a guide to

PROTECTING PERENNIALS

Commercial perennial production still offers growth opportunities for growers. With increasing expectations from the marketplace, there is constant pressure on growers to deliver a continuous supply of high-quality perennials in bloom to consumers. With the current economic environment and pressure to maintain profitability, growers cannot afford to experience any losses associated with their production practices.

This guide is intended to help commercial growers produce healthy and high-quality perennials. There are a number of areas covered in this perennial reference that include characteristics of growing media, effective use of plant growth regulators, and implementing integrated crop management (ICM) practices, including insect and disease identification and management.

CHOOSING PERENNIALS *for* TODAY'S MARKETPLACE

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There are numerous considerations when deciding which perennials to produce and what type of variety selection to offer. The number of varieties to grow often depends on the expectation of your customer. Do they require large quantities of a limited selection of perennials at any given time or do they expect smaller quantities of a wide range of perennial varieties?

Every perennial has its own set of forcing requirements necessary to produce flowering plants for the marketplace. Perennials are commonly classified into groups based on these requirements. To successfully and predictably produce flowering perennials, growers must understand each plant's requirements for flowering and ensure these needs are delivered prior to or during production. The forcing requirements include juvenility (maturity), vernalization (cold treatment), and photoperiod (day length). In many instances, plants will have multiple requirements from these categories that must be met in order to consistently produce flowering plants. Table 1 contains the terminology most commonly used when describing how to force perennials into bloom.

Table 1	
Cold beneficial	Plants that do not require cold for flowering but experience some benefit from receiving a cold treatment. The benefit is often a reduced time to reach flowering, increased flower number per plant, and/or more uniform flowering.
Photoperiod	The number of hours of light provided to or perceived by the plant each day. Most perennials have a certain photoperiod necessary for flowering to occur.
Long day required	Perennials with an obligate requirement for long days simply will not flower unless they are grown under long days.
Long-day beneficial	Also referred to as long-day facultative, refers to plants that receive some benefit, such as increased flower number or decreased time to flower, from being produced under long-day conditions.
Day extension*	Method of lighting used to create long-day conditions during naturally short photoperiods by extending the number of hours per day a perennial is exposed to light up to the desired day length.
Night interruption*	Also referred to as night break or "mum lighting," is a method used to create long-day conditions by lighting from 10:00 PM to 2:00 AM.
Short day required	Plants that will only flower following the onset of short days.
Black out	Method used to create short-day conditions by blocking out all of the light for a minimum of 13 hours per day.
Facultative short day	Also referred to as short-day beneficial, refers to plants that will eventually flower under other photoperiods, but flower better when produced in short-day conditions.
Day neutral	Perennials that will readily flower under any photoperiod.

In most instances, plants have more than one requirement for flowering. For example, a perennial may have both an obligate cold requirement and require long days for flowering. If neither requirement is provided, flowering will not occur or may be inconsistent.

*5- to 10-foot candles of light should be delivered at the darkest spot in the production area.

Breeding efforts in recent years have brought many perennials to the marketplace that are easier to produce into bloom. For example, plants that historically would not bloom the first year after sowing the seed often had a juvenile period and an obligate requirement for vernalization. Today, there are numerous varieties that have reduced or no juvenility periods and do not require cold in order for them to bloom the first growing season. These plants are commonly referred to as "first-year-flowering perennials." Additionally, breeding efforts are bringing perennials to the market with increased resistance to certain diseases. Collectively, these improvements allow growers to more easily and cost-effectively select and produce flowering perennials for their markets.

Syngenta Flowers, Inc. offers a wide range of seed and vegetative perennial varieties to the industry. Many of these perennials, as well as the new genetics in the pipeline, are designed to be easy to grow and offer first-year flowering. Syngenta Flowers, Inc. is committed to developing and bringing quality perennials to the market.

PROPERTIES OF GROWING MEDIA FOR PERENNIALS

The growing media is the foundation to successful perennial production. The properties of a good container mix are adequate porosity and drainage, acceptable but not excessive water-holding ability, and the capacity to hold nutrients and make them available for root absorption. A growing mix with the proper characteristics will reduce crop production times, decrease crop and overwintering losses, and improve the quality characteristics of perennials.

Ideal physical properties of a perennial media mix are not all that different from those provided by annual mixes (quick plant establishment and growth), with the exception of longevity. Unlike many annual crops which are in commercial production for a maximum of three to four months, perennial crops are in production significantly longer (up to 12 months or more in some cases). The growing media for perennials needs to provide all of the benefits of annual mixes, maintain ease of production for growers, and have relatively stable components over time.

Conrad Fafard, Inc. specializes in the production of the highest quality growing mixes for commercial growers. Fafard 52™, a bark-based media, is considered the "industry standard" for perennial growers. Conrad Fafard, Inc. offers numerous formulations developed to maintain the proper balance of water, air, and pH using weed- and pathogen-free components and offers custom-blended mixes to address individual growers' needs.

APPLYING PGRS ON PERENNIALS

To improve the quality characteristics and produce perennials of a desired shape and size, many growers apply plant growth regulators (PGRs) during production to reduce undesirable stem elongation. In addition to controlling plant height, PGRs can effectively be used to improve the ship-ability and lengthen the shelf life of treated plants. When used properly, growth regulators can make a big difference on crop production, plant quality, and your bottom line.

APPLYING PGRS ON PERENNIALS

GUIDELINES FOR BONZI® PGR SPRAY APPLICATIONS

When making spray applications of Bonzi®, it is important to ensure uniform coverage of an appropriate spray volume to sufficiently cover the stems where it is absorbed by the plants. Generally, it is recommended to apply two quarts of spray solution over every 100 ft² of production space. Improper volumes will lead to undesirable levels of height control.

For example, when applying a 30 ppm spray solution of Bonzi and the volume of spray solution applied is only one quart per 100 ft², then only half of the intended active ingredient is applied to the crops which results in reducing the rate of Bonzi applied by 50% to 15 ppm. At this reduced volume, it is difficult to get adequate coverage on the stems and the amount of height control achieved will be dramatically decreased. Conversely, applying significantly more volume than intended will significantly increase the height control obtained.

For larger plants where there is a well-developed canopy, it is often necessary to increase the spray volume to three quarts per 100 ft² to allow adequate penetration through the canopy and get good contact on plant stems.

GUIDELINES FOR DRENCH APPLICATIONS

Similar to spray applications, the volume of solution applied to the growing media with drench applications greatly affects the true amount of active ingredient that is applied to each pot and the amount of height reduction that will result. For example, when a drench application of 10 ppm Bonzi is applied using 4.0 ounces per six-inch container, 1.25 mg active ingredient is applied into the root zone. If the volume applied is increased to 6.0 ounces per container, 50% more active ingredient would be applied and consequently too much height control will likely occur.

6 ppm Drench *30 ppm Spray* *Control*

To improve the effectiveness of the drench applications, they should be made to containers with moist growing medium. This is most commonly done by watering the crop the day before the PGR drenches are applied.

GUIDELINES FOR WATERING-IN APPLICATIONS

The watering-in method is a variation of the drench method and entails applying a larger volume of drench solution in a manner more consistent with routine irrigation applications. With the watering-in method, approximately twice the volume of drench solution is applied to each container, therefore it is necessary to decrease the concentration of the solution by half in order to deliver the same amount of active ingredient per pot as delivered using traditional drench applications.

For example, when a traditional drench application of 10 ppm Bonzi is applied using 4.0 ounces per six-inch container, 1.25 mg active ingredient is applied per container. If the watering-in method is used and twice the volume (8.0 ounces) of solution is applied per container, then it is necessary to decrease the concentration of the solution by half to deliver the same amount of active ingredient. With the watering-in method, a 5 ppm solution applied at an average of 8.0 oz per container would deliver the same results (1.25 mg AI per pot) as a 4.0 oz traditional drench application.

Similar to the other application methods, the volume of solution applied also affects the amount of height control obtained.

Bonzi® Ornamental Growth Regulator

For more information on Bonzi, visit www.Bonzitraining.com

0.5 ppm Bonzi
Delphinium 'Summer Nights'

1.0 ppm Bonzi
Delphinium 'Magic Fountains' Mix

2.0 ppm Bonzi
Scabiosa 'Butterfly Blue'

8.0 ppm Bonzi
Monarda 'Garden View Scarlet'

USING BONZI ON PERENNIALS

Variety	Spray rate*	Traditional drench rate	Watering-in rate
Achillea millefolium	30 ppm	6 ppm	3 ppm
Alcea rosea	15 ppm	3 ppm	1.5 ppm
Aquilegia x hybrida	30 ppm	6 ppm	3 ppm
Calamagrostis acutiflora	Not responsive	12 ppm	6 ppm
Campanula carpatica	15 ppm	3 ppm	1.5 ppm
Coreopsis grandiflora	30 ppm	6 ppm	3 ppm
Delphinium elatum	45 ppm	10 ppm	5 ppm
Dianthus barbatus	45 ppm	6 ppm	3 ppm
Digitalis purpurea	45 ppm	10 ppm	5 ppm
Echinacea purpurea	45 ppm	6 ppm	3 ppm
Gaura lindheimeri	30 ppm	6 ppm	3 ppm
Hemerocallis (most varieties)	45 ppm	6 ppm	3 ppm
Hosta (most varieties)	30 ppm	6 ppm	3 ppm
Lamium maculatum	30 ppm	3 ppm	1.5 ppm
Lavandula angustifolia	30 ppm	6 ppm	3 ppm
Leucanthemum superbum	30 ppm	6 ppm	3 ppm
Miscanthus sinensis	Not responsive	12 ppm	6 ppm
Monarda didyma	45 ppm	6 ppm	3 ppm
Nepeta faassenii	30 ppm	6 ppm	3 ppm
Penstemon x hybrida	30 ppm	6 ppm	3 ppm
Phlox paniculata	45 ppm	10 ppm	5 ppm
Rudbeckia fulgida	45 ppm	6 ppm	3 ppm
Salvia x sylvestris	30 ppm	6 ppm	3 ppm
Scabiosa columbaria	30 ppm	3 ppm	1.5 ppm
Veronica spicata	30 ppm	6 ppm	1.5 ppm
General perennial	30 ppm	6 ppm	3 ppm
General perennials—Sensitive varieties	15 ppm	3 ppm	1.5 ppm

* These are suggested beginning rates and may require multiple applications to obtain desirable control of plant height.

PEST MANAGEMENT

Disease and insect pests can cause injury to perennials and reduce the plant's quality and the marketable value. To prevent disease organisms and insect pests, it is essential for growers to implement management strategies or follow an integrated crop management (ICM) program. Any crop management program should involve fundamentally sound cultural practices, early detection of cultural problems, including the presence of insects and diseases, proper identification of these problems and pests, and if necessary, effective control strategies.

SCOUTING TOOLS

- ○ Carrying case for scouting tools
- ○ Clipboard
- ○ Scouting forms
- ○ Site maps
- ○ Diagnostic clinic forms
- ○ Pencil
- ○ Permanent fine-tipped black marker
- ○ Sticky cards
- ○ 10X to 16X hand lens
- ○ Horticultural knife
- ○ Plastic bags
- ○ Vials with isopropyl alcohol
- ○ Latex gloves
- ○ Hand cleaner/sanitizer
- ○ Digital camera
- ○ Reference library

Scouting is an essential process for perennial growers and involves routine monitoring of crops to detect the presence of any potential insect or disease problems. Scouting is useful to determine when control strategies must be implemented as well as to determine whether the current management practices have been effective.

DISEASES OF PERENNIALS

There are a number of diseases that attack the leaves, stems, crowns, and roots of various perennial crops. Detecting and controlling plant diseases are some of the most challenging aspects of growing perennials. In many instances, significant injury is evident before many plant diseases are detected and properly diagnosed. Disease identification is problematic for many growers as the visible symptoms between bacteria, fungal pathogens, nutritional disorders, and plant viruses are often similar. Successful control of plant diseases requires early detection, proper identification, and the appropriate control strategy.

BACTERIAL LEAF SPOTS AND WILTS

Bacterial diseases (*Agrobacterium*, *Corynebacterium*, *Erwinia*, *Pseudomonas*, and *Xanthomonas*) often infect perennial crops. They can cause blights, crown galls, fasciation, leaf spots, soft rots, and vascular wilts. Diseases caused by bacteria develop very quickly and can be very devastating. It is often challenging to properly identify these diseases as many of the symptoms they express are similar to fungal pathogens. Controlling bacterial diseases is extremely difficult and it is best to manage them on a preventive basis.

SYMPTOMS OF BACTERIAL DISEASES

Bacterial leaf spots

- Water-soaked spots on leaves and other plant tissues.
- Often located between the leaf veins and have angular shapes with straight sides.
- Holding the infected leaf up to a light source reveals a definite yellow outline or halo surrounding the leaf spot.
- May have a rotten odor.

Bacterial soft rots and wilts

- Wilted foliage accompanied by brown and yellow leaves and dieback of plant parts.
- Sudden collapse of new leaves or shoots (blight) often with a slimy appearance.
- Plant tissues become dark and mushy, may have a foul odor.
- Soft rots commonly occur near the soil line or crown of the plant.

CONDITIONS NECESSARY FOR BACTERIAL DISEASES

- Most prevalent during warm weather and prolonged wet periods.
- An open wound or a natural opening (stomata) to enter the plant.
- Extended periods with wet foliage.
- Spreads from plant to plant by splashing water.

CULTURAL METHODS OF CONTROL

- Inspect incoming plant materials—start with clean "certified" materials.
- Reduce or eliminate overhead irrigation if possible.
- Water early in the day to allow the foliage to dry quickly.
- Scout at least once a week.
- Remove infected plants immediately as they appear.
- Sanitize production areas between crops.
- Disinfect tools between each plant.
- Avoid reusing pots from previously infected crops.

Crown Gall on Achillea Moonshine

Fasciation Leucanthemum

BOTRYTIS

Nearly all perennials are susceptible to the foliar diseases caused by *Botrytis cinerea*. *Botrytis* infections are commonly referred to as *Botrytis* blight or gray mold. It is typically identified by fuzzy gray or brown spore masses that develop on infected plant parts. *Botrytis* readily invades wounded, yellowing, or senescent leaves and stems, but under certain circumstances emerging leaves, young tender shoots, and flowers are also susceptible.

Initially, the infected leaves form tan to brown lesions along the leaf margins, infected stems become dark and sunken, and flower petals develop small light brown flecks. These symptoms progress quickly and under optimal conditions for disease development will cause the plant tissues to collapse and the presence of the fuzzy spore masses will appear virtually overnight.

CONDITIONS NECESSARY FOR *BOTRYTIS* INFECTIONS

- Wet foliage or flowers for four or more hours.
- High relative humidity (>85%).
- Thrives in cool, humid environments.

CULTURAL METHODS OF CONTROL

- Remove all plant debris from the production area.
- Clean and sanitize between crops.
- Maintain relative humidity levels below 85% to avoid condensation on the crops if the temperatures drop. Purge or ventilate greenhouses during the night.
- Avoid extended periods of free water on plant surfaces.
- Water early in the day to allow the foliage to dry before night.
- Provide adequate spacing between plants to allow good air circulation and low relative humidity near the canopy of the crop.
- Use HAF fans to increase air circulation.
- Scout regularly—daily when conditions for disease development are present.
- Carefully remove infected plants from the production site.

Botrytis on Phlox

Echinacea Botrytis Cinerea

DOWNY MILDEW

Downy mildew (*Bremia*, *Bremiella*, *Basidiophora*, *Pereonospora*, and *Plasmopara*) infects a wide range of perennials, but each mildew infects a small range of closely related plants. For example, the downy mildew that attacks Coreopsis is different from the mildew that attacks Digitalis. The reproductive structures (sporangia) of downy mildew are the most distinguishing characteristic of this disease, and most commonly appear on the underside of the leaves as white, gray, or slightly purple, velvet-like fuzz.

Quite often the symptoms of mildew infections are visible before the sporangia develop. These early symptoms appear slightly different on some perennials, but generally yellowish, tan, or reddish purple leaf splotches will form on the upper leaf surface. In some perennials, these spots will appear more angular and are bounded between the veins of the leaf. Other symptoms of downy mildew include chlorotic foliage, downward curled leaves, stunted plants, and flower buds that do not open properly. These symptoms are similar to those often observed with chemical or foliar nematode injury. In most cases, the "fuzzy" sporangia on the leaf undersides are directly opposite the discolored patches found on the upper leaf surfaces.

CONDITIONS NECESSARY FOR DOWNY MILDEW INFECTIONS

- Wet leaves for at least six hours.
- Cool to moderate temperatures (50° to 75° F).
- Moist conditions.
- High humidity.

CULTURAL METHODS OF CONTROL

- Carefully remove infected plants from the production site.
- Clean and sanitize between crops.
- Avoid extended periods of free water on plant surfaces.
- Irrigate early in the day to allow the leaves to dry before night.
- If possible, keep the growing environment warm (>75° F) and dry.
- Maintain relative humidity levels below 85% to avoid condensation on the crops if the temperatures drop. Purge or ventilate greenhouses during the night.
- Scout susceptible crops at least once a week.

Downy Mildew on Underside of Veronica

Downy Mildew on Underside of Veronica Leaf

Downy Mildew on Topside of Veronica Leaf

CROWN AND ROOT ROTS

There are a number of pathogens (*Fusarium, Phytopthora, Pythium, Rhizoctonia,* and *Thielaviopsis*) that infect and cause significant injury to the crowns and roots of perennials.

These pathogens are often difficult to detect until significant injury to the crop has occurred. Some indications that crown and root rot pathogens are present include decreased plant growth, uneven or variable crops, and symptoms of nutrient disorders. In many instances, these diseases progress very gradually and eventually may result in plant death.

COMMON CROWN AND ROOT ROT PATHOGENS OF PERENNIALS

Fusarium

- Whitish fungal growths on the lower stem in conjunction with a lower stem rot.
- Initially appears as slight vein clearing on the outer portion of young leaves followed by drooping of the older leaves.
- Plants turn yellow, wilt, and die quickly.
- Infection occurs at and below the soil line.
- Vascular streaking can occur.
- Orange-pink color fruiting bodies may develop on infected plant tissue.

Phytopthora

- May cause root and stem rots on various perennials.
- Forms a brown canker at or just above the soil without a distinct margin between healthy and damaged tissue, eventually girdling and killing the plant.
- The margin of this canker appears water-soaked.
- Roots often appear brown, but root rots do not always develop on infected plants.
- Stem rot or foliar blight appears as brown/black lesions on the leaves and dieback of the stems.
- Infected plants usually have nutrient deficiency symptoms and wilt readily on sunny days.

Pythium

- Leaves often appear gray/green and flag slightly during the heat of the day.
- Lower leaves become yellow and wilted.
- Severe infections may cause leaf drop and stunting.
- The root tips appear blackened and mushy.
- Severely infected roots turn gray to dark brown.
- The outer cortex of the root is easily removed when gently pulled on, leaving a stiff thread-like core (inner cortex).
- If the lower stem becomes girdled, a soft brown rot often develops just below the soil line, causing the plant to collapse and die.
- Cool, wet (saturated) conditions favor *Pythium* development. Also commonly infects plants grown with excessive soluble salt levels in the root zone.

Rhizoctonia

- Brown lesions and rotted tissue appear at the crown, move up the stem, collapsing the plant.
- Web-like mycelium is often present at the soil surface and on the lower stem tissue.
- Stem cankers at the soil line often girdle plants, causing them to develop nutrient deficiency symptoms and wilt.
- Infected stems turn brown and shrivel, giving them a tough, wiry appearance.
- May affect the foliage of some crops, causing an aerial blight.
- The plant canopy may appear webbed with fungal threads. Web development most commonly occurs during hot, humid weather.
- The dead leaves remain attached to the stems.
- Thrives primarily under high humidity levels and does not need saturated soils to prosper.

Thielaviopsis

- Plants have reduced vigor and appear stunted.
- Older foliage often turns yellow and shriveled.
- In some cases, the older leaves are yellowish-green with green veins which mimic the symptoms of nutrient deficiency.
- Young leaves often tinged with purple or red.
- Small black lesions visible along the length of the root. Root tips appear black.
- Roots appear black under severe infestations. *Thielaviopsis* is commonly referred to as "black root rot."
- Prefers neutral to alkaline soil conditions (pH 6.2 or above).

CONDITIONS NECESSARY FOR CROWN AND ROOT ROT INFECTIONS

- Cool conditions (*Pythium*).
- Hot conditions (*Rhizoctonia*—web development).
- Water molds (*Pythium* and *Phytopthora*) prefer wet conditions.
- High relative humidity (*Rhizoctonia*).
- pH levels greater than 6.2 are favorable for *Thielaviopsis*.
- *Pythium* is commonly observed where the salt levels are too high (> 2.5 mmhos/cm using the saturated media testing method).
- Fungus gnats and shore fly adults can spread soilborne pathogens throughout the production area.
- Overhead irrigation favors *Phytopthora* (foliar blight) and *Rhizoctonia*.
- Using recycled and recirculated water increases the risk of *Phytopthora* and *Pythium* infections.

CULTURAL METHODS OF CONTROL

- Inspect incoming plant materials.
- Sanitize production area between production cycles.
- Avoid reusing pots from previously diseased crops.
- Use well-drained growing media.
- Do not overwater.
- Monitor fertility levels: avoid high salt levels.
- Control fungus gnats and shore flies.
- Inspect root systems once a week for visible signs of decay.
- Use preventive fungicide drench applications.
- Apply preventive fungicide applications in the fall.
- Fall drench applications to perennials should occur several weeks (four to six weeks) before the temperatures cool down.

Root Rot—Pythium

Rhizoctonia on Salvia

Phytopthora on Lavendar

FUNGAL LEAF SPOTS

A great number of fungal pathogens cause leaf spots on perennials. There is a wide range of symptoms plants express when infected with the various fungal leaf spots. For example, leaf spots vary from the size of a pinpoint to lesions that practically cover the entire leaf. These spots range in coloration often including various hues of black, brown, gray, purple, red, and yellow. Depending on the pathogen, leaf spots may be solid or form concentric rings that resemble a bull's eye. As the disease spreads, the spots often merge together, forming large angular or irregular spots on the leaves.

Although most pathogens causing leaf spots do not cause plant mortality, they greatly reduce the appearance and marketability of the plants they infect.

COMMON PATHOGENS CAUSING LEAF SPOTS

Alternaria

- Takes on numerous appearances and can be difficult to identify.
- Most commonly appears as small (< 1/8") spots which initially appear water soaked.
- These spots often enlarge into 1/4" circular patterns with reddish brown centers and yellow borders.
- Some plants exhibit symptoms as reddish-brown to black spots with tan to white centers.
- Often described as brown to black spots with concentric rings.
- As the disease progresses, the spots merge and can completely cover leaf surfaces or the entire plant.
- May infect leaves, stems, and flowers.
- Lesions or cankers on stems may cause dieback and plant death in severe cases.
- Ten hours of free water on plant surfaces is needed for disease infection to occur.

Cercospora

- Forms 1–3 mm tan-brown to black-purplish spots with sunken centers.
- Spots may appear transparent with web-like growth.
- On some perennials, such as hostas, the spots appear tan to reddish-brown with a darker, rust-colored border.
- On other perennials, this fungus causes small purple lesions that have a web-like or feathery appearance.
- Spots often merge together and cover the entire leaf.
- Infected leaves often turn yellow and fall off of the plant.

Colletotrichum

- Initial symptoms appear as pale yellow spots with black borders.
- Over time, the center of the spot appears dry, tan, and sunken with concentric rings.
- Develops into brown blotches or dead areas on leaves and stems.
- May also cause blights with favorable conditions.
- Infected petioles and flower stalks appear girdled at the point of infection.
- Light to dark brown spots appear on infected flowers.
- Flowers become distorted.
- Eliminate leaf wetting and the disease will not develop.

Septoria

- First appears as small dark brown lesions 1/8" to 1/4" in diameter. Lesions on some perennials, namely Echinacea and Rudbeckia appear purple.
- Lesions usually have rounded edges but can be angular in shape.
- Usually appears in the late spring or early summer on the lower leaves and progresses to the upper leaves as the season progresses.
- Later in the season, spots merge into large brown spots that can cover much of the leaf surface.
- Can be serious problem during warm and wet periods.
- Avoid overhead irrigation or water early in the day to allow the foliage to dry.

CONDITIONS NECESSARY FOR FUNGAL LEAF SPOT INFECTIONS

- Cool conditions.
- Wet foliage.
- High relative humidity.
- Little air movement.
- Splashing water is the most common method of spreading spores from plant to plant.
- Spores are also spread by insects, wind, and rain.

CULTURAL METHODS OF CONTROL

- Clean and sanitize between crops.
- Use disease-free propagation materials or plug liners.
- Keep the foliage as dry as possible.
- Irrigate early in the day to allow the leaves to dry before night.
- Provide good air circulation when growing inside structures.
- Provide adequate spacing between plants to allow good air circulation and low relative humidity near the canopy of the crop. This also minimizes contact from plant to plant.
- Maintain low relative humidity (<80%).
- Scout perennials weekly to detect leaf spots early.

Colletotrichum on Miscanthus

Leaf Spot Gallardia Smut

Septoria Leaf Spot on Rudbekia

POWDERY MILDEW

Powdery mildew attacks a great number of perennial species. Infections are most commonly identified by the presence of whitish-gray talcum-like powdery patches (¼" to ½" in diameter) of fungal growth on the leaf surfaces. Depending on the severity of the infection, these patches, often referred to as colonies, can appear on any above-ground plant tissue.

The first mildew colonies are difficult to detect and usually are located on the lower leaves. When conditions become favorable for disease development, these small colonies quickly coalesce together and often cover the entire plant. Severe infections restrict plant growth and cause the leaves to turn yellow and appear wilted.

There are several pathogens (*Erysiphe*, *Leveillula*, *Microsphaera, Oidium*, *Podosphaera*, and *Spaerotheca*) that cause powdery mildew diseases. These pathogens are host specific, meaning that the pathogen that infects Phlox is different from the mildew that attacks Monarda. Powdery mildew reduces plant performance, affects plant quality, and greatly reduces the aesthetic appeal of infected perennials.

CONDITIONS NECESSARY FOR POWDERY MILDEW INFECTIONS

- High relative humidity (>70%).
- Moderate temperatures (62° to 72° F).
- Can attack plants at low relative humidity, but epidemics develop when the humidity levels are high.
- Does not require free moisture on the leaves.
- Spores spread from plant to plant by air movement.

CULTURAL METHODS OF CONTROL

- Maintain relative humidity levels below 70%.
- Avoid dramatic swings in temperature and humidity.
- Purge or ventilate greenhouses during the night.
- Maintain sufficient plant spacing and increase air circulation to reduce humidity levels near the plant canopy.
- Remove and discard any leaves from plants with mild infections to reduce the spores from spreading to non-infected crops. Discard any heavily infected plants.
- Scout susceptible crops at least once a week. Look for small colonies on the lower and middle portion of the plants. Examine the upper and lower leaf surfaces.
- Control strategies for using fungicides should be implemented as soon as mildew colonies are detected.
- Preventive strategies are usually not necessary unless routine scouting is not being performed.

Powdery Mildew Colonies on Rose

Powdery Mildew on Monarda

RUST

Rust diseases (*Coleosporium*, *Phragimidium*, *Puccinia*, *Pucciniastrum*, and *Uromyces*) often become problematic for perennial growers. Each rust disease is usually specific to a particular host plant or range of plants, such as perennials within the same family.

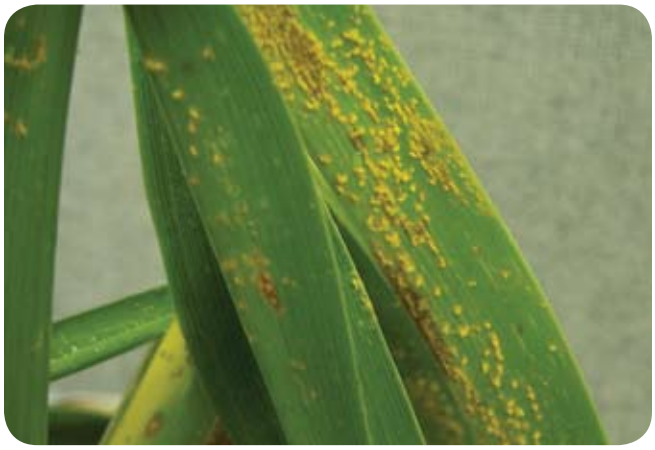
Rust is most commonly identified by the presence of raised yellow, orange, or brown pustules or spore masses on the undersides of plant leaves or along leaf petioles and plant stems. Most rust diseases can be initially identified by the appearance of pale green to yellow spots on the upper leaf surfaces. These spots often develop necrotic or dead areas in their centers. The pustules described above are often visible on the leaf undersides directly below the spotting on the upper leaf surfaces. With severe infections, the lesions may coalesce and result in large areas of necrosis, leaf distortion, or defoliation.

CONDITIONS NECESSARY FOR RUST INFECTIONS

- Wet leaves for three to six hours.
- High relative humidity (>80%).
- Cool to moderate temperatures (50° to 75° F).
- Spores are spread by air currents and splashing water.

CULTURAL METHODS OF CONTROL

- Inspect incoming plants for any signs of infection.
- Remove and discard any leaves from plants with mild infections to reduce the spores from spreading to non-infected crops. Discard any heavily infected plants.
- Maintain relative humidity levels below 80% to avoid condensation on the crops if the temperatures drop. Purge or ventilate greenhouses during the night.
- Avoid extended periods of free water on plant surfaces.
- Water early in the day to allow the foliage to dry before night. If available, use drip irrigation to avoid splashing water and wet foliage.
- Provide adequate spacing between plants to allow good air circulation and low relative humidity near the canopy of the crop.
- Scout susceptible crops at least once a week. Look closely on the undersides of plant leaves for the presence of the characteristic pustules.



Rust on Daylily

Rust on Aster

VIRUSES

Many perennials are susceptible to virus infections. Viruses differ from all other plant pathogens as they do not produce any kind of reproductive structures (spores). Viruses are tiny particles containing small pieces of DNA or RNA encapsulated in a protein coat. Plant viruses can be very difficult to identify, but often have a profound effect on crop development and appearance. Once inside the plant, viruses basically take over plant cells, forcing them to replicate more virus particles and causing plant cells to function improperly.

Viruses enter host plants through some type of wound or injury to a plant cell. A vector is the carrier of the virus, which transmits it to uninfected plants. Insect feeding and vegetative propagation are examples of how viruses can be spread from one plant to another. Identifying virus symptoms can be very challenging as they often resemble other cultural problems such as fungal diseases, herbicide injury, and nutritional disorders.

COMMON VIRUSES OF PERENNIALS

Alfalfa Mosaic Virus (AMV)	Impatiens Necrotic Spot Virus (INSV)	Tobacco Ringspot Virus (TRSV)
Arabis Mosaic Virus (ArMV)	Potyvirus Group (POTY)	Tomato Ringspot Virus (ToRSV)
Cucumber Mosaic Virus (CMV)	Tobacco Etch Virus (TEV)	Tomato Spotted Wilt Virus (TSWV)
Hosta Virus X (HVX)	Tobacco Mosaic Virus (TMV)	

VIRUS SYMPTOMS

Abnormal flower formation	Discolored flowers	Necrotic spots
Abnormal growth	Distortion of the foliage	Ring patterns
Bumps	Mosaic	Stunting
	Mottling	

Symptoms vary with the virus present and in many cases, plants may exhibit multiple symptoms from one or more viruses. The age of the plant, how long it has been infected, the environment, and the amount of stress on the plant are additional factors that affect symptom expression.

REDUCING THE OCCURRENCE OF PLANT VIRUSES

- Purchase "certified" seeds, cuttings, and plugs/liners.
- Inspect incoming plant materials.
- Control virus vectors (aphids, thrips, and whiteflies).
- Scout at least once a week.
- Remove infected plants immediately as they appear.
- Remove/control all weeds within and around the production facility.

Scouting programs can help detect vectors of viruses and help identify plants expressing early virus symptoms. Controlling insect vectors and weed host plants are currently the most effective means of reducing viruses from infecting perennial crops. Once a plant has been diagnosed with a virus, it should be removed from the production area and discarded immediately.

Ajuga virus (Katlin's Giant)

Anemone Virus

Hosta Virus X—Unusual Symptom on Hosta Queen Joshephine

Hosta Virus X on Hosta PeeDee Gold

Phlox Paniculata Missy Mary with Potyvirus

Impatiens Necrotic Spot Virus (INSV Virus) Symptoms

INSECTS OF PERENNIALS

Numerous insect pests are known to attack and feed on various perennial crops. Depending on the production environment (greenhouse or outside), there are a number of traditional crop pests (aphids, fungus gnats, spider mites, thrips, and whiteflies) growers commonly observe feeding on perennials. Additionally, there are numerous insect pests (broad mites, foliar nematodes, and leafminers to name a few) many growers are not familiar with that may on occasion become problematic. Similar to managing diseases, successful management of insect pests requires early detection and proper identification in order to implement the most effective control strategies when necessary.

APHIDS

Most crops in commercial production are suitable hosts for aphid feeding and perennials are no exception. Aubretia, Bellis, Bergenia, Monarda, and Veronica are some favorite hosts. The most common aphid species found on perennials are the chrysanthemum aphid (*Macrosiphoniella sanborni*), foxglove aphid (*Aulacothum solani*), green peach aphid (*Myzus persicae*), melon/cotton aphid (*Aphis gossypii*), and the potato aphid (*Marcosiphum euphorbiae*). The presence of aphids on perennials causes injury to the crop, potentially vectors plant viruses such as cucumber mosaic virus (CMV), dasheen mosaic virus (DsMV), and tobacco ringspot virus (TRSV), and reduces a plant's marketability. Generally, the biology and methods of controlling aphids are the same for all species.

Aphid Infestation on Leucanthemum

Aphids on Rose

Green Peach Aphid

Melon Aphid

CHARACTERISTICS OF APHIDS

- Small 1–3 mm soft bodies.
- Pear-shaped.
- Range in coloration—light pink, yellow, light to dark green.
- Piercing-sucking mouthparts.
- Presence of two cornicles (resembling small tailpipes) projecting from their abdomen.
- Most adults are wingless. Winged aphids occasionally observed with high aphid populations.
- Slow-moving.
- Often found in large groups.
- Most commonly observed feeding on young succulent stems, but can be found on all parts of the host plant.
- Exude honeydew on the leaves which can develop into sooty mold under high humidity levels.
- After molting they leave behind small white skins (castings).
- Feeding injuries include curled, distorted leaves, stunting, and distorted flowers.

LIFE CYCLE

- Populations usually consist of all females that give live birth to young nymphs.
- Each female aphid gives birth to 50 to 200 nymphs in her one-month life span.
- Young nymphs mature in seven to 10 days and can give birth to their own offspring.

CULTURAL METHODS OF CONTROL

- Inspect incoming materials for the presence of aphids before moving them into the production area.
- Eliminate weeds from the production area as they are a good host for aphids and viruses that could vector to crops.
- Screening can reduce them from getting blown into the production facility.
- Scout perennial crops at least once a week. Look for small colonies near the top of the plant.

FOLIAR NEMATODES

Foliar Nematode on Buddleia

Several perennials are susceptible to injury from foliar nematodes (*Aphelenchoides fragariae*, *A. ritzemabosi*, and *Ditylenchus dipsaci*). Foliar nematodes are essentially small microscopic plant parasitic roundworms that enter the plant through wounds and natural openings (stomata, hydathrodes) and feed within plant leaves and stems.

CHARACTERISTICS OF FOLIAR NEMATODES

- Microscopic (about 1/15" in length).
- Must have a thin film of water on the leaf and plant surfaces to move across the plant.
- Moves from plant to plant with splashing water from rainfall or overhead irrigation.
- Enters plant leaves through the stomata.
- Once inside the leaf, they feed on the spongy mesophyll cells.
- Usually not apparent on crops until after injury symptoms are present.
- Nematode populations are usually high if visible symptoms are present.
- Most common symptom is brown to necrotic regions confined to areas between the veins of plant leaves (angular spots), creating a patch-like appearance on dicots and a stripe-like pattern on monocots.
- Plant injury is often confused with bacterial leaf spots or downy mildew symptoms.
- Can vector viruses: tobacco ring spot virus (TRSV) and tomato ring spot virus (ToRSV).

LIFE CYCLE

- Do not persist in the soil and need a living host to survive.
- Adult females lay 25 or more eggs within plant tissues of the host plant.
- There are three juvenile stages before they mature into worm-like adults.
- They complete their life cycle in as little as two weeks inside plant leaves.
- Commonly overwinters in an inactive state on plant debris and becomes active again when the temperatures warm up and wet conditions are present.

CULTURAL METHODS OF CONTROL

- Inspect incoming materials for symptoms of nematode injury, namely angular spots. Symptoms may also resemble moisture stress or nutrient deficiencies.
- Submit symptomatic tissues to a diagnostic clinic to verify whether the injury is bacterial, fungal, or caused by foliar nematodes.
- Scout susceptible crops regularly.
- Remove and destroy severely infected plants from the production area.
- Avoid extended durations with wet leaves and avoid overhead irrigation to prevent splashing from plant to plant.
- Avoid using potting mixes containing mineral soils.
- Remove and discard any plant debris from floors and benches.
- Remove any weeds from the production area as they can also be host plants for foliar nematodes.

INSECTS OF PERENNIALS

FUNGUS GNATS

Fungus Gnat

Fungus gnats (*Bradysia coprophillia* and *Bradysia impatiens*) are almost always present in greenhouses and nurseries. Most growers consider these pests only to be a nuisance and not a threat to crop production. However, fungus gnats can cause injury to crops either directly or indirectly. Fungus gnat larvae injure plant roots by feeding on them; this is particularly problematic during propagation. Otherwise, all life stages of fungus gnats indirectly cause injury to plants by their transmission of diseases (*Botrytis*, *Cylindrocladium*, *Fusarium*, *Pythium*, *Phytopthora*, *Rhizoctonia*, *Thielaviopsis*, and *Verticillium*), either on their bodies or fecal deposits.

*Fungus Gnat Larvae**

CHARACTERISTICS OF FUNGUS GNATS

- Adults are small, 1/8" long, slender dark brown to black flies.
  - – They have long dangling legs, resembling those of a mosquito.
  - – Long antennae.
  - – Clear wings with a distinct Y-shaped vein on each wing.
  - – Weak flyers.
  - – Attracted to growing mixes containing bark and peat moss.
- The larvae measure 1/4" long or less.
  - – White, translucent bodies with visible digestive tracts.
  - – Black, shiny head capsule.
- Adults and larvae prefer areas with moderate moisture.
- Adults do not cause injury to crops. The larvae feed on algae, soil fungus, decaying organic matter, roots, and plant parts that are in direct contact with the soil.
- Plant wounds create entrance points for fungal pathogens.

LIFE CYCLE

- Females mate within two to three days after emerging from the soil and can lay eggs within two days of mating.
- Lay 100 to 200, small <1/32" long, creamy white, oval eggs.
- Eggs hatch within three to six days.
- Four larval stages within the top inch or two of the growing medium.
- Larvae take approximately two weeks to develop into pupae just beneath the media surface.
- It takes four to seven days for adults to emerge from the pupal skin.
- Depending on temperature, it typically takes three to four weeks to complete an entire life cycle (egg to adult).
- Adults live for about 10 days.

CULTURAL METHODS OF CONTROL

- Inspect incoming materials for the presence of larvae and adults before moving them into the production area.
- Remove all plant debris and old growing medium from the production area.
- Remove weeds from the production area as they create good environments for fungus gnat development.
- Eliminate algae and free-standing water.
- Water only when necessary, allowing the top layers of growing medium to become dry between irrigations.
- Scout routinely using sticky cards to detect adults and potato wedges placed on the surface of the growing medium to detect larvae. If adults are present, larvae will be too!

LEAFMINERS

Leafminer

There are several leafminer species (*Liriomyza huidobrensis*, *L. sativae*, and *L. trifolii*) that commonly attack a number of perennial crops. Leafminer adults are small, yellow and black flies. The females lay their eggs inside of plant leaves. The larvae hatch and feed between the upper and lower leaf surfaces. As they tunnel within the leaf, they weave winding opaque trails commonly referred to as "mines." The presence of these mines can greatly reduce the aesthetic appearance of the plant.

CHARACTERISTICS OF LEAFMINERS

- Adults have small 2- to 3.5-mm yellow and black bodies.
- Females make small punctures on the upper leaf surface with their ovipositor. The males and females feed on the sap that exudes from them. The females lay a single egg in some of the punctures.
- Punctures turn white and take on a speckled appearance over time.
- "Mines" are formed by larvae as they slash open plant cells with their sickle-like mouthparts and move between the leaf surfaces.

Leafminer Gaillardia

LIFE CYCLE

- Eggs hatch into bright yellow to white larvae within four to five days of being laid.
- The larvae feed within the leaf for four to six days where they molt two times.
- The third-instar larvae cuts a semi-circular slit in the lower leaf surface and falls to the soil surface to pupate.
- The oblong, brown to gold pupal stage lasts nine to 35 days depending on the temperature.
- The pupal stage requires darkness and usually occurs deep within the growing medium.
- Complete life cycle from egg to adult requires 15 to 40 days (16 to 21 days on average).
- Females live for approximately three weeks, laying an average of 60 eggs during their life span.

CULTURAL METHODS OF CONTROL

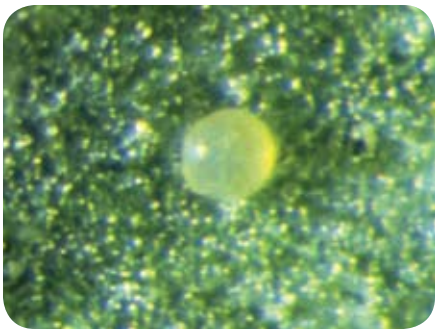
- Inspect incoming materials for the presence of leaf stipples and active mines. If stippling is present, hold the plants for several days to see if the stipples develop into mines.
- Routinely monitor adults using yellow sticky cards and examine leaves for small punctures and mines.
- Install exclusion screening on greenhouse openings such as vents, sidewalls, and air intake fans to prevent adults from entering the production site.
- Removing heavily infested plants or leaves before the leafminers pupate will reduce future leafminer populations.

TWO-SPOTTED SPIDER MITES

Perennials are very susceptible to two-spotted spider mite (*Tetranychus urticae*) infestations. Spider mites are problematic for growers because they are difficult to detect until their populations are high. Nearly every commercially grown perennial can be an acceptable food source for them. They can be difficult to control once they are detected. Spider mites are not actually insects; they are related to spiders and ticks as they have eight legs, two body regions, and lack antennae.

Spider Mites Injury on Rose

Buddleia Spider Mite Feeding Injury



Two-Spotted Spider Mite Egg

CHARACTERISTICS OF TWO-SPOTTED SPIDER MITES

- Adult and nymphal stages are small, measuring 1.6 mm or less in length.
- Oval-shaped bodies.
- Range in coloration—usually light yellow to dark green, but may appear orange, dark brown, or straw brown to black depending upon temperature, time of the year, and host crop.
- Most distinguishing characteristic is the presence of two dark spots on each side of the body.
- Four pairs of legs.
- Piercing-rasping mouthparts.
- Feeding injury appears as numerous small, pinpoint-sized, silvery-gray to yellowish spots, creating a mottled, speckled, or stippled appearance on the upper leaf surface.
- Heavy infestations may lead to severe chlorosis and leaf drop.
- Most commonly found under the lower leaf surfaces of leaves when the population is low.
- Severe infestations usually have mites on all above-ground plant parts and are covered with the characteristic webbing of the mites.
- Thrive under hot, dry growing conditions.
- Cooler temperatures will slow down but not eliminate mite development.

LIFE CYCLE

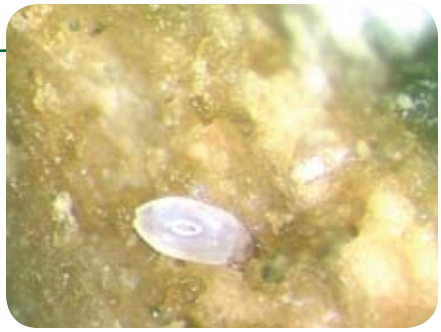
- Females begin laying eggs within three days of becoming an adult. Unmated females have only male offspring, while mated females produce both male and female offspring.
- Newly laid eggs are round, white, and translucent in appearance and deposited on the undersides of plant leaves. As the eggs mature, they turn a yellow-strawlike color. Females lay 100 to 200 eggs in their lifetime (30 days).
- The eggs hatch into tiny six-legged larvae in as little as three days.
- Larvae change to eight-legged nymphal stage after five days.
- Development time from egg to adult typically takes 14 days under warm conditions (80°F), but can vary widely with temperature.

CULTURAL METHODS OF CONTROL

- Inspect incoming materials for the presence of spider mites before moving them into the production area. Mites are also commonly introduced into production sites on equipment or people, and by wind.
- When possible, avoid sustained periods of high temperatures and low humidity.
- Eliminate weeds from the production area as they can be alternate hosts for spider mites.
- Avoid over-fertilizing plants which results in softer plant tissues that are easier for mites to penetrate with their mouthparts.

TARSONEMID MITES

There are several mites in the Tarsonemidae family that also feed on a number of perennials. The two most common mites in this family known to infest ornamentals are the broad mite (*Polyphagotarsonemus latus*) and cyclamen mite (*Steneotarsonemus pallidus*).



Tarsonemid Mites

Tarsonemid Mite Close-up

Broad Mite Injury on Delphinium

CHARACTERISTICS OF TARSONEMID MITES

- Tarsonemid mites are very tiny (less than 0.25 mm), much smaller than two-spotted spider mites.
- Translucent, mostly colorless bodies, although they may appear light amber to dark green (broad mite) or yellow to pale brown (cyclamen mite) at times.
- Due to their small size, they are difficult to detect when their populations are low.
- Requires the use of a 12X to 16X hand lens or dissecting microscope to observe their presence.
- Mites and eggs are commonly found near buds, flowers, or the growing points of the plant.
- They move rapidly when exposed to light.
- Feeding injury most commonly appears as bronzing of the leaves or stunted and severely distorted terminal shoots. Expanding leaves appear curled and distorted. The plant may look "hardened."
- Injury symptoms are commonly confused with thrips feeding injury, chemical phytotoxicity, or physiological disorders.
- They are more problematic under cool, humid conditions.

LIFE CYCLE

- Females do not require mating and begin laying eggs.
- One to three tiny, oval-shaped eggs are laid per day on the undersides of young leaves. Female broad mites lay up to 25 eggs during their lifetime and female cyclamen mites lay up to 16 eggs during their life span.
- Broad mites complete their life cycle from egg to adult in less than one week. Cyclamen mites complete their life cycle in one to three weeks.

CULTURAL METHODS OF CONTROL

- Inspect incoming materials for the presence of spider mites before moving them into the production area. Mites are also commonly introduced into production sites on equipment or people, and by wind.
- When possible, avoid sustained periods of high temperatures and low humidity.
- Eliminate weeds from the production area as they can be alternate hosts for spider mites.
- Avoid over-fertilizing plants which results in softer plant tissues that are easier for mites to penetrate with their mouthparts.

WESTERN FLOWER THRIPS

Western Flower Thrip

Western flower thrips (*Frankliniella occidentalis*) are a common insect pest for numerous perennial growers across the country. Thrips can be problematic in perennials grown inside greenhouse structures and at outside facilities. Thrips cause injury to crops and transmit plant viruses which can reduce the appearance and quality characteristics of plants and may render them unsalable in many circumstances. Western flower thrips are problematic for perennial growers since they can infest nearly every perennial in production, their populations can increase very quickly, and they are often difficult to control.

CHARACTERISTICS OF WESTERN FLOWER THRIPS

- Adult thrips are small, 2 mm (1/8") long, slender insects with two pairs of fringed or hairy wings.
- Appear straw yellow to brown in color.
- Nymphs are slightly smaller than the adults, measuring 1 mm (1/16") in length. They are wingless and usually appear creamy white to brown.
- They feed by piercing plant cells and sucking out the sap.
- Feeding injury often appears scarred, deformed, and distorted with silvery-white trails on the upper leaf surface. The leaves often appear stippled. The youngest, most tender growth often looks distorted and deformed. Injury to the flowers appears deformed, flecked, mottled, or streaked.
- Thrips can carry and vector plant viruses: INSV (impatiens necrotic spot virus) and TSWV (tomato spotted wilt virus).
- They are usually evenly distributed throughout the crop.
- Thrips are attracted to flowers for their pollen if they are present.
- Can be challenging to control due to their small size, ability to hide in tight inaccessible parts of the plant, quick life cycle, and resistance to several insecticides.

LIFE CYCLE

- Eggs are inserted into plant tissues.
- Within two to four days, the eggs hatch into larvae and remain in terminal or flower buds where they have two larval stages lasting three to six days.
- After the second larval stage, they undergo two transformational (pupal) stages in the growing medium before emerging as adults two to five days later.
- The complete life cycle (egg to adult) is fairly quick, averaging eight to 21 days depending on temperature.
- Adults usually live about 45 days.
- Females are capable of laying 40 to 250 eggs in their lifetime.

CULTURAL METHODS OF CONTROL

- Inspect incoming materials for the presence of thrips or feeding injury before moving them into the production area.
- Eliminate weeds from the production area as they can be alternate hosts for western flower thrips. Maintain a weed-free barrier around the facility.
- Remove plant debris and old growing medium from the production site.
- When disposing of plant materials, place them in containers with tight sealing lids to prevent the thrips from migrating back onto the main crops.
- Install thrips exclusion screening on greenhouse openings such as vents, sidewalls, and air intake fans to prevent them from entering the production site.
- Monitor the growing area regularly using yellow or blue sticky cards as well as inspecting plants and flowers for their presence.

WHITEFLIES

Banded-Wing Whiteflies

The greenhouse whitefly (*Trialeurodes vaporariorum*) and silverleaf whitefly (*Bemisia argentifolii*) are the two most common whitefly species found on perennials. Whiteflies can cause significant injury to many species of perennials if populations are allowed to build, greatly reducing the marketability of the crop.

CHARACTERISTICS OF WHITEFLIES

Whitefly Adults and Nymphs

- All life stages (egg, nymph, pupa, and adult) can be found on the undersides of plant leaves.
- Adult whiteflies are typically 1.5 to 2.0 mm in length. Greenhouse whiteflies are slightly larger than silverleaf whiteflies.
- The wings of greenhouse whiteflies appear flat or parallel to their bodies. Silverleaf whitefly wings have a slight yellow coloration and appear more roof-like (approximately a 45° angle with the leaf surface).
- Nymphs are oval and have a pale green to yellow coloration.
  - The pupal case of the greenhouse whitefly has parallel sides that are perpendicular to the leaf surface, giving the pupa a disk- or cake-shaped appearance. There is also a fringe of wax filaments around the edge of the pupal case.
  - The pupal case of the silverleaf whitefly is yellowish and appears more rounded or dome shaped. The sides are also not parallel and lack filaments.
  - The pupal cases of both whiteflies have several pairs of filaments arising from the top of the pupa.
- The spindle-shaped eggs are white and turn gray with time and often are in a crescent-shaped pattern on the undersides of leaves.
- Nymphs and adults have piercing-sucking mouthparts.
- Feeding injury is usually not noticeable, but may reduce plant vigor or result in chlorotic spots, mottling, and net veining when their populations are high.
- They secrete "honeydew" from their bodies, which often leads to the development of black sooty mold.

LIFE CYCLE

- Females can lay eggs one to three days after emerging as an adult. Mating is not necessary.
- The eggs of greenhouse whiteflies hatch in about eight to 10 days. Silverleaf whitefly eggs take approximately 10 to 12 days to hatch.
- There are four nymphal stages. The first nymphal stage or crawler stage is the only mobile stage and often only moves a few millimeters. The fourth nymphal stage can be recognized by the red eye spots that are visible through the pupal case.
- From egg to adult, it takes an average of 32 days for greenhouse whiteflies and 39 days for silverleaf whiteflies to mature.
- Development time from egg to adult is 14–39 days and will vary with temperature, (14–21 days is typical during warmer temperatures).
- Females live approximately two to four weeks and are capable of laying 200 to 300 eggs during their life span.

CULTURAL METHODS OF CONTROL

- Inspect incoming materials for the presence of whitefly eggs, nymphal stages, or adults on the undersides of leaves before moving them into the production area.
- Eliminate weeds from the production area as they can be alternate hosts for whiteflies.
- Remove any plant debris, old stock plants, and "pet" plants from the production site.
- Avoid over-fertilizing plants since whiteflies tend to feed on and lay more eggs on plants that receive abundant levels of fertilizer.
- Install exclusion screening on greenhouse openings such as vents, sidewalls, and air intake fans to prevent adults from entering the production site.
- Monitor the growing area regularly using yellow cards as well as randomly inspecting the undersides of plant foliage for their presence.

SOLUTIONS BY PEST

Disease	Effective fungicides
Botrytis	Daconil® • Heritage® • Medallion®
Downy mildew	Heritage • Subdue MAXX®
Fungal leaf spot	Banner MAXX® (*outside use only*) • Daconil • Heritage • Medallion
Fusarium	Heritage • Medallion
Phytopthora	Heritage • Hurricane® • Subdue MAXX
Powdery mildew	Banner MAXX (*outside use only*) • Heritage
Pythium	Heritage • Hurricane • Subdue MAXX
Rhizoctonia	Heritage • Hurricane • Medallion
Rust	Banner MAXX (*outside use only*) • Daconil • Heritage
Thielaviopsis	Hurricane—*preventive only* • Medallion

Insect	Effective insecticide/miticide
Fungus gnat	Citation® (insect growth regulator) • Flagship® • Scimitar® GC (adults)
Leafminer	Avid® • Citation • Flagship • Scimitar GC (adults)
Tarsonemid mite	Avid (larva, nymph, adult)
Two-spotted spider mite	Avid (larva, nymph, adult)
Western flower thrip	Avid • Scimitar
Whitefly	Avid • Endeavor® Flagship • Scimitar

***Scimitar GC is a Restricted Use Pesticide**

DISEASE AND INSECT PRESSURES BY CROP*

Disease	Host crop
Botrytis	All perennials
Downy mildew	Agastache, Alyssum, Anemone, Antirrhinum, Artemisia, Aster, Aurinia, Buddleia, Corydalis, Coreopsis, Dicentra, Digitalis, Echinaceae, Erigeron, Erysimum, Fragaria, Galium, Gaura, Geranium, Geum, Helianthus, Lamium, Lathyrus, Ligularia, Linaria, Lupinus, Mertensia, Myosothis, Oenothera, Papaver, Phlox, Pysostegia, Potentilla, Prenanthes, Ranunculus, Rose, Rudbeckia, Salvia, Scabiosa, Silene, Solidago, Statice, Stokesia, Verbascum, Verbena, Veronica, Viola
Fungal leaf spot	All perennials
Fusarium	All perennials
Phytopthora	All perennials
Powdery mildew	Achillea, Aconitum, Agastache, Anemone, Antirrhinum, Aquilegia, Arenaria, Aster, Astilbe, Baptisia, Boltonia, Campanula, Centeraurea, Chelone, Clematis, Coreopsis, Cosmos, Dahlia, Delphinium, Doronicum, Echinacea, Erica, Erigeron, Erysimum, Eupatorium, Euphorbia, Filipendula, Fragaria, Gaillardia, Galium, Gaura, Geranium, Geum, Helianthus, Helenium, Helianthus, Heliopsis, Heuchera, Hibiscus, Hypercium, Iberis, Lathyrus, Leucanthemum, Lupinus, Mertensia, Malva, Mentha, Monarda, Nepeta, Oenothera, Paeonia, Papaver, Penstemon, Phlox, Polemonium, Potentilla, Primula, Prunella, Pulmonaria, Ranunculus, Rosa, Rosmarinus, Rudbeckia, Rumex, Salvia, Saxifraga, Scabiosa, Sedum, Senecio, Solidago, Stachys, Stokesia, Tanacetum, Thalictrum, Tiarella, Trollius, Verbascum, Verbena, Veronica, Viola
Pythium	All perennials
Rhizoctonia	All perennials
Rust	Acorus, Agastache, Alcea, Alchemilla, Amsonia, Anchusa, Andropogon, Anemone, Antennaria, Arabis, Armeria, Artemisia, Asarum, Asclepias, Aster, Athyrium, Calamagrostis, Canna, Carex, Chrysanthemum, Cimicifuga, Convallaria, Convolvulus, Coreopsis, Corydalis, Dianthus, Erigeron, Erysimum, Galium, Gaura, Geranium, Geum, Helianthus, Hollyhock, Iris, Lupinus, Mertensia, Phlox, Potentilla, Ranunculus, Solidago
Thielaviopsis	Many perennials, particularly Aster, Phlox, Subulata, Scabiosa

Insect	Host crop
Foliar nematode	Anemone, Aquilegia, Astilbe, Aubretia, Bergenia, Brunnera, Campanula, Delphinium, Digitalis, Echinaceae, Ferns, Filipendula, Geranium, Hellebores, Heuchera, Hosta, Ligularia, Lysimachia, Monarda, Peony, Phlox, Salvia, Tricyrtis, Viola
Fungus gnat	All perennials
Leafminer	Aquilegia, Asclepias, Buddleia, Coreopsis, Delphinium, Eupatorium, Gaillardia, Geum, Helianthus, Heliopsis, Leucanthemum, Lupine, Monarda, Platycodon, Polemonium, Verbena, Veronica
Tarsonemid mite	Aster, Buddleia, Eupatorium, Fragaria, Lamium, Potentilla, Rubeckia, Salvia, Verbena
Two-spotted spider mite	All perennials, particularly susceptible ones include Aster, Buddleia, Eupatorium, Fragaria, Lamium, Potentilla, Rose, Rudbeckia, Verbena
Western flower thrip	All perennials
Whitefly	All perennials

***Certain insects, diseases, and viruses affect every crop. The above list includes diseases and insects that are not common to every perennial. Diseases and viruses that affect every crop include *Botrytis*, crown and root rots, and fungal leaf spots. Insects that affect every crop include aphids, fungus gnats, tarsonemid mites, and two-spotted spider mites.**

PRODUCTS *for* PROTECTION OF PERENNIALS

FUNGICIDES

A preventive approach against disease requires knowledge of the pathogens, as well as a management strategy utilizing a rotation of fungicides with different modes of action. Banner MAXX, Heritage, Hurricane, Daconil, Medallion, and Subdue MAXX provide the protection to control diseases that threaten perennials.

Banner MAXX® Fungicide

- Superior control of powdery mildew and rust.
- Broad-spectrum control of fungal leaf-spotting diseases in a low odor, highly compatible, and easy-mixing MAXX® formulation.
- The unique formulation and fine particle size allows for excellent coverage and activity on the plant.
- Systemic action delivers effective performance.

Daconil ULTREX® Fungicide

SuperWeatherStik®

- Effective on *Botrytis*, *Cercospora*, and *Colletotrichum* (anthracnose).
- Take note that it may fade dark flowers.
- Multi-site mode of action is effective in resistance management programs.
- Premium contact fungicide.

Heritage® Fungicide

- Long-lasting broad-spectrum preventive ornamental fungicide.
- Controls all four major classes of fungi, up to 28 days.
- Highly effective as the only systemic fungicide.
- Provides protection with foliar and drench applications.
- A highly effective application as a drench or foliar spray in a rotation.

Hurricane® Fungicide

- Delivers effective, easy protection against all major root rot diseases (one 1.5 oz bag/100 gal).
- Systemic and contact dual action provides comprehensive control of *Pythium*, *Phytophthora*, and *Rhizoctonia* stem and root disease through both systemic and contact action.
- Reduces the need to tank-mix several products and eases the time-consuming identification of root rot diseases.
- Hurricane can be applied to the roots of the plants by drenching using microjet, drip irrigation, or hydraulic systems. It can also be incorporated as a pre-potting media drench.

Medallion® Fungicide

- Most effective contact fungicide for control of *Rhizoctonia*.
- Broad-spectrum control against root and other foliar disease.
- A contact fungicide, discovered from naturally occurring compounds produced by bacteria.
- Low-use rates with little odor and no residue.
- Use after flower bud initiation.
- Two–four oz/100 gals for *Botrytis*, alternate with Heritage 50WG.
- One–two oz/100 gals for *Alternaria*, *Cercospora*, *Septoria*, and *Myrothecium*.
- Apply before/after seedling or transplanting of plugs.
- Repeat after transplanting plants.

Subdue MAXX® Fungicide

- Long-lasting, cost-effective control of damping-off and root and stem rot diseases caused by *Pythium* and *Phytophthora* spp.
- Foliar applications for control of downy mildew and aerial *Phytophthora*.
- Quality formulation, mixes clear in water and won't settle out in tank or clog filters. Leading-edge MAXX formulation technology.

INSECTICIDES

Insects pose a threat to perennials due to unsightly residues, damage to stems or foliage, and in some cases, the vectoring of pathogens. Measures can be taken, such as improved sanitation, careful inspection of all plant materials before they enter or leave a nursery, avoiding over-watering and over-fertilization to reduce algae growth. The optimal use of products, following an integrated solution with scouting for early detection and resistance management practices, will help to eliminate the threat.

Avid®
Miticide/Insecticide

- The standard for mite and leafminer control.
- Suppression of aphids, thrips, and whiteflies.
- Avid insecticide/miticide's mode of action make it ideal for rotation in resistance management programs.

Citation®
Insect Growth Regulator

- Insect growth regulator for effective, economical control of leafminers, fungus gnats, and shorefly larvae.
- Does not harm insect predators used in integrated crop management (ICM) programs.
- For use in indoor and outdoor nursery settings.
- Excellent resistance management tool.

Endeavor®
Insecticide

- Systemic activity in the plant controls aphids and whiteflies.
- Inhibits feeding activity resulting in death of the insect.
- Compatible with beneficial species.

Flagship®
Insecticide

- Fast systemic activity allows for soil drench or foliar spray applications.
- Fast foliar translaminar absorption stores Flagship within the leaves for longer control.
- Broad-spectrum control of soil, sucking, chewing insect pests controlled with flexible application methods and excellent plant tolerance.
- Flagship can be used as a tool in integrated pest management programs.
- Available in sprayable, wettable granules and ready-to-use granule formulations.

Scimitar® GC
Insecticide

- Water-based capsule suspension. Pyrethroid formulation that is safe to use on a wide range of plants.
- Fast-acting, long-lasting control of aphids, armyworms, caterpillars, and sawflies.
- **Scimitar GC is a Restricted Use Pesticide.**

Fafard® The Science Behind the Art

For uniform quality production use Fafard® premium soil-less growing media customized to your crop needs. **www.fafard.com**

bioline

For more information on beneficials such as predatory mites and parasitic wasps, contact Syngenta Bioline® at 1-805-986-8265 or visit **www.syngentabioline.com**

syngenta *flowers*

For more information on the breeding, production, and distribution of high-quality pot and bedding plants in the form of seeds, young plants, and cuttings. **www.syngentaflowers.com**

Choosing the right protection for each of your perennials is essential. Syngenta offers not only the products needed to help protect your plants, but the industry's leading technical support as well, all to help you keep your crops beautifully strong. We're here should you have any questions about disease or insect pests affecting your crops or the best way to use a particular product. **Call 1-866-SYNGENTA (796-4368) to contact the Syngenta Customer Center and we will provide the support you need.**

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