications (drenches or incorporated granular materials) can be used preventively to control crown rot.

Resource for additional information: *Crown Rot, A Serious Disease of Hosta and Other Ornamentals*, an Iowa State University Extension publication, February 2000.

Thielaviopsis or black root rot

Pathogen: *Thielaviopsis basicola.*

Hosts include: *Digitalis, Gaillardia, Geranium, Lathyrus, Lupinus, Pachysandra, Phlox* and *Viola.*

Symptoms: Stunting, yellowing and plant death. Symptoms are often mistaken for nutrient deficiency symptoms.

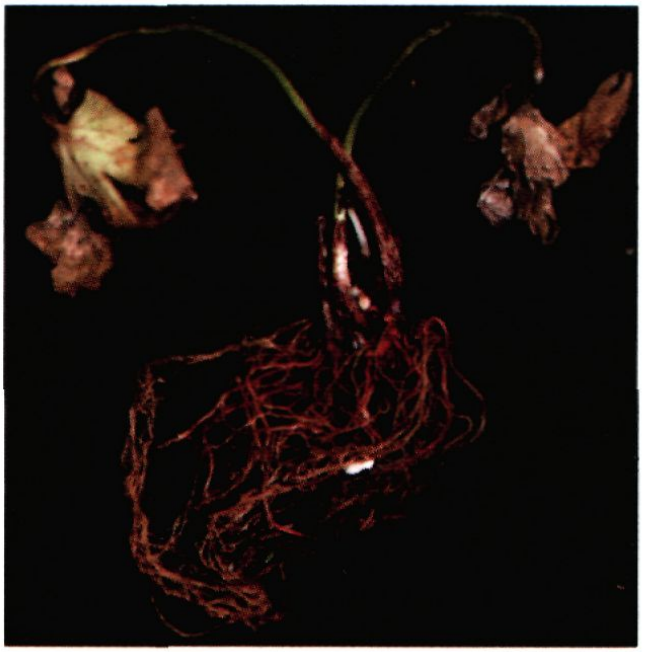
Spread: *Thielaviopsis basicola* produces spores that can persist for long periods of time in soil or

Chlorotic foliage caused by *Thielaviopsis basicola.* These symptoms are easily mistaken for a nutrient deficiency. At right, infected roots are darkly colored and rotted by black root rot.

Thielaviopsis/black root rot – *continued*

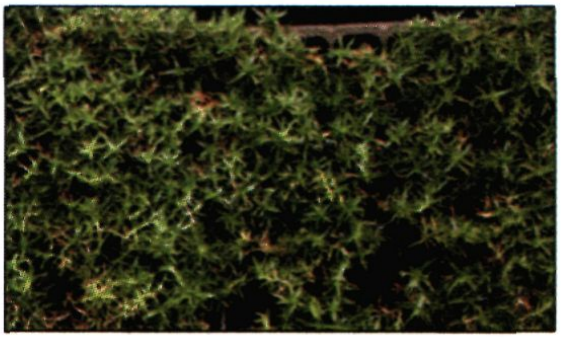
on infested pots and equipment. Reusing contaminated equipment is a common source of disease. Fungus gnats and shore flies can vector spores.

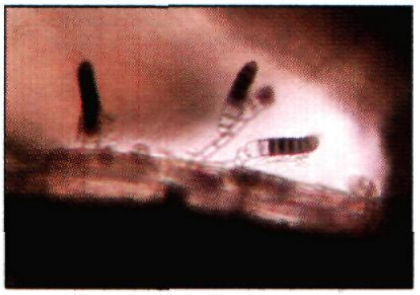
Management: Do not reuse plug trays, flats or pots for susceptible crops. Keep good records of the production areas where there have been problems with *T. basicola*. Avoid growing susceptible crops in these areas for several years. Fungicide drenches should be used to protect very susceptible plants from infection.



Infected geranium with poor vigor and dieback symptoms.

Yellowing of phlox foliage caused by black root rot.





Darkly colored spores of *Thielaviopsis basicola* have a distinctive morphology. Their thick spore wall helps them persist for several years in soil.

Rusts and smuts

Daylily rust

Powdery yellow-orange pustules on the surface of infected daylily foliage.

Pathogen: *Puccinia hemerocallidis*.

Hosts: *Alcea* and *Patrina* (alternate host).

Symptoms: Raised, yellow-orange, powdery pustules on the surface of infected foliage. Significant foliar dieback occurs on especially susceptible cultivars.

Spread: Spores can be dispersed by wind or air movement. Movement of infected plant material is responsible for much of the long-distance dissemination. This pathogen is not known to survive winters in the northern United States.

Management: Do not move or transport infected plant material. Carefully inspect incoming plant material for signs of rust. Fungicide applications are needed for disease management, especially on susceptible cultivars. Contact your local Extension office for information on ratings of cultivar susceptibility and current fungicide control recommendations.

Hollyhock rust

Pathogen: *Puccinia malvacearum.*

Hosts: *Alcea, Althaea, Lavatera* and *Malva.*

Symptoms: Small, brown spots develop on the underside of foliage. Raised, bright yellow or orange pustules are visible on upper leaf surfaces. When disease is severe, large portions of the foliage are killed.

Spread: Spores can overwinter on diseased plant tissues and infect new foliage the following year. Spores are also produced on susceptible weeds. These can subsequently infect and cause

Numerous rust pustules on hollyhock foliage.

Hollyhock rust – *continued*

disease on hollyhocks. Spores are wind-dispersed.

Raised, orange-brown pustules of hollyhock rust on the lower leaf surface.

Management: Disease control on seedlings is especially important. Fungicide applications at regular intervals are necessary when disease is severe. Plants should be cut back as soon as flowering is done. Plant debris should be removed and destroyed, not composted. Several weeds in the mallow family are also susceptible and should be controlled to limit inoculum in the growing area.

Lesions caused by hollyhock rust on the upper leaf surface.

Veronica rust

Pathogen: *Puccinia veronicae-longifoliae*.

Mike Bryan, MDA

Hosts: *Veronica longifolia* and *V. spicata*.

Symptoms: Bronze, purplish overcast on the upper surface of infected foliage. Raised, reddish brown pustules on the underside of foliage. When disease is severe, significant foliar blighting occurs.

Spread: This disease was unintentionally introduced to Michigan in 2004 and was found again in 2005. The

Mike Bryan, MDA

Raised rust pustules on the underside of a *Veronica* leaf.

Veronica rust – *continued*

disease occurred on field-grown *Veronica*. To date it has been a problem in very few nurseries. Long-distance disease spread is thought to occur when infected propagation material is moved. Spores, produced on foliage, are carried by wind currents.

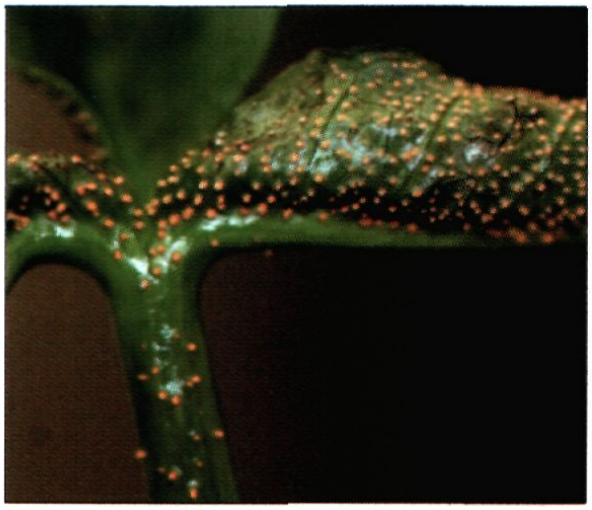
Management: Carefully inspect incoming plant material for signs of rust; pay particular attention to material that originated offshore. Plants with rust pustules or other disease symptoms should be destroyed. Fungicide applications are needed for disease control in some situations. Resistance development is a concern – follow recommended fungicide resistance management strategies.

Mike Bryan, MDA

Foliar blighting of field-grown *Veronica* caused by rust.

Other rust diseases

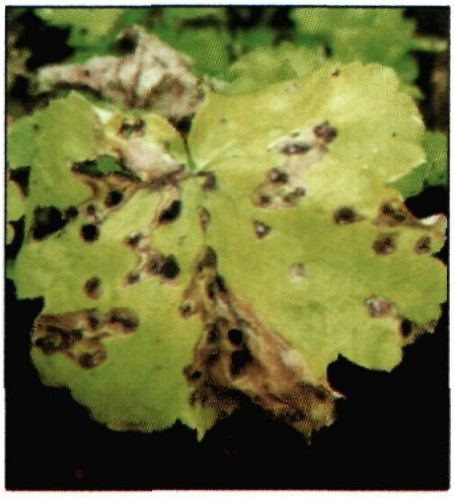
Hosts include: *Aconitum, Anemone, Aquilegia, Arisaema, Aster, Campanula, Hemerocallis, Heuchera, Liatris, Lupinus* and *Monarda*.



Raised reddish orange pustules on propagated *Arisaema*.

Several perennials are commonly affected by rust diseases. Each rust pathogen has its own relatively small host range. Disease management strategies are fairly similar for this group of pathogens.

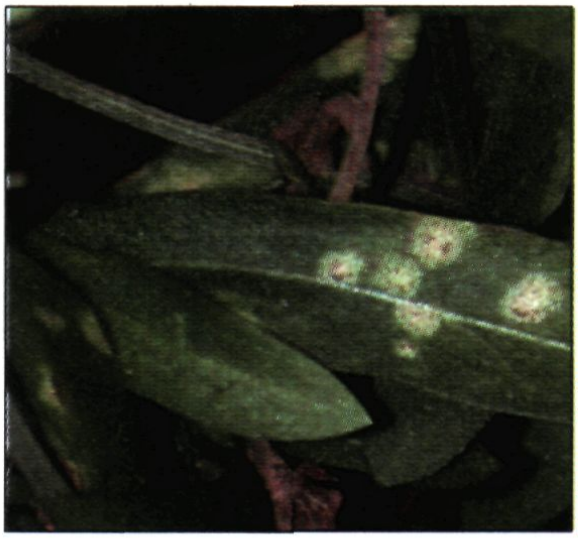
Rust lesions on *Heuchera*. The lesions may drop out of the leaf, creating a shot hole.



White smut

Pathogen: *Entyloma polysporum*.

Hosts: *Aster, Echinacea, Gaillardia, Helianthus* and *Rudbeckia*.



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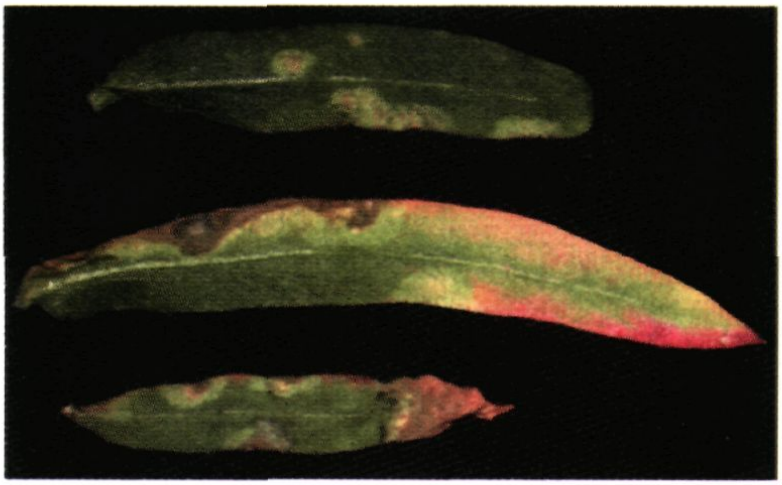
Whitish, round lesions on *Gaillardia* foliage.

Symptoms: Round, white spots, up to 1 centimeter in diameter. Young lesions may create very faint spots. Over time, the spots turn brown and become necrotic.

Spread: Spores are formed inside the leaf tissue. As lesions mature, the leaf surface ruptures,



Older lesions caused by white smut on *Gaillardia* have coalesced and are causing necrosis.

White smut – *continued*

releasing the spores. Spores are wind-dispersed. A white, powdery material may be visible on the leaf surface. Spores of this fungus are not known to survive winters in the northern United States.

Management: Remove all symptomatic plants. Plants in greenhouses may need fungicide applications for good disease control. The disease is favored by cool, humid conditions; disease spread will be slow under warm, dry conditions.

Note: Of the hosts listed, *Gaillardia* is most susceptible. The disease has been documented on the cultivars 'Goblin', 'Baby Cole' and 'Fanfare.' This disease has been seen with increasing frequency in the past few years.

D. Brown-Rytlewski, MSU

Dieback caused by a severe white smut infestation on a landscape planting of *Gaillardia*.

Damping-off

Pathogen: Multiple including *Pythium* spp. and *Rhizoctonia* spp.

Hosts: Very large host range.

Symptoms: Damping-off is a general term describing disease problems that occur while seeds are germinating or shortly thereafter, causing pre- and postemergence disease problems.

Damping-off of young *Delphinium* plants in a plug tray, caused by *Rhizoctonia*.

Damping-off – *continued*

Very young seedlings can be infected causing rapid seedling death.

Spread: Damping-off disease problems are generally caused by soil-borne pathogens. Avoid planting in infested soil or infested sites and reusing plug trays.

Management: Maintain good sanitation. Avoid overwatering and limit frequent, light waterings. Germinate seedlings at recommended temperatures to promote rapid germination and development of seedlings. See specific pathogens for more detailed information.

A web of *Pythium* mycelium on the surface of a plug tray. Stems of these seedlings were infected at the soil line.

Cucumber mosaic virus

Pathogen: Cucumber mosaic virus (CMV).

Hosts include: *Aconitum, Aster, Astilbe, Campanula, Coreopsis, Delphinium, Echinacea, Gypsophila, Helianthus, Heuchera, Hosta, Ligularia, Lilium, Lysimachia, Oenothera, Penstemon, Phlox, Primula, Scabiosa, Sedum* and *Viola*. Many annuals and vegetables are also susceptible.

Symptoms: Symptoms vary widely, depending on the host plant; possibilities include distorted foliage, mosaic, mottling, stunting and necrosis. Symptoms can resemble herbicide injury.

Mottling on lily.

Cucumber mosaic virus – *continued*

B. Olson, Okla. State Univ.

Spread: This virus is spread by several aphid vectors. Aphids acquire and transmit virus particles by probing or feeding on plant tissues. An aphid can transmit the virus to susceptible plants for up to 2 hours after acquiring the virus from an infected plant.

Management: Infected plants cannot be treated and should be removed and destroyed. Suspect plants should be tested for CMV by a diagnostic lab or on site using specialized tests available through several plant diagnostic companies.

Weeds can also be infected with CMV, although they usually have no symptoms. Infected weeds in production areas are a source from which the virus can spread. Good weed control, especially of perennial weeds, is important. Aphid populations should be controlled to limit potential insect vectors.

Hosta virus X

Pathogen: Hosta virus X (HsVX).

Hosts: *Hosta*.

Mottling on hosta foliage caused by hosta virus X.

Symptoms: Cultivars vary in their susceptibility, symptoms vary as well. Mottling or mosaic patterns on the foliage are common. Foliage may be puckered or distorted. Severely affected foliage may become necrotic. Blue-flowered cultivars may have color breaking.

Spread: The most significant source of disease spread is through movement of infected plant material. The virus is sap transmissible and therefore, can easily be spread during plant propagation. This virus is not spread by insect vectors.

Hosta virus X – *continued*

Management: Infected plants can not be treated and should be removed and destroyed. Carefully inspect all incoming plant material, particularly that coming in from outside the United States, to be sure it is free from symptoms. Material to be used for propagation should be tested prior to propagation. Contact your local plant diagnostic lab to see what testing options are available. The MSU Diagnostic Services lab offers HsVX testing by ELISA. Regularly disinfest equipment used during propagation or trimming to avoid sap transmission of the virus.

Impatiens necrotic spotted wilt virus

Pathogen: Impatiens necrotic spotted wilt virus (INSV).

Hosts include: *Ajuga, Aster, Bracteantha, Campanula, Delphinium, Dianthus, Digitalis, Echinacea, Gaillardia, Gaura, Heuchera, Hosta, Leucanthemum, Lobelia, Lysimachia, Monarda, Oenothera, Penstemon, Phlox, Platycodon, Primula, Salvia, Scabiosa, Sedum, Tradescantia* and *Veronica*.

Symptoms: Symptoms vary depending on the host but may include necrosis and spotting,

Mottling and distortion on foliage of Bracteantha caused by INSV.

Impatiens necrotic spotted wilt virus – *continued*

ringspots, mosaic, mottling, distortion of new growth, stunting and plant death.

Spread: INSV is spread by western flower thrips. Once a thrips acquires INSV, it can vector the virus to susceptible hosts it feeds on throughout its lifetime. The pathogen can also be spread by sap transmission. Plants can be infected and show no symptoms; the virus can be spread from these plants. INSV can overwinter in the roots of infected plants.

Management: Scout incoming plant material for signs of disease and for thrips. Susceptible plants

Puckering and thickening of *Leucanthemum* foliage infected with INSV.

Impatiens necrotic spotted wilt virus – *continued*

should be scouted regularly for thrips (see thrips section for more information). Avoid intermixing of more and less susceptible crops within the same greenhouse. Also avoid intermixing seed- and cutting-propagated crops. Eliminate weeds from the propagation area. Immediately remove symptomatic plants from the growing area. Diagnostic testing can be done by a plant diagnostic lab or at the growing facility with testing strips available from plant diagnostic companies.

Downward curling caused by INSV.

Verticillium wilt

Pathogen: *Verticillium alboatrum* and *V. dahlia.*

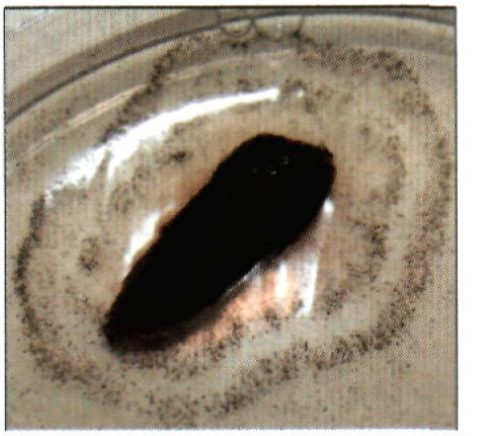
Hosts include: *Aconitum, Aster, Chrysanthemum, Coreopsis, Dahlia, Delphinium, Dianthus, Helichrysum, Papaver, Paeonia* and *Phlox.*

Symptoms: Wilting and dieback, stunted growth and yellowing, sometimes affecting only part of the plant. Some plants may have discoloration or streaking in the vascular system.

Severe dieback of *Coreopsis* caused by *Verticillium* infection. Both stems and crowns are infected by this pathogen.

Verticillium wilt – *continued*

Spread: Verticillium is common in soil, where it survives as mycelium. *Verticilium dahlia* can also produce microsclerotia, a long-term survival structure. Plants are infected through roots, and infection moves into the vascular system. Wood chips produced from infested trees and used in potting media or as mulch can spread the disease. Disease incidence is less common in plants grown in soilless potting media.



Verticillium produces microsclerotia in soil and infested plant debris. The fungal pathogen readily grows out of infected material that is cultured in a diagnostic lab. The black microsclerotia are a diagnostic feature.

Management: Remove all symptomatic plants; fungicide treatments are generally not helpful. Avoid planting susceptible plants in fields with high populations of *Verticillium*. Feeding by root and lesion nematodes can increase damage from *Verticillium* wilt. Plants and soil can be tested for nematodes and the populations quantified by submitting samples to a diagnostic lab. Maintain good control of weed hosts in the field – some weeds are hosts for *Verticillium*.

Glossary

Apothecia: A small almost mushroomlike structure, shaped like a satellite dish or a saucer on a stalk. Visible with the naked eye. Certain fungi produce these structures and develop spores within them.

Frass: Plant fragments excreted by caterpillars during feeding.

Inoculum: The pathogen or part of the pathogen used to start disease (spore, mycelium, sclerotia, bacterial cell, etc.).

Larva or larvae (plural): Immature stage of insects – between the egg and pupa – that undergo complete metamorphosis (egg, larva, pupa and adult).

Mycelium: Filamentous strands or threadlike structures that make up the vegetative part of a fungus.

Nymph: Immature stage of insects – between the egg and adult – that undergo incomplete or gradual metamorphosis (egg, nymph and adult).

Pycnidia: Flask-shaped reproductive structure produced by some fungi within which spores are produced asexually. Structures may be embedded in the diseased tissue and look like grains of pepper within a lesion or a leaf spot. (See *Septoria*.)

Sclerotia: Hard, vegetative structure produced by some fungi, which can remain in a dormant state for extended periods of time. Typically found in soil and plant debris.

Setae: Dark-colored, hairlike structures (similar to an eyelash) produced by some fungi. Sometimes visible with a hand lens on infected plant material. (See *Anthracnose*.)

Sporodochia: A mat or cushionlike reproductive structure produced by some fungi. Sometimes visible with a hand lens on infected plant material. (See *Myrothecium*.)

Vector: Insect capable of transmitting pathogens such as viruses from one plant to another.

Index of species

Insects and nematodes

Diseases

R. Gillis, Dow Gardens, www.ipmimages.org

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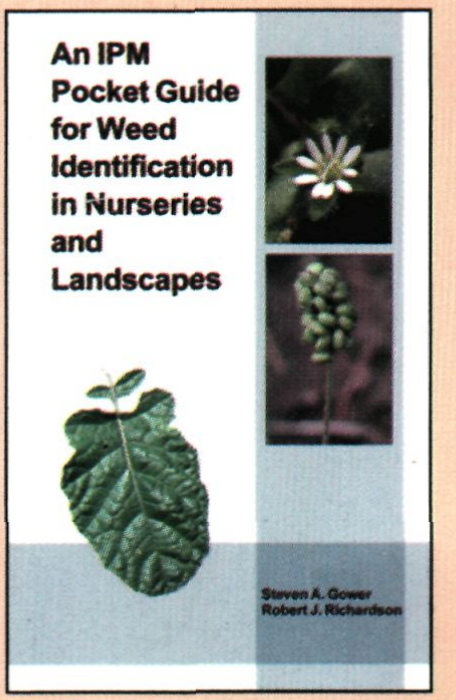

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