Floriculture and Ornamental Nurseries

March 2021

PEST MANAGEMENT GUIDELINES FOR AGRICULTURE

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Authors and Credits

Crop Leadership Team: C.A. Wilen (emeritus), UC IPM Program, UCCE San Diego Co. (Crop Team Leader and UC IPM Facilitator); S.T. Koike (emeritus), TriCal Diagnostics, Hollister; A.T. Ploeg, Nematology, UC Riverside; S.A. Tjosvold (emeritus), UCCE Santa Cruz Co.
Diseases: S.T. Koike, (emeritus), TriCal Diagnostics, Hollister; S.A. Tjosvold (emeritus), UCCE Santa Cruz Co., D.M. Mathews, Plant Pathology, UC Riverside
Insects, Mites, and Other Invertebrates: S.A. Tjosvold, UCCE Santa Cruz Co.; R.A. Redak, Entomology, UC Riverside; S.H. Dreistadt, UC IPM Program, C.A. Wilen, UC IPM Program, UCCE San Diego Co.
Nematodes: J.J. Stapleton, UC IPM Program, Kearny Agricultural Center; A.T. Ploeg, Nematology, UC Riverside
Weeds: C.A. Wilen (emeritus), UC IPM Program, UCCE San Diego Co.

Acknowledgements for contributions

Insects and Mites: J.A. Bethke, UCCE San Diego Co.; D.O. Gilrein, Long Island Horticultural Research and Extension Center, Cornell University; K.L. Robb, UCCE Mariposa Co.; H.S. Costa, Entomology, UC Riverside; R.S. Cowles, Connecticut Agricultural Experiment Station, Windsor, CT; M.P. Parrella, Entomology, University of Idaho
Nematodes: J. Ole Becker, UC Riverside; Becky B. Westerdahl, UC Davis; M.V. McKenry (emeritus), Kearney Agricultural Center, Parlier
Weeds: L.R. Oki, UC Davis; T.M. Bean, UC Riverside; C.L. Elmore (emeritus), Vegetable Crops/Weed Science, UC Davis

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Guidelines Coordinators: S.H. Dreistadt, P. Kosina
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- **Online: http://ipm.ucanr.edu**
- **UC Cooperative Extension County Offices**
- **University of California**
  ANR Communication Services
  2801 Second Street
  Davis, CA 95618-7779
  510-750-1213; 800-994-8849

Updates: These guidelines are updated regularly. Check with your University of California Cooperative Extension Office or the UC IPM website for information on updates.

Note to readers: These guidelines represent the best information currently available to the authors and are intended to help you make the best choices for an IPM program. Not all formulations or registered pesticides are mentioned. Always read the label and check with local authorities for the most up-to-date information regarding registration and restrictions on pesticide use. Check with your agricultural commissioner for latest restricted entry intervals.

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General Management in an IPM Program

INTEGRATED PEST MANAGEMENT (3/21)

Integrated pest management (IPM) is an ecosystem-based strategy that focuses on long-term suppression of pest abundance and prevention of pest damage through a combination of control strategies. Management actions are taken according to established guidelines or action thresholds after monitoring indicates that control action is warranted. IPM requires knowledge of pest life cycles and pertinent biology and an understanding of crop production. Pesticides when warranted are selected and applied in ways that minimize risks to workers and other persons, beneficial and nontarget organisms, and the environment (e.g., air and water quality). The goal is to suppress the abundance of, or exclude or remove, only the target organism(s) while maintaining the economic viability of the cropping system. Collectively all measures taken under an IPM strategy should attempt to minimize economic crop losses and environmental impact while simultaneously minimizing control efforts such that overall profitability is maximized.

Key components of an IPM program in general order of implementation are:

- Take preventive control measures, the start-clean and grow-clean strategy.
- Monitor crops regularly.
- Accurately identifying pests and their natural enemies and correctly diagnose the cause(s) of plant problems.
- Develop thresholds or guidelines for when and how to take control actions.
- Take appropriate and effective actions, generally both non-chemical and chemical controls in combination.

For more information see *What is Integrated Pest Management (IPM)*, *For Retail Nurseries & Garden Centers*, and University of California (UC) Agriculture and Natural Resources (ANR) printed publications that include *Container Nursery Production and Business Management Manual*, *Integrated Pest Management for Floriculture and Nurseries*, and *Water, Root Media, and Nutrient Management for Greenhouse Crops*.

DIAGNOSING PLANT PROBLEMS (3/21)

Diagnosis is the art and science of identifying the cause of the plant problem under investigation. Problem causes can be

- abiotic (cultural and environmental) including chemical injury, inappropriate temperatures or soil moisture, mechanical injury, nutrient deficiency or excess, and salt damage
- biotic (living organisms, pests) including insects, nematodes, mites, mollusks, plant pathogens, and weeds
- combinations of causes including both abiotic and biotic (e.g., drought stress and spider mite damage) or a pest insect and plant pathogen it vectors (glassy-winged sharpshooter and *Xylella fastidiosa*)

To diagnose the cause(s) of unhealthy plants

- Ask and answer appropriate questions to define the problem and obtain information relevant to the situation under investigation. See Diagnosing the Cause(s) of Unhealthy Plants for a detailed example of this.
- Thoroughly examine the plants, production areas, and plant care practices.
- Use appropriate field diagnostic (quick-test) kits and properly collected samples for laboratory analyses of specific, suspected causes of abiotic and biotic maladies.
- Compile the information and consult additional references and resources including local University of California Cooperative Extension (UCCE) Advisors and their publications.
- Make an informed diagnosis.

For example, to diagnose whether an insect is the cause of damage, it is important to

- Learn the pest's life cycle.
- Be able to identify each of development stages of the pest.
- Know how that pest feeds on the crop or otherwise damages plants.
- Learn which pest life stages are susceptible to the available management methods.

Note that the most apparent life stage (e.g., flying adults captured in sticky traps, or adult female pests) can differ from the stage(s) that feed on and damage plants and are susceptible to control actions (commonly the immatures, larvae or nymphs). To help you diagnose pest problems, consult Common Signs and Symptoms on Plants Damaged by Pest Insects, Mites, Slugs, and Snails (Arthropods) and the Probable Causes.

See Diagnosing the Cause(s) of Unhealthy Plants for a detailed example.

DIAGNOSING THE CAUSES(S) OF UNHEALTHY PLANTS

(3/21)

Diagnosing the cause(s) of plant problems can be done by asking a series of pertinent questions and investigating the answers:

Questions About the Plant

- What are the genus, species, and cultivar of the plant in question?
- Is this particular plant suited to the production area?
- Is the cultivar resistant or especially susceptible to diseases or other problems?
- Is the plant sensitive to certain environmental factors (e.g., salinity, excess or deficient soil moisture)?
- How does the plant normally appear when grown under various conditions (full sun, shadehouse, greenhouse, coastal versus inland production locations, winter versus summer) or at different stages of growth and development?
- What is the normal growth rate?
- What are the characteristics, appearance, and growth habits of a healthy plant, and could these features be confused with an unhealthy plant?

Questions About the Symptoms

- What are the symptoms of the affected plant?
- What plant parts are affected?
- Are symptoms restricted to external plant surfaces or are there also internal symptoms (vascular streaking, discolored crown tissue)?
- Are symptoms present only on exposed plant surfaces or also on protected covered tissues such as unexpanded inner leaves or unopened flowers?
- What is the distribution of the symptoms on any one particular plant (do symptoms occur on one side of the plant, only on older or newer leaves, on secondary roots but not on primary roots, etc.)?
- How did the symptoms first start?
- How do early symptoms differ from more advanced symptoms?
- How long have the symptoms been present?
- What is the extent (distribution and severity) of symptoms in the population of plants of a given species or cultivar?

Growth Stage

- What is the growth stage of the affected plant (seedling, cutting, newly transplanted, mature flowering or fruiting plant, senescent plant)?
- Is a particular growth stage associated with the problem?
- What was the condition of the plant when first placed in the production area?
- How does the growth rate of the affected plant compare to that of a healthy plant?

Symptoms on Other Plants

- Are symptoms restricted to one species or one cultivar of plant?
- Do the same symptoms occur on one type of plant that is located in different growing areas?
- Alternatively are there different plantings of the same plant type that are symptomless?
- What other plant species and cultivars appear affected?
- Do adjacent plantings, weeds, or nearby landscape plants exhibit similar symptoms?
- If other plants are affected, do they belong to a common group or family of plants?

Patterns

- How are the symptoms distributed within the specific production area(s) of concern?
- Are there patterns (repeating numbers of plants or plant rows) to the symptoms or do symptoms occur randomly throughout the planting?
- Are symptomatic plants found in clustered groups?

- Do the symptoms occur in lines, streaks, or circles?
- Are symptomatic plants found mostly along the edges of the planting?
- Are affected plants next to buildings, ditches, roads, weedy areas, or other crops or production areas?
- Are symptoms associated with subsets of plants within the planting, indicating an association with plants from certain transplant trays, different sources of plant material, or other production factors?
- Are symptoms associated with physical features at the nursery, such as low or high spots of the field, places where water does not drain well, presence or absence of underlying gravel, or particular soil types?
- Do such areas become flooded after rains or receive irrigation runoff?
- Are affected areas under sprinklers or watered by drip irrigation?

Timing

- What temporal factors are important?
- When did the symptoms first occur?
- Are there various stages of symptoms indicating new infections versus older ones?
- Have the features or severity of the symptoms changed over time?
- Do symptoms appear to have developed gradually over a period of time or rapidly and all at once?

Biotic or Abiotic

- Do symptoms resemble those caused by biotic agents, such as pathogens, nematodes, arthropods, or vertebrate pests?
- Alternatively, are symptoms more suggestive of physiological or abiotic factors, such as nutritional problems, physiological disorders, genetic mutations (chimeras), chemical damage, or environmental extremes?
- Do the symptoms provide evidence that more than one factor or pathogen is involved?

Signs

- A sign is the visible presence of a causal agent or factor. Are such signs present?
- Examples of signs are bacterial ooze, chemical residue, fungal growth (e.g., mycelia or spores), and insect bodies or excrement (frass).
- Are there multiple signs indicating that more than one factor may be involved?
- What is the distribution of signs on the affected plant (present on all or only on certain plant parts)?
- Are signs present on all symptomatic plants and do they appear to be associated with the symptoms?
- Are signs present on adjacent plantings or nonsymptomatic plants?

Timing and Context

- What time of year did the problem occur?
- If the problem occurred before, did it take place during the same time of year?
- What are the current and past weather conditions?
- Have there been any unusual weather patterns or developments recently or in the past few weeks or months?
- Have there been any conditions that would hinder plant growth or favor arthropod or pathogen development?
- Is there evidence of abiotic stress factors (e.g., mineral deficiencies and toxicities, pollution, temperature extremes, salt buildup, water stress or excess, wind or other mechanical damage, etc.)?
- What is the general location of the nursery (coastal versus inland, next to other crops or nurseries, next to roads, etc.)?

Biotic Factors

- Which arthropod pests, nematodes, pathogens, snails and slugs, and vertebrate pests are known to occur on the host or cause feeding damage or other injury to the host?

- Which biotic agents occur in the geographic area of concern?
- Compile a list of common pests that occur in the area and may be the cause(s) of the current problems. For sources of this information see Common Signs and Symptoms on Plants Damaged by Pest Insects, Mites, Slugs, and Snails (Arthropods) and the Probable Causes, the "Crop Tables" at the back of *Integrated Pest Management for Floriculture and Nurseries* and the similar information online: *Flowers*; *Fruit Trees, Nuts, Berries, and Grapevines*; *Trees and Shrubs*; and *Vegetables and Melons*.

Source: *Container Nursery Production and Business Management Manual*. See this publication for more detailed help with problem diagnosis, such as example answers and problem-solving steps for the questions above.

CONTROL PESTS BY HEAT TREATMENT OF PLANTS IN NURSERIES (01/22)

Many bacteria, fungi, insects, mites, and nematodes can be controlled by briefly exposing infested plants to aerated steam, dry heat, or hot water as listed in the table Pests Controlled by Heat Treatment of Plants. Certain viruses can be eliminated from cuttings by heat treating mother plants before propagation from meristem tissue. Heat-treating seeds is commonly used to eliminate Xanthomonas bacteria and certain other pathogens. Immersing bulbs, corms, cuttings, rhizomes, roots, seeds, or other parts in hot water before planting or storage can disinfect crops such as amaryllis, daffodil, calla, gladiolus, iris, lily, palm, rose, statice, tulip, and zinnia.

The temperature and time needed to provide control depend on the crop and pests:

- Insufficient temperatures or too short an exposure may not kill the pests.
- Too high a temperature or too long an exposure can damage plants.
- Inadequate equipment or technique, such as failing to maintain the proper temperature consistently throughout the treated batch and specified time can cause variation within a treated batch, resulting in some plants heat-damaged, others inadequately disinfested of pests, only a portion of the plants properly treated, or all three outcomes together.

Conduct on-site experiments with small batches, consult an expert, or both before deciding how to perform any large-scale, heat treatments:

- Specify and record the methods for each particular situation.
- Start small and expose portions of infested crops to those specific treatments carefully controlled, then observe plants for control efficacy and potential heat damage.
- Adjust methods if warranted, then retest small batches.
- After obtaining satisfactory results, treat larger numbers of those same crops and varieties.
- If alternative control methods are available, consider applying those to a different portion of the same crop that is being heat treated and compare the results.

A general recommendation is to presoak bulbs, corms, or rhizomes for 2 to 3 hours or overnight in 75°F (24°C) water containing a wetting agent before immersing them in 111°F (44°C) water for about 1-1/2 hours. Cool plants immediately afterward with clean, cold water; dry them thoroughly in warm air or sunshine; then store them under cool, low-humidity conditions until plants are used.

Each pest species and crop cultivar should be tested for susceptibility on a small scale before treating large portions of the crop. An ice chest with an electric immersion heater may be sufficient for small volume treatments. Commercial treatment can be done in larger tanks into which stock is lowered by a forklift or hoist, treated for a specified period of time, and then removed, cooled, and dried. Or stock can be placed onto a conveyer belt that moves through uniformly hot air, aerated steam, or hot water at a calibrated speed.

Consider using a pretreatment to partially raise the planting stock to the required temperature, especially if stock is taken from cold storage or cold soil shortly before treatment. The volume of hot air or water in the primary tank should be large enough to prevent a significant drop in temperature when the stock is added. The shorter the treatment time, the more critical it is to quickly reach and maintain the required temperature. Depending on how quickly stock must be cooled after treatment, an additional cool-water tank or facilities for hosing down treated stock with clean, cool water may be needed.

Accurate time and temperature controls are critical. Use a circulating fan or pump or other method to continually mix the treatment air or water to assure uniformity within the tank. Monitor temperature uniformity for each treatment using several, properly calibrated thermometers in the treatment tank. In California, the local office of the county agricultural commissioner may be able to provide information on calibration of thermometers.

Pests Controlled by Heat Treatment of Plants.			
Crop	**Pest common name**	**Pest scientific name**	**Treatment suggestions**
amaryllis, daffodil, gladiolus, iris, lily, tulip, and some other bulbs, corms, and rhizomes during storage	bulb flies bulb mites bulb scale mites gladiolus thrips lily bulb thrips stem and bulb nematodes tulip bulb aphid	*Eumerus* and *Merodon* spp. *Rhizoglyphus* spp. *Steneotarsonemus laticeps* *Thrips simplex* *Liothrips vaneeckei* *Ditylenchus* spp. *Dysaphis tulipae*	Presoak bulbs, corms, or rhizomes for 2 to 3 hr or overnight in 75°F (24°C) water containing a wetting agent. Immerse in 111°F (44°C) water for 1-1/2 hr. Cool plants immediately afterwards with clean, cold water, then dry thoroughly in warm air or sunshine. Store under cool, low-humidity conditions.
caladium tubers, gladiolus corms, iris rhizomes	crown rot, southern wilt	*Sclerotium rolfsii*	Immerse corms, rhizomes, or tubers in 122°F (50°C) water for 30 min plus the time necessary for plants to reach this temperature. Cool plants immediately afterward with clean, cold water. Dry thoroughly in warm air or sunshine.
calla	mosaic	*Dasheen mosaic virus*	Heat to 150°F (66°C) for 10 min. Then culture tissue.
daffodil bulbs	basal rot crown rot scorch stem and bulb nematodes	*Fusarium oxysporum* f. sp. *narcissi* *Sclerotium rolfsii* *Stagonospora curtisii* *Ditylenchus dipsaci*	Store bulbs at 60° to 64°F prior to treatment to reduce heat injury. Presoak for 2 to 3 hr or overnight in 75°F (24°C) water plus a wetting agent. Maintain water at 109° to 111°F (43° to 44°C) for 3 to 4 hr after temperature reaches 109°F. Cool and dry bulbs immediately.
Easter lily, heat-tolerant cuttings of other hosts	foliar nematodes	*Aphelenchoides fragariae*, *A. ritzemabosi*	Dip bulblets of Lilium longiflorum in 125°F (52°C) water for 10 minutes before planting. Dip cuttings of other heat-tolerant hosts in hot water at 122°F (50°C) for 5 minutes or at 111°F (44°C) for 30 minutes. Cool and dry tissues immediately after heat treatment.
gladiolus corms	blue mold, corm rot Fusarium yellows neck rot, corm disease dry rot	*Penicillium spp.* *Fusarium oxysporum* f. sp. *gladioli* *Botrytis cinerea, B. gladiolorum* *Stromatinia gladioli*	Cure corms immediately after digging by storing them in shallow trays at 95°F (35°C) and 80% relative humidity (RH). Use fans to provide continuous air circulation through trays and around corms. When old corms break off easily, usually after 6 to 8 days, break off and clean the remaining new corms. Cure new corms 4 days or longer at 95°F, 80% RH. Treat the corms with hot water: select sound, hard, fully dormant cormels grown in warm soil and harvested before cold weather. Cure corms as above. Presoak cormels for 2 days in 60° to 80°F (16° to 27°C) water. Discard any corms that float. Immerse corms 30 min in 131°F

			(55°C) water. Cool corms immediately afterward with clean, cold water. Dry corms thoroughly in warm air or sunshine. Apply fungicide. Store corms at 40°F (4°C), 70 to 80% RH.
grape cuttings	vine mealybug	*Planococcus ficus*	Dip dormant stock (grape cuttings) for 5 min in each of three water tanks in sequence: preheating 86 +/- 5°F (30 +/- 3°C), hot-water 127 +/- 0.6°F (52.8 +/- 0.3°C), and cooling 73.4 +/-5°F (23 +/- 3°C).
iris bulbs	blue mold	*Penicillium* spp.	Within 5 days of digging, cure bulbs for several days in shallow trays at 95°F (35°C) and 80% RH. Store under cool, lower-humidity conditions. Avoid injuring bulbs and do not dig them too early or too late.
iris bulbs	bulb nematodes	Ditylenchus destructor	Harvest bulbs 7 to 10 days early. Immerse them in 110°F (44°C) for 3 hr, then cool and dry promptly. Store under cool, dry conditions.
palms, potted	ground mealybugs	*Rhizoecus* spp.	Submerge pots in 120°F (49°C) until the internal temperature of the rootball reaches 115°F (46°C).
rose	mosaic rose ring pattern	*Prunus necrotic ringspot virus* unknown; probably a virus	Hold mother plants at 100°F (38°C) for 4 weeks; virus will be inactive in 99% of the cuttings taken after this heat treatment.
seeds of statice, stock, zinnia and others	bacterial blight	*Xanthomonas campestris*	Soak seed in 122° to 131°F (50° to 55°C) water for 10 min to disinfect seed surface or apply aerated steam to seed for somewhat longer. Cool seeds rapidly after heat treatment.
ranunculus seed	bacterial blight	*Xanthomonas campestris*	Soak seed in a solution of 1 part chlorine bleach and 9 parts clean water for 30 min at room temperature or at 122°F (50°C) for 15 min. Cool seeds rapidly after heat treatment.
many hosts	cyclamen mite broad mite, and possibly other tarsonemids	*Phytonemus pallidus* *Polyphagotarsonemus latus*	Thoroughly immerse plants in 111°F (44°C) water for 30 min or hold plants at 100% humidity and 111°F for 11 hours. First test some plants before treating the entire crop to determine if they will tolerate these conditions, then carefully inspect treated plants under magnification to ensure the method is effective.

Adapted from *Integrated Pest Management for Floriculture and Nurseries*. 2001. UC ANR Publ. 3402. Oakland, CA

Heat can injure plant parts, causing stunting, deformation, or flower drop. Before any large-scale treatments, consult an expert and test portions of each crop and variety for control efficacy and crop tolerance to heat.

Note that heat at higher temperatures can also be used to disinfect heat-tolerant containers, equipment, tools, and other materials and to pasteurize growing media. For example steam treat planting beds or otherwise pasteurize growing media to the recommended pasteurization temperature before planting or

immediately after removing any pest-infested crop to kill pests before replanting beds. Steam is difficult to use in field soils but can be applied using a plowlike steam rake to raise the topsoil temperature to levels sufficient to kill most pests.

MORE INFORMATION

- *Brief Exposure to Dry Heat or Hot Water Can Disinfest Many Crops of Insects*. 2013. Bethke JA. UCCE San Diego.
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REFLECTIVE MULCHES (3/21)

Reflective mulch delays or prevents certain flying insects from infesting plants because reflected ultraviolet light confuses insects' ability to locate their hosts. Reflective mulches have been effectively used to greatly reduce colonization of young crops by winged aphids, leafhoppers, thrips, and whiteflies. Although few floral crops have been studied, reflective mulches have been shown to be effective in various vegetable row crops against melon aphid, silverleaf whitefly, and western flower thrips. In field-grown crops especially sensitive to viruses or other insect-vectored pathogens, the added cost of reflective mulch may be justified because the mulch can be significantly more effective than insecticides in preventing pathogen infection. Insects that migrate onto a crop often have time to feed long enough to transmit viruses before being killed by pesticide residue on treated crops; reflective mulches can prevent such pests from alighting on the crop. Reflective mulches also conserve soil moisture and can improve crop growth beyond that provided by pest control, possibly due to warmer night soil temperatures, additional available soil moisture, more even soil moisture, and increased (reflected) light levels.

Reflective mulch is most effective during early growth when plants are small. As plants grow larger, reflective mulch becomes less effective and other management methods may be warranted. Reflective mulches cease to repel insects when the plant canopy covers more than about 60% of the soil surface. Note that working around reflective mulches can be annoying to workers and require protective eyewear.

Transplant through holes in the mulch or apply the mulch before seeded plants emerge from the soil by leaving a thin mulch-free strip of soil along the planting row. Reflective mesh is also available for application over the top of a crop; light-weight material is lifted as plants grow. Various materials, such as plastic (polyethylene or nylon) film, can be used. Silver or gray are the most effective colors for reflective mulch or mesh. White also works, but may not sufficiently suppress weed growth beneath it. Commercially available products include aluminum-metalized or silver embossed polyethylene. Aluminum foil is also effective, but it is expensive, delicate to handle, and not economically feasible on a large scale. Reflective material can also be sprayed onto planting beds.

MANAGING PESTICIDE RESISTANCE (01/22)

Pesticide resistance can develop over time when pesticides with the same mode of action (same way of affecting pests) are repeatedly applied in the same area. Resistance occurs when a pesticide exhibits reduced effectiveness or no longer controls the pest population at the formerly effective rate. If the pesticide or others with the same mode of action continue to be applied, eventually not even higher rates or more frequent applications provide control. At this point the pest population becomes dominated by individuals that are not susceptible to pesticides of that particular chemical class or mode of action.

Pesticide mode-of-action codes are listed on the label of many trade-name products. The codes are assigned for

- bactericides, fungicides, and oomycides by the Fungicide Resistance Action Committee (FRAC)
- herbicides and plant growth regulators by the Herbicide Resistance Action Committee (HRAC) and Weed Science Society of America
- insecticides, miticides (acaricides), nematicides, and molluscicides by the Insecticide Resistance Action Committee (IRAC)

Manage pesticide resistance using strategies that include avoid, delay, learn, and reverse:

1. **Avoid** the development of pesticide resistance by using integrated pest management (IPM), which employs a combination of control methods and commonly reduces reliance on pesticides.
2. **Delay** resistance by using pesticides only when needed, as indicated by monitoring and using action thresholds when available. Make an application only when pests are present at the life stage(s) susceptible to that particular product. Do not apply pesticides on a regular schedule regardless of monitoring results or thresholds.
3. **Learn** the mode of action, the physiological way target organisms are killed, for the products you use. Do not make more than two consecutive applications of pesticides with the same mode of action even when allowed by the label. Alternate (rotate) applications between pesticides with different modes of action, which are generally those from different chemical classes (e.g., *Bacillus thuringiensis*, *Beauveria bassiana*, carbamates, chitin synthesis inhibitors, neonicotinoids, organophosphates, pyrethroids, etc.).
4. **Reverse** resistance in some instances by not applying for an extended time any pesticides with a mode of action that is known or suspected of becoming less effective because of resistance development. Suspending use of certain products for several generations of a pest's development may cause pesticide-resistant individuals to become less prevalent and pesticide-susceptible individuals to become relatively more abundant in the local pest populations. For more information see *What Is Integrated Pest Management (IPM)?*

KEY PRACTICES OF RESISTANCE MANAGEMENT

Ask your University of California Cooperative Extension county advisor how to establish an IPM program and consult University of California publications such as *Container Nursery Production and Business Management Manual*; *Integrated Pest Management for Floriculture and Nurseries*; *Retail Garden Center Manual*; and *Water, Root Media, and Nutrient Management for Greenhouse Crops*. Minimize pesticide use, and employ only nonchemical practices when these are sufficiently effective. Avoid tank mixes (applications of multiple insecticides simultaneously); this advice is for insects and mites and differs from management of plant pathogens and weeds where mixes commonly are recommended. Avoid and minimize use of persistent insecticides and miticides; residues persist and a single application can expose multiple generations of pests, which favors resistance development. Rotate applications among different modes of action.

Minimize pesticide use

Minimizing pesticide use is fundamental to resistance management. Periodic, informed monitoring (scouting) and keeping good records of pest presence, relative abundance, and damage will help you determine the need and best timing for pesticide application, improve management effectiveness, and help to reduce the total number of applications. Use nonchemical strategies, such as biological control, crop rotation, host-free periods, pest exclusion (e.g., screening), and weed control to reduce the need to frequently apply pesticides.

Avoid tank mixes

Avoid combinations (mixes) of two insecticides or miticides in a single application. Especially avoid mixing two with the same mode of action, such as the organophosphates acephate and malathion; this increases selection for resistant pests. Mixing pesticides with different modes of action sometimes provides

increased control, but this result is temporary and has the longer-term effect of increasing resistance development, and in multiple species of pest arthropods.

Applying two different types of insecticides may be warranted in particular situations, but consider avoiding unnecessary tank mixes. For example, insect growth regulators (IGRs) that control only immature stages might be combined with a product that affects adults. It might be possible to deliver these in different ways, such as applying the IGR as a foliar spray and the insecticide for adults as an aerosol; this provides rapid kill of adults but also little residual control. Using the adulticide in a different and minimally persistent way reduces its effect on immature stages targeted by the IGR. This approach reduces the selective pressure in comparison with the two pesticides applied together the same way.

Avoid persistent insecticides and miticides
Select pesticides with little or no residual activity when feasible. The longer a pesticide persists the more it favors development of resistant pest populations.

When application of a persistent pesticide is warranted, minimize the number of its applications. If monitoring and threshold levels suggest it is necessary, before reapplication consider other pesticides with different modes of action and little or no persistence. Also carefully consider the order and timing of applications. For example, if applying a neonicotinoid (e.g., acetamiprid, imidacloprid) to control whiteflies, avoid such application during early crop production because this prolongs exposure of whitefly populations to these persistent insecticides. Early in the crop cycle, rely on nonchemical management methods such as exclusion and sanitation, natural enemies, and selective and non-persistent pesticides such as botanicals, insect growth regulators, insecticidal soaps, microbials, and oils. Delay application of the neonicotinoid and other nonselective, persistent products until later during the crop. Note that the effectiveness of systemics applied to growing media or soil can be delayed while the pesticide is absorbed and moved (translocated) by plants, so applying too late can reduce effective control. For example imidacloprid (soil treatment) for whitely control in poinsettia should be applied no later than 3 weeks before color initiation.

Use long-term rotations
Resistance management for insects and mites, fungal pathogens, and weeds includes rotating applications among pesticide classes or modes of action. However, rotation strategies differ according to the targeted pest types. With fungicides, modes of action commonly are rotated every application, and more than one mode of action can be mixed together. Generally to help maintain pesticide efficacy with insecticides and miticides, rotate through different modes of action in successive generations and avoid more than two consecutive applications of the same mode of action. Some pesticide labels are even more restrictive.

Sometimes only one or very few pesticides are effective against a particular pest, and other available products are only marginally effective. In this case one strategy is to use less effective pesticides when marketed portions of the crop are less susceptible to damage or not present while pest numbers are relatively low. Reserve the more effective products for times when control must be most effective.

Diseases

(Section reviewed 11/20)

General Information

MANAGEMENT OF SOILBORNE PATHOGENS (11/20)

Soil is a reservoir for many plant pathogens and plants are under regular attack by these soilborne organisms. If inoculum levels are high enough and environmental conditions become favorable for infection, susceptible plants will develop disease. Soilborne pathogens are readily spread if infested soil or contaminated water moves into other fields or planting areas. Levels of soilborne pathogens, including bacteria, fungi, nematodes, and some viruses can be reduced in the soil by appropriate treatments.

Learn which pathogens attack the crop to be grown. Examine the crop regularly, at least weekly, for symptoms of disease or signs of pathogens.

To monitor for root diseases in floriculture and ornamental nurseries

- Select a few plants from different locations, remove plants from their containers, and gently scrape or wash away soil.
- Examine roots and crowns for discoloration, softness, shriveling, or other early indications of disease.
- Know what healthy roots look like so diseased roots can be detected early. Healthy root characteristics may change or be different depending on species, root age, or growing conditions.
- Look for discolored or wilted plants and fungal growths aboveground, which may indicate more advanced stages of disease.
- Use test kits in combination with other information to make good pest management decisions. Test kits are readily available for detecting *Phytophthora* pathogens infecting greenhouse and container-grown nursery plants. Agdia (Elkhart, IN) supplies simple immunological test kits that detect *Phytophthora* species in minutes. A positive detection can usually help with the diagnostic process and get you quickly on the path to managing the problem. Sometimes, however, a positive result might be deceiving because these tests are not entirely accurate and can occasionally react to certain *Pythium* or *Phytopythium* species. These latter two groups of species may or may not be the primary cause of root disease or even a problem at all. Some of these are soil microbes that only break down already dead material, and many we do not fully understand yet. A non-positive reaction of the immunological test might be deceiving also. Sometimes the tested root tissue may not have been sampled from infected root pieces, and certain *Phytophthora* species do not react with the tests.
- Send a sample of diseased plants and their roots to an appropriate laboratory to test for the presence and identification of pathogens. Proper diagnosis is vital to making the correct management decisions.

Understand the conditions and practices that promote disease and regularly examine for and remedy disease-promoting conditions and practices. Poor sanitation, inadequate drainage, and improper irrigation are the primary conditions that promote diseases of roots. Remove crop residue and old or low-quality plants that will not be marketed.

Soil Solarization

In warmer climatic areas, solarization has been effective for disinfesting containerized soil or growing medium, soil in cold frames, and soil in open fields.

For soil in containers

- Use either in bags or flats covered with transparent plastic or in layers 3- to 9-inches wide sandwiched between two sheets of plastic to solarize planting media. A double layer of plastic can increase soil temperature by up to 50°F.

- Monitor the temperature of the growing medium closely by placing a temperature-measuring probe into the center of the mass of the soil mix to ensure the temperature is high enough to control pests.
- In warmer areas of California, soil inside black plastic sleeves can reach 158°F (70°C) during solarization, equivalent to target temperatures for soil disinfestation by aerated steam. At this temperature, soil is effectively solarized within 30 minutes. At 140°F (60°C), soil is solarized in 1 hour.

In open fields, soil is more easily covered with a single layer of transparent plastic. Soil temperatures will be highest at the soil surface (first 12 inches). The plastic needs to be left in place for 4 to 6 weeks. For maximum effectiveness and treatment predictability, solarize open fields only in warmer climatic areas, unless previous testing has given consistently desirable results. The effectiveness of solarization, especially in cooler climatic areas, can be improved by adding various botanical products containing glucosinolates, such as mustard seed meal, broccoli, and cabbage. Solarization is acceptable where a non-chemical approach is desired.

Heat

Heating the soil is very effective and the soil can be used immediately after cooling, unlike chemically treated soil. Many plant pathogens are killed by short exposures to high temperatures. Most plant pathogens can be killed by temperatures of 140°F (60°C) for 30 minutes. However, some viruses such as *Tobacco mosaic virus* (TMV) may survive this treatment. Where weed seeds are a problem, a higher treatment temperature is required, and even then, some weed seeds may still survive.

Although pure steam at sea level is at 212°F (100°C), the temperature of the steam used to treat soil is usually about 180°F because of air that is present in the steam or soil being treated. If air is mixed with steam, the temperature of the steam-air mixture can be closely controlled, depending on the ratio of air to steam. It has been demonstrated that some diseases, such as *Rhizoctonia* damping-off, are much less severe in soil that has been treated at 140°F rather than at 180°F. Experience will tell the grower which temperature will best treat the soil, but as a starting point try 140°F (60°C) for 30 minutes.

If a cement mixer is used to heat a bulk quantity of soil, generally it is not necessary to introduce air into the steam because a large amount of air is present in the mixer and the temperature can be controlled by simply regulating the flow of steam. Expensive air blowers are not required for this method.

Steam heating of containers filled with soil in vaults likewise may not require the introduction of air into the steam to control the temperature. However, circulation within the vault is important to ensure even distribution of heat. Circulating fans can be located within, or external to, the vault and the steam can be introduced into the recirculating air. Leave space between the vaults and check temperatures throughout the vault to ensure that there is good circulation of steam air.

Soil Fumigants

Only three fumigants with very limited suitability for soil fumigation remain allowed in California. Registered fumigants are chloropicrin, 1,3-dichloropropene (1,3-D), and methyl isothiocyanate (MITC) generators such as metam sodium, metam potassium, and Basamid. However, these products have many statewide regulatory restrictions and are also subject to local regulations. In the absence of methyl bromide, the most promising registered fumigants are chloropicrin alone or chloropicrin mixed with 1,3-dichloropropene applied sequentially in combination with metam sodium or metam potassium. These fumigants can be applied to the raised beds through drip irrigation systems. In drip fumigation, it is critical to distribute the water evenly throughout the field and throughout the target soil treatment zone. Chloropicrin and 1,3-dichloropropene should not be applied simultaneously with metam sodium to avoid their rapid degradation in the irrigation water. Only certified applicators can apply fumigants.

Metam-sodium (Vapam), and dazomet (Basamid) alone are not very effective for controlling many soilborne pathogens, including *Verticillium* and *Fusarium oxysporum*. See the Activity of Soil Fumigants table for how effective each fumigant is against various types of pests.

Chloropicrin (trichloronitromethane) is the best fumigant for controlling *Verticillium dahliae*. In the past it was combined with methyl bromide in various mixtures depending upon the organisms in the soil. If used alone, a water seal may be used to confine the gas; however, the gas is very objectionable and irritating (it is commonly known as tear gas) and, if not effectively confined, it may drift to inhabited areas.

This is a restricted use material and requires a permit from the county Agricultural Commissioner to be purchased or applied.

Activity of soil fumigants.

Common name	Trade name	Activity against Nematodes	Fungi	Weeds
chloropicrin	TriClor	fair	excellent	poor
	TriClor EC	fair	excellent	fair*
1,3-dichloropropene	Telone II	fair	excellent	fair
1,3 dichloropropene plus chloropicrin	Telone C35	excellent	very good	fair
	InLine	excellent	excellent	good*
chloropicrin plus 1,3 dichloropropene	Pic-Clor60	excellent	excellent	good*
	Pic-Clor60EC	excellent	excellent	good*
metam sodium	Vapam HL	good	good	good
	Sectagon 42	good	good	good
metam potassium	K-Pam HL	good	good	good
	Sectagon-K54	good	good	good
dazomet	Basamid	good	good	good

* Using high rates or retentive plastic mulch (especially totally impermeable film) improves weed control.

Soil Fungicides

Some fungicides work best if incorporated before planting. Others may be incorporated or applied after sowing or planting. Some soil fungicides control a narrow range of organisms while others control a wide range of organisms. Some of the narrow range chemicals are the most effective in controlling a specific organism. Combinations are used to increase the number of organisms controlled.

The Examples of Conventional and Biological Fungicides table is not a complete list of available and active fungicides against soilborne pathogens. It provides examples of conventional and biological fungicides.

Examples of conventional and biological fungicides.

Common name (Example trade name)	Alternaria and Phomopsis wilt	Black root rot	Cottony rot	*Cylindrocladium* spp.	Damping-off	Foliar downy mildew	*Fusarium* sp.	Penicillium blue mold	*Phytophthora*	*Pythium*	*Rhizoctonia*	Root & stem rot	*Sclerotinia*	*Sclerotium rolfsii*	Seed rot
Salts or esters of phosphorous acid (Aliette)									C	P					
Gliocladium virens (SoilGard)										C	C				
Iprodione (Chipco 26019)											C		C		
Mefenoxam (Subdue Maxx)						C			C	C					
PCNB - pentachloronitrobenzene or quintozene (Terraclor)									N	N	C		C	C	
Streptomyces griseoviridis (Mycostop)	C				C				P[1]	P[1]	P[1]	C			C
Thiabendazole (Mertect)							C[2]	C[2]							
Thiophanate-methyl (Talaris)		C	C	C			N		N	N	C			N	

Trichoderma spp. (RootShield)							C			C	C				
Triflumizole (TerraGuard)				C											

C = control; P = partial control/suppression; N = no control

[1] In the greenhouse it may suppress root rots of *Pythium, Phytophthora,* and *Rhizoctonia.*

[2] Used for bulb or corm dips to control Fusarium basal rot and Penicillium blue mold

Seed Treatments

Streptomyces griseoviridis (Mycostop) is used as a seed treatment for damping-off and early root rots for ornamentals planted in fields or greenhouse. Captan is also a seed treatment, but offers only a limited protection.

Treatment of Containers and Equipment

Debris, soil, and plant material cling to containers and equipment; thoroughly wash equipment to remove all soil or planting mix particles. Heat treatment is effective in killing the plant pathogens that adhere to containers or that are in the debris. Where steam is not available, hot water or solarization can be very effective. Most plastic can be treated with hot water at temperatures that cause minimal softening. The minimum water temperature should be 140°F (60°C) whenever possible. Treatment time can be as short as 1 minute. Longer treatment times are more reliable, and the container or equipment must reach at least 140°F (60°C). For solarization, containers should be moistened, stacked, and placed beneath a double-layer tent. Incubate for 30 minutes at or above 158°F (70°C), or 1 hour at or above 140°F (60°C).

Sodium hypochlorite (the active ingredient in bleach) is effective in killing most types of fungal spores and bacteria. However, it penetrates clinging soil and plant material very poorly. It is effective only as a surface disinfectant, so containers, tools, etc. must be free of soil and plant material and clean before treatment. Sodium hypochlorite is generally used as a surface disinfectant at 0.5%. To achieve this concentration of sodium hypochlorite, household bleach can be diluted 1 part bleach to 9 parts water. For known contaminated materials, a stronger solution diluted 1 part bleach to 4 parts water (1% sodium hypochlorite), may be more effective in killing pathogens. Allow the solution to be in contact with nonporous materials for a minimum of 5 to 10 minutes, then rinse well with clean water to remove bleach and avoid phytotoxicity. Bleach dilutions must be made fresh each day because once diluted, the effectiveness of the solution diminishes over time (50% loss occurs every 2 hours). Debris, potting mix, and other residues left over in bleach washes will also greatly reduce bleach concentration and effectiveness.

Quaternary ammonia compounds are excellent bactericides and viricides and are effective in killing some kinds of fungal spores. They penetrate plant material and soil poorly, so containers, tools, etc. must be clean before treatment.

GENERAL PROPERTIES OF FUNGICIDES (11/20)

Common name (trade name)	Chemical class	Activity	Mode of action[1]	Resistance potential	Comments
ametoctradin/dimethomorph (Orvego)	QoSI/carboxylic acid amides	systemic (local)	45/40	low	
azoxystrobin (Heritage)	QoI[2]	single-site	11	high	
boscalid/pyraclostrobin (Pageant)	carboximide/QoI[2]	multi-site	7/11	medium	resistance to FRAC 7 has been documented
Captan (Captan)	phthalimides	multi-site (contact)	M 04	low	
chlorothalonil (Daconil)	chloronitrile	multi-site	M 05	low	
cyazofamid (Segway)	cyanoimidazole	contact	21	—	resistance risk unknown, but assumed to be medium to high
cyprodinil/fludioxonil (Palladium)	anilinopyrimide/phenylpyrrole	contact	9/12	low to medium	
dicloran (Botran)	aromatic hydrocarbon	systemic (local)	14	medium	
dimethomorph (Stature)	carboxylic acid amines	—	40	low-medium	
etridiazole (Terrazole CA)	heteroaromatic	—	14	low-medium	
fenamidone (Fenstop)	QoI[2]-imidazolinones	contact	11	high	cross-resistance to fungicides of QoI group documented
fenhexamid (Decree)	hydroxyanilide	—	17	low-medium	
fixed copper (Kocide)	inorganic	multi-site	M 01	low	
fludioxonil (Medallion)	phenylpyrroles	—	12	low-medium	
fluopicolide (Adorn)	pyridinylmethyl-benzamides	systemic (locally)	43	low	
fluoxastrobin (Disarm)	QoI[2]–dihydro-dioxazines	systemic	11	high	cross-resistance to fungicides of QoI group documented
flutolanil (Prostar)	succinate-dehydrogenase inhibitor	—	7	medium	
Gliocladium virens (SoilGard)	biological	—	NC	low	
iprodione (Chipco 26019 N/G)	dicarboximide	multi-site	2	medium-high	
lime sulfur	inorganic	multi-site	M 02	low	incompatible with most other pesticides
mancozeb (Dithane)	dithio-carbamate (EBDC)[4]	multi-site	M 03	low	
mandipropamid (Micora)	mandelic acid amides	—	40	low to medium	
mefenoxam (Subdue Maxx)	acylalanine	single-site	4	high	
myclobutanil (Rally)	DMI[3]-triazole	single-site	3	medium	
neem oil (Triact)	oil	—	NC	none	
PCNB (Terraclor)	aromatic hydrocarbon	single-site	14	low-medium	
piperalin (Pipron)	amines	—	5	low-medium	
potassium bicarbonate (Kaligreen)	inorganic	—	NC	none	
propiconazole (Banner Maxx)	DMI[3]-triazole	single-site	3	medium	
Reynoutria sachalinensis - knotweed, plant extract (Regalia)	biological	—	NC	low	
Salts or esters of phosphorous acid (Aliette)	phosphonate	multi-site	P 07	low	
Streptomyces griseoviridis (Mycostop	biological	—	BM 02	low	
stylet oil (JMS)	oil	—	NC	none	
tebuconazole (Torque)	DMI[3]–triazole	single–site	3	medium	Resistance is known in several fungal species, cross-resistance is present in DMI–group
thiabendazole (Mertect)	benzimidazole	single-site	1	high	

thiophanate-methyl (Talaris)	thiophanate	single-site	1	high
triadimefon (Bayleton)	DMI[3]-triazole	single-site	3	medium
Trichoderma spp. (RootShield)	biological	—	BM 02	low
trifloxystrobin (Compass O)	QoI[2]	single-site	11	high
triflumizole (TerraGuard)	DMI[3]-imidazole	single-site	3	medium
wettable sulfur	inorganic	multi-site	M 02	low

— = no information

NC = not classified

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions (for more information, see http://frac.info/). Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action group number.

2 QoI = quinone outside inhibitor

3 DMI = demethylation (sterol) inhibitor

4 EBD = ethylene bisdithiocarbamate

C

Key Diseases

ARMILLARIA ROOT ROT (OAK ROOT FUNGUS) (11/20)

Armillaria mellea and other species

SYMPTOMS AND SIGNS

Infected field-grown plants can be stunted, show poor growth, have smaller than normal leaves, and can have other symptoms associated with diseased roots and crowns. Eventually, foliage will wilt, turn brown, and die. The disease usually results in the complete collapse and death of the plant. Diseased crowns and main roots will have white to cream-colored fan-shaped mycelial mats, growing underneath the outer tissues. Dark brown to black stringy mycelial structures (rhizomorphs) are rarely seen on the root surface.

COMMENTS ON THE DISEASES

Armillaria mellea is a soilborne pathogen that is only found in field soil. The fungus survives on dead roots left in the ground. Woody crops, planted in areas that were formerly oak woodland, can become infected many years after infested oaks were removed. The fungus can spread from one plant to another through the contact of diseased roots with healthy roots. Wet soil conditions resulting from heavy rainfall or excessive irrigations can exacerbate the disease. Under suitable conditions, the mushroom stage of the fungus can emerge from buried diseased roots. The mushroom is large (cap diameter up to 6 inches wide), has a cap with variable coloration (yellow, tan, honey-colored, brown), and bears typical radiating gills with white spores.

MANAGEMENT

For field grown ornamental crops the only treatment is fumigation. Before chemical treatment, remove all infected plants and as many large roots as possible. Complete eradication is rarely achieved, and retreatment may be necessary in localized areas. If the soil is wet or if it has extensive clay layers to the depths reached by the roots, fumigant treatment may not be successful. Other management options include rotating crops and planting ornamentals that are not hosts to this pathogen.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

SOIL FUMIGATION

A.	CHLOROPICRIN*§	Label rates	See label
	COMMENTS: Inject into soil and cover immediately with plastic tarps. Fumigants are a source of volatile organic compounds (VOCs) but are not reactive with other air contaminants that form ozone.		
B.	***Sequential application of:*** (***Note:*** *Fumigants such as 1,3-dichloropropene and metam products are a source of volatile organic compounds (VOCs) but minimally reactive with other air contaminants that form ozone.*		
	CHLOROPICRIN*§/1,3 DICHLOROPROPENE*§		
	(Pic-Clor60)	300–332 lb (shank)	See label
	(Pic-Clor60 EC)	200–300 lb	See label
	COMMENTS: Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed control. For drip fumigation the use of VIF will improve both nematode and weed control. According to state permit conditions, the maximum application rate of 1,3-dichloropropene is 332 pounds active ingredient per acre. Pic-Clor60: One gallon of weighs 12.1 lb; Pic-Clor60 EC: One gallon of weighs 11.8 lb.		

Following 5–7 days after fumigation:

METAM SODIUM*§
(Vapam HL, Sectagon 42) 37.5–75 gal See label
COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 4.26 lb of metam sodium.

. . . or . . .

METAM POTASSIUM*§
(K-Pam HL, Sectagon–K54) 30–45 gal See label
COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium.

. . . or . . .

DAZOMET*§
(Basamid) 200 lb See label
COMMENTS: Powder incorporated into the soil, followed by irrigation or tarping. It decomposes to a gaseous fumigant (methyl isothiocyanate).

* Permit required from county agricultural commissioner for purchase or use.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action group number.

§ Do not exceed the maximum rates allowed under the California Code of Regulations Restricted Materials Use Requirements, which may be lower than maximum label rates.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

ASTER YELLOWS (11/20)

Aster yellows phytoplasma

SYMPTOMS AND SIGNS

Symptoms of aster yellows includes yellowing, dwarfed or distorted foliage, and the abnormal production of shoots. Flowers may not develop normally and are often replaced by green leafy structures. Aster yellows symptoms may closely resemble those caused by viruses.

COMMENTS ON THE DISEASE

Aster yellows is caused by a microscopic organism called a phytoplasma. Phytoplasmas are closely related to bacteria but are somewhat smaller in size and do not have a rigid cell wall.

Initially, the aster yellows phytoplasma was thought to be a virus. Phytoplasmas are vectored by leafhoppers, plant hoppers, and psyllids and invade the phloem of infected plants. The aster yellows phytoplasma is vectored by leafhoppers, in which it can multiply. It has a very wide host range, which includes many ornamentals, food crops, and weeds.

MANAGEMENT

Aster yellows is difficult to control, in part, because of the extensive host range of the pathogen. Over 300 species of food, forage, ornamental, and weed plants are susceptible. While weed management should be practiced, this will have little effect on aster yellows. Plant pathogen-free plants and use good sanitation. Remove and destroy infected plants. There are no chemical controls for the aster yellows phytoplasma. Control of the leafhopper vector could reduce transmission of the phytoplasma.

EXAMPLES OF HOSTS OF ASTER YELLOWS PHYTOPLASMA

Ornamental hosts	Crop plant hosts	Weeds and native plant hosts
alyssum, calceolaria, calendula, China aster, chrysanthemum, cineraria, daisies, delphinium, gladiolus, gloxinia, gypsophila, larkspur, petunia, statice, sweet william, tagetes, veronica, zinnia, and many others	buckwheat, carrots, celery, lettuce, onion, parsley, parsnip, potato, safflower, spinach, tomato, and many others	California poppy, dandelion, plantain, and many others

BACTERIAL LEAF SPOTS, BLIGHTS, CANKERS, AND ROTS

(11/20)

Bacterial blight of chrysanthemum: *Dickeya* (=*Erwinia*) *chrysanthemi*
Bacterial blight of geranium: *Xanthomonas axonopodis* pv. *pelargonii* (formerly *X. campestris* pv. *pelargonii)*
Bacterial leaf spot of begonia: *Xanthomonas axonopodis* pv. *begoniae* (formerly *X. campestris* pv. *begoniae*)
Bacterial leaf spot of poinsettia: *Curtobacterium flaccumfaciens* pv. *poinsettiae*
Bacterial wilt of carnation: *Burkholderia* (=*Pseudomonas) caryophylli*
Black leaf spot of delphinium: *Pseudomonas syringae* pv. *delphinii*

SYMPTOMS AND SIGNS

Foliar diseases caused by plant pathogenic bacteria result in a wide range of symptoms that vary greatly depending on the particular pathogen and the host plant. Leaf spots (also called leaf lesions) are discrete diseased sections of leaves that initially appear water-soaked, but later turn yellow, brown, or black. Leaf spots are usually angular in shape and bordered by the veins in the leaf. Leaf petioles can also develop such spots. Merging of numerous leaf spots results in the infection of large portions of the foliage; such symptoms are called blights. Rots occur when the bacteria infect fleshy stems, crown, bulbs, corms, and other parts of plants and cause a soft, watery decay. Infections on twigs and branches can cause cankers, which are sunken, discolored, and cracked areas in the woody tissue. In some cases, bacteria inside the diseased tissue will ooze to the surface of the plant and are visible as cream to yellow colored exudates, collecting outside the plant.

COMMENTS ON THE DISEASES

There are many different kinds of bacterial diseases of flower and nursery crops. In many cases these bacteria are host specific and will only infect one plant species. In other cases, for example with soft rot bacteria, the pathogen is able to infect a larger number of plant hosts. All bacteria in this section can be spread through infected cuttings and other propagative material, and some of these bacteria may be carried in seed and irrigation water. Bacteria are dependent on splashing water for their dispersal and for creating a suitable environment for infection and disease development.

MANAGEMENT

Use pathogen- and disease-free seed, cuttings, transplants, and other propagative materials.

- Implement sanitation measures when dealing with containers, flats, benches, pruning tools, and other items that come in contact with plants.
- Avoid using overhead sprinkler irrigation.
- Rogue out (remove) diseased cuttings, transplants, and plants.
- Sanitize hands or use disposable gloves when handling diseased plants.
- Prevent injuring bulbs, corms, and other fleshy parts of plants to avoid soft rot problems.

Copper-based fungicides may provide some control but can be phytotoxic to some ornamentals.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. FIXED COPPER
(Kocide 2000)# — Label rates — 48
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M 01)
COMMENTS: A protectant fungicide. Growth of some plants may be reduced by this material; follow label directions carefully to reduce the risk of phytotoxicity. Check label for registered use ornamental species list in California. Not all copper compounds are approved for use in organic production; be sure to check individual products.

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of actions. Fungicides with a different group number are suitable to alternate in a resistance management program. In

California, make no more than one application of fungicides with mode of action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action group number.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

Acceptable for use on organically grown ornamentals. Check with your certifier.

BLACK ROOT ROT (11/20)

Thielaviopsis basicola

SYMPTOMS AND SIGNS

Black root rot is also called Thielaviopsis root rot. Plants are stunted and grow poorly. Infected roots may initially have small dark brown to black bands where infection has taken place. As the disease progresses, roots can become badly rotted. Stems below ground may enlarge and develop black, rough, longitudinal cracks. Characteristic dark brown to black, thick-walled, barrel-shaped chlamydospores form in infected tissues and may be visible under magnification.

COMMENTS ON THE DISEASE

The fungus has a wide host range: 120 species in 15 families are known to be susceptible. Strains of the fungus are known that differ in pathogenicity and virulence. Important ornamental hosts include begonia, cyclamen, geranium, gerbera, kalanchoe, pansy, petunia, poinsettia, primula, snapdragon, sweet pea, verbena, and viola. The disease is favored by wet, cool soil and any condition that weakens plants; it is most severe from 55° to 61°F, while only a trace of disease develops at 86°F. Alkaline soil favors the disease, which can be prevented at pH 4.8 and greatly reduced at pH 5.5 or below. However, many plants do not grow well under such acidic conditions.

The fungus is soilborne and capable of prolonged survival in the absence of susceptible plants. Two kinds of spores are formed:

- barrel-shaped chlamydospores (resting spores) in short chains of three to seven and
- rectangular-shaped endoconidia.

The fungus can be spread in water, soil, by infected plants or vectored by fungus gnats and shore flies. Some sources of peat are known to harbor *Thielaviopsis* spores.

MANAGEMENT

Use appropriate sanitation measures to prevent spread of the pathogen via diseased plant material, contaminated soil mixes and containers, and contaminated water runoff. The use of pathogen-free plants, along with improved sanitation and cultural practices, has reduced the importance of this disease, which at one time was widespread, especially in poinsettias. The fungus can still be troublesome in field-grown flowers. The benzimidazole fungicides such as thiophanate-methyl are very active against the fungus and are used as soil treatments to control it.

To treat container media, steam (at 140°F for 30 minutes), or solarize (double-tent at 160°F for 30 minutes or 140°F for 1 hour). For flower production in outdoor fields, solarization in warmer climates has been successful for control of *Thielaviopsis* in many crops. Solarization and steaming are acceptable for organic production. For more information, see MANAGEMENT OF SOILBORNE PATHOGENS.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. THIOPHANATE-METHYL
(Talaris 4.5 F) — 20 fl oz/100 gal water — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Methyl benzimidazole (1)
COMMENTS: Apply as a drench or heavy spray. Generally applied after sowing. Absorbed by plant parts exposed to the chemical. Roots may absorb the fungicide (or its breakdown product carbendazim), which moves in the xylem to transpiring leaves.

B. TRIFLUMIZOLE
(TerraGuard SC) — 2–8 fl oz/100 gal water — 12

MODE OF ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)
COMMENTS: Apply as a cutting soak or soil drench at 3 to 4 week intervals as needed on potted plants. A protectant fungicide; use is restricted to enclosed commercial structures such as greenhouses and shade houses.

C.	FLUDIOXONIL (Medallion WDG)	Label rates	12

MODE OF ACTION GROUP NAME (NUMBER[1]): Phenylpyrroles (12)

[1] Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action group number.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

Cottony Rot (11/20)

Sclerotinia sclerotiorum

SYMPTOMS AND SIGNS

Under high humidity the fungus produces a mass of white cottony mycelia on the soil or plant surface. Later, large (1/4 to 1 inch long), black sclerotia (hard, dark masses of hyphae) are formed on and inside infected plant parts. Frequently the sclerotia are found inside hollow stems. Plant tissues killed by the fungus often take on a bleached appearance. Gray mold (*Botrytis cinerea*) causes a similar bleaching and also has black sclerotia, but they are much smaller than those of *Sclerotinia*. Additionally, *Botrytis* produces gray mycelium and spores instead of the mass of white, cottony growth that *Sclerotinia* does.

COMMENTS ON THE DISEASE

Cottony rot, also called Sclerotinia rot or white mold, affects many kinds of plants. It is also a disease of vegetables, such as beans, carrots, celery, and lettuce. Moisture and high humidity are necessary for development of the disease and this is one reason the disease is found lower in the plant canopy. Infection can either be soilborne or airborne.

Sclerotinia sclerotiorum does not produce asexual conidia. Sclerotia formed by the fungus undergo a dormant period that is broken by low temperatures (optimal is 56° to 59°F) and high soil moisture. In fall and spring, when temperatures are in the optimal range, sclerotia germinate and can infect the plant near the soil line either directly by producing vegetative strands (hyphae) or by forming apothecia (saucer-shaped, dime-sized structures on stalks) that produce ascospores (sexual spores). Ascospores are discharged forcibly into the air and are carried by air currents. They do not directly infect healthy tissue, but if they land on injured tissue in the presence of moisture, infection can occur on any aboveground part. Flower petals of many plants are susceptible. Foliage may become infected if there is an injury or if the tissue is senescent. If diseased tissue comes in contact with healthy tissue, the fungus can invade the healthy tissue.

MANAGEMENT

Protective fungicides, as well as steaming (at 140°F for 30 minutes), solarization (double-tent at 160°F for 30 minutes or 140°F for 1 hour), or fumigation of the growing medium can be helpful. For flower production in open fields, solarization in warmer climates has been successful for control of *Sclerotinia* diseases in many crops. Solarization and steaming are acceptable for organic production. In open fields airborne spores can blow in from outside the field, so soil treatment may be limited in its effectiveness.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. BOSCALID/PYRACLOSTROBIN
(Pageant) 12–18 oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Carboximide (7) and quinone outside inhibitor (11)

B. CYPRODINIL/FLUDIOXONIL
(Palladium) 2–4 oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Amino acids and protein synthesis (9) and signal transduction (12)

C. IPRODIONE
(Chipco 26019 N/G) 6.5 oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Dicarboximide (2)
COMMENTS: Apply as a drench (1–2 pt/sq ft) at seeding or transplanting. Effective against Rhizoctonia damping-off and *Sclerotinia*. Some iprodione is absorbed by plant parts.

D. PCNB
(Terraclor 400) Label rates 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Aromatic hydrocarbon (14)
COMMENTS: Inhibits germination of sclerotia when incorporated into top two inches of soil. Insoluble in water. Must be thoroughly mixed with soil to reach its desired depth of control. Works through vapor action and has good residual action. Germination of some seeds may be inhibited and small plants may be stunted by this fungicide.

E. THIOPHANATE-METHYL
(Talaris 4.5 F) 20 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Methyl benzimidazole (1)
COMMENTS: Apply as a drench or heavy spray (1–2 pt/sq ft) after sowing. Absorbed by plant parts exposed to the chemical. Roots may absorb the fungicide (or its breakdown product carbendazim), which moves in the xylem to transpiring leaves.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action group number.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

CROWN GALL (11/20)

Agrobacterium tumefaciens

SYMPTOMS AND SIGNS

Crown gall is caused by a bacterium that produces galls at the base of the stem, root crown or on other plant parts. The bacterium infects only through fresh wounds. If infected at a young age, plants may be stunted and not grow properly.

COMMENTS ON THE DISEASE

A wide variety of both woody and herbaceous plants are susceptible. The disease is most damaging to trees because the galls are perennial and increase in size with growth of the tree. Galls may occur on roots, stems, and even leaves. Aerial galls are common on grapes and caneberries. Under moist conditions aerial galls are often seen on chrysanthemum. The disease may have further impact on growers, because regulations prohibit the sale of some plant materials infected with crown gall.

Gall tissue is disorganized growth with an enlarged cambium layer and irregular vascular tissue. Movement of water and nutrients is severely impaired by galls. The early stages of gall formation can be difficult to distinguish from normal callus tissue. Isolation of the pathogenic bacterium is the most common method of confirming that the bacterium is present. Callus tissue, which is soft and easily wounded, can be a common site of infection.

The bacterium *Agrobacterium tumefaciens* is common in many agricultural soils. When the plant is wounded, the bacterium attaches to an exposed plant cell and transfers a portion of its genetic material, DNA (deoxyribonucleic acid), into the cell where it is incorporated into the genetic material of the host cell. The host cell is induced to become a tumor cell and also to produce a unique substance (opine) that only the crown gall bacterium can readily utilize. *Agrobacterium tumefaciens* is then able to multiply between cells and in cracks of the gall with somewhat less competition from other microorganisms.

MANAGEMENT

The only useful method of treating soil for crown gall pathogen is with heat. The common soil fumigants reduce the amount of bacteria but do not result in satisfactory control of the disease. Steam (at 140°F for 30 minutes) or solarize (double-tent at 160°F for 30 minutes or 140°F for 1 hour) the soil. For flower production in open fields, solarization in warmer climates has been successful for control of crown gall. Steaming and solarization are acceptable for organic production.

Sanitation is very important in a control program, especially where cuttings are produced. Rose propagative material and work areas are often soaked or cleaned with hypochlorite solution to kill any bacteria that may be present on the surface. Grape propagative material, and perhaps some others, have also been treated in this manner. In some plants, such as grape, the bacterium may occasionally enter the xylem. Cuttings taken from such plants may develop crown galls.

Tools and surfaces that contact the propagative material should be cleaned and periodically treated with a disinfectant.

Monitoring and Treatment Decisions

The K-84 strain of *Agrobacterium tumefaciens* (formerly *A. radiobacter*), which is available for use in preventing infection by the crown gall pathogen, is an excellent biological control agent.

Galls on many woody plants can be treated with a mixture of chemicals that are toxic to and kill crown gall tissue but are safe on uninfected woody tissue. The mixture, which is currently marketed under the name Gallex, was previously sold as Bacticin. It has been used with success on rose crown galls.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A.	*AGROBACTERIUM TUMEFACIENS* K-84		
	(Galltrol)#	Label rates	4
	. . . or . . .		
	AGROBACTERIUM TUMEFACIENS K-1026		
	(Nogall)	Label rates	4
	COMMENTS: Products may list bioagent under former name *A. radiobacter.* Prevents infection by the crown gall pathogen if it is applied to fresh wounds. It must be applied as soon as possible after wounding; i.e., within 24 hours. It has been used with success on *Prunus* spp. and *Rosa* spp.		
B.	2,4-XYLENOL/META-CRESOL		
	(Gallex)	Label rates	24
	COMMENTS: For killing of existing galls; apply directly to galls winter through spring.		

Acceptable for use on organically grown ornamentals.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

DAMPING-OFF (11/20)

Damping-off: *Pythium* spp., *Rhizoctonia solani*, and others

SYMPTOMS AND SIGNS

Emerging seedlings rot at or below the soil line and are killed. Some seedlings may be infected before emergence and therefore not appear above ground. If the problem is caused by *Pythium*, it usually begins at the root tips. Damping-off pathogens can also infect planted seeds and cause death of the seed before it germinates.

COMMENTS ON THE DISEASE

Damping-off is the name given to seedling diseases most often caused by fungi and oomycetes (fungus-like organisms). As the name implies, the disease is associated with damp conditions. Some *Pythium* species are favored by cool, wet conditions, but *Rhizoctonia* and other *Pythium* species can cause disease under drier and warmer conditions.

MANAGEMENT

Vigorous seedlings grown from the best seed under ideal light and temperature conditions may survive in the presence of these fungi, while seedlings low in vigor will succumb under unfavorable conditions. Damping-off can be minimized by providing good drainage (raised beds, properly graded fields), careful irrigation, planting when soil and air temperatures are favorable for rapid seedling emergence, proper depth and spacing of planting, seed treatments, and drenches of soil fungicides. For more information, see MANAGEMENT OF SOILBORNE PATHOGENS.

For container media, steam (at 140°F for 30 minutes) or solarize (double-tent at 160°F for 30 minutes or 140°F at 1 hour). For flower production in open fields, solarization in warmer climates has been successful for control of damping-off in many crops. Reports of inadequate control of some high temperature species (e.g., *P. aphanidermatum*) have been made. Solarization and steaming are acceptable for organic production.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

SEED TREATMENT

A. *STREPTOMYCES GRISEOVIRIDIS*
(Mycostop)# — 0.08 oz/lb of seed — 4
MODE OF ACTION GROUP NAME (NUMBER[1]): Microbial (BM 02)
COMMENTS: For control of seed rots, root and stem rots, and wilt diseases of ornamental crops caused by *Alternaria*, *Fusarium*, and *Phomopsis*. Suppresses also *Botrytis*, *Pythium*, and *Phytophthora*. May be used for both field-grown and greenhouse ornamentals.

SOIL FUNGICIDE – Pythium spp.

A. CYAZOFAMID
(Segway) — 1.5–3.0 fl oz/100 gal water — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone inside inhibitor (21)
COMMENTS: Toxic to aquatic organisms.

B. FENAMIDONE
(Fenstop) — 7–14 fl oz/50–100 gal water — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Toxic to aquatic organisms.

C. FLUOPICOLIDE
(Adorn) — 1–4 fl oz/100 gal water — 12

MODE OF ACTION GROUP NAME (NUMBER[1]): Benzamides (43)
COMMENTS: Toxic to aquatic organisms.

D. MEFENOXAM
(Subdue Maxx) Label rates 48
MODE OF ACTION GROUP NAME (NUMBER[1]): Phenylamide (4)
COMMENTS: Applied at planting as a drench and periodically thereafter as needed. Available also in a granular formulation to use before planting. It is water-soluble and readily leached from soil. It is absorbed primarily through roots and is translocated in the plant through the xylem. Use of this material over a period of time may lead to resistance.

SOIL FUNGICIDE – Rhizoctonia solani

A. FLUDIOXONIL
(Medallion WDG) Label rates 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Phenylpyrroles (12)

B. IPRODIONE
(Chipco 26019 N/G) 6.5 oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Dicarboximide (2)
COMMENTS: Apply as a drench at seeding at the rate of 1–2 pt/sq ft

C. FLUTOLANIL
(Prostar 70 WG) 3–6 oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Succinate-dehydrogenase inhibitor (7)

D. PCNB
(Terraclor 400) Label rates 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Aromatic hydrocarbon (14)
COMMENTS: Insoluble in water. Must be thoroughly mixed into the top 2 inches of soil to reach its desired depth of control. It works through vapor action and has good residual action. Germination of some seeds may be inhibited, and small plants may be stunted by this fungicide.

E. THIOPHANATE-METHYL
(Talaris 4.5 F) 20 fl oz/100 gal for 800 sq ft bench area 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Methyl benzimidazole (1)
COMMENTS: Generally applied after sowing, as a drench or heavy spray. Thiophanate-methyl is absorbed by plant parts exposed to the chemical. Roots may absorb the fungicide (or its breakdown product carbendazim), which moves in the xylem to transpiring leaves.

F. TRIFLUMIZOLE
(TerraGuard SC) 4–8 fl oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)
COMMENTS: For use in enclosed commercial structures only; less effective against *Rhizoctonia* than other materials. Apply as a soil drench at 3 to 4 week intervals as needed.

SOIL FUNGICIDE – Pythium spp. and Rhizoctonia solani

A. BOSCALID/PYRACLOSTROBIN
(Pageant) 12–18 oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Carboximide (7) and quinone outside inhibitor (11)

B. *TRICHODERMA* spp.
(RootShield)# Label rates NA
MODE OF ACTION GROUP NAME (NUMBER[1]): microbial (BM 02)
COMMENTS: Formulated as a seed protectant, a soil drench, and as granules. This biological fungicide may provide some protection against both *Pythium* and *Rhizoctonia.*

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Acceptable for use on organically grown ornamentals.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

NA Not applicable.

DOWNY MILDEW (11/20)

Downy Mildew: *Bremia* sp., *Peronospora* spp., *Plasmopara* spp.

SYMPTOMS AND SIGNS

The name downy mildew is somewhat descriptive of the fluffy appearance of the white, lavender, or purple sporulation that occurs usually on the undersides of diseased leaves. Downy mildew leaf lesions are often angular in shape and delimited by veins. Paleyellow, purple, or necrotic areas often are visible from the upper side of the leaf. Extensive disease can result in the death of large portions of the leaves.

In some plants, when young shoots are infected, the fungus may become systemic and the resultant growth is stunted, malformed, and discolored.

COMMENTS ON THE DISEASE

In contrast to powdery mildews, the downy mildews require very wet or humid conditions to flourish. Water is required for infection, and humidity above 90% is needed for sporulation. Growth of the pathogens is favored by cool temperatures.

Downy mildew spores are usually short-lived, although they may survive several days under cool, moist conditions. They are airborne, and when they land on a susceptible plant with free water present, germination and infection generally occur within 8 to 12 hours. Some downy mildews also produce a sexual spore (oospore) that can survive dry conditions. This enables the pathogen to survive in the absence of a host. Downy mildews are favored by moist and cool conditions (40° to 60°F).

MANAGEMENT

Use varieties resistant to downy mildew. Avoid sprinkler irrigation and reduce relative humidity in greenhouses. Fungicide treatment of susceptible varieties is needed when the disease occurs on transplants or early in crop development in the field; repeated applications may be required to protect new growth. Treatment during early flowering is required on some seed crops.

Organically Acceptable Methods

Resistant varieties and some copper sprays are suitable for organically grown crops.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. AMETOCTRADIN/DIMETHOMORPH
(Orvego) 11–14 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Mitochondrial respiration inhibitor (45) and cell wall synthesis inhibitor (40)

B. BOSCALID/PYRACLOSTROBIN
(Pageant) 12–18 oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Carboximide (7) and quinone outside inhibitor (11)

C. FIXED COPPER
(Kocide 2000)# Label rates 48
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M 01)
COMMENTS: A protectant fungicide. Growth of some plants may be reduced by this material; follow label directions carefully to reduce the risk of phytotoxicity. Not all copper compounds are approved for use in organic production; be sure to check individual products.

D. CYAZOFAMID
(Segway) 2.1–3.5 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Ubiquinone reductase, Qi site (21)
COMMENTS: Toxic to aquatic organisms.

E. FENAMIDONE
(Fenstop) 7–14 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Toxic to aquatic organisms.

F. FLUOPICOLIDE
(Adorn) 1–4 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Benzamides (43)
COMMENTS: Toxic to aquatic organisms.

G. SALTS OR ESTERS OF PHOSPHOROUS ACID
(Aliette WDG) 2.5–5 lb/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Phosphonate (P 07)
COMMENTS: For control of downy mildew on roses. Spray to wet using no more than 400 gal/acre.

H. MANCOZEB
(Dithane 75DF) 1–1.5 lb/100 gal water 24
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M 03)
COMMENTS: A protectant fungicide. Thorough coverage is important for control.

I. MANDIPROPAMID
(Micora) 4–8 fl oz/100 gal 4
MODE OF ACTION GROUP NAME (NUMBER[1]): Carboxylic acid amides (40)

J. MEFENOXAM
(Subdue Maxx) 0.5–1.0 fl oz/100 gal water 48
MODE OF ACTION GROUP NAME (NUMBER[1]): Phenylamide (4)
COMMENTS: Tank-mix with a non-Group 4 fungicide labeled for downy mildew.

K. *REYNOUTRIA SACHALINENSIS*#
(Regalia CG) Label rates 4
MODE OF ACTION GROUP NAME (NUMBER[1]): anthraquinone elicitor (P 05)

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action group number.

Acceptable for use on organically grown ornamentals.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

FUNGAL LEAF SPOTS, BLIGHTS, AND CANKERS (11/20)

Leaf spot of aster: *Stemphylium callistephi*
Ovulinia petal blight of azalea: *Ovulinia azaleae*
Alternaria blight of carnation: *Alternaria saponariae* (formerly *A. dianthi)*
Leaf blotch of peony: *Cladosporium paeoniae*
Black spot of rose: *Diplocarpon rosae*
Cercospora leaf spot of statice: *Cercospora insulana*

SYMPTOMS AND SIGNS

Foliar diseases caused by plant pathogenic fungi result in a wide range of symptoms that vary greatly depending on the particular pathogen and the host plant. Leaf spots (also called leaf lesions) are discrete, diseased sections of leaves that initially may be dull green or yellow in color, but later turn brown, black, or display another abnormal color. Leaf spot shapes also vary greatly, but usually are oval, oblong, or round. Leaf petioles can also develop such spots. The occurrence and merging of numerous leaf spots results in the infection of large portions of the foliage; such symptoms are called blights. Infections on twigs and branches can cause cankers, which are sunken, discolored, and cracked areas in the woody tissue. In many cases, the mycelium and fruiting structures of the pathogenic fungi will grow on top of the diseased leaf spot, blight, and canker areas.

COMMENTS ON THE DISEASE

There are many different kinds of foliar fungal diseases of flower and nursery crops. In many cases these fungi are host specific and will only infect one plant species. Most of these organisms produce spores that are spread by wind currents and splashing water from rain or sprinklers. Moist, humid conditions are needed for infection and disease development. Some of these fungi are carried in the seed; all can be carried in infected cuttings and other propagative material.

MANAGEMENT

Use pathogen- and disease-free seed, cuttings, transplants, and other propagative materials. Implement sanitation measures when dealing with containers, flats, benches, pruning tools, and other items that come in contact with plants. Avoid using overhead sprinkler irrigation. Rogue out diseased cuttings, transplants, and plants. Sanitize hands or gloves after handling diseased plants. Fungicides provide some control.

Common name (Example trade name)	Amount to use	REI‡ (hours)
Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.		
A. Strobilurins such as AZOXYSTROBIN, PYRACLOSTROBIN, TRIFLOXYSTROBIN and FLUOXASTROBIN		
(Heritage, Compass O 50WDG)	Label rates	See label
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)		

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action group number.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

FUSARIUM WILT (11/20)

Fusarium oxysporum

SYMPTOMS AND SIGNS

Symptoms include yellowing, stunting, and death of seedlings and yellowing and stunting of older plants. Infected plants wilt readily, lower leaves yellow and dry, the xylem tissues turn brown, and the plant may die. In the early stages of disease, the roots are not rotted. In many plants such as carnation and gladiolus, the symptoms may be one-sided at first.

COMMENTS ON THE DISEASE

The fungi that cause Fusarium wilt diseases are composed of a group of host-specific forms (*forma specialis*) abbreviated f. sp. For example, the fungus that causes wilt of carnations is *Fusarium oxysporum* f. sp. *dianthi* and infects only carnations and closely related plants. Generally, the f. sp. relates to the host; e.g., *callistephi* (China aster), *pisi* (pea), *cyclaminis* (cyclamen), etc.

Within the specialized forms are races of the fungus that are characterized by specialization on different cultivars of a host species. Cultivar A may be susceptible to race 1 and resistant to race 2, while cultivar B may be susceptible to both race 1 and race 2. This complicates the grower's task of selecting which cultivars to grow, as well as making it more difficult to select a breeding strategy for developing resistant cultivars.

There are many saprophytic forms of *F. oxysporum*, and recovery of this fungus from diseased plant material does not mean that the isolate is a wilt pathogen. For example, it is quite common to recover a saprophytic *F. oxysporum* from the roots of chrysanthemum plants killed by *Pythium* spp. or other pathogens. There are also strains of *F. oxysporum* that cause root rots but are not wilt pathogens.

The fungus can produce several different kinds of spores. Chlamydospores have thick walls and are resistant to drying and adverse conditions, enabling the fungus to survive for extended periods (years) in the soil. Conidia are thin–walled spores that can be either long and multi-celled (macroconidia) or short and only one- or two-celled (microconidia). Conidia are produced in a sporodochium, which is a mass of conidiophores (conidia-bearing stalks) growing tightly together. However, sporodochia are rarely seen in Fusarium wilt diseases. Conidia are spread in contaminated soil, by splashing water, and on contaminated tools and hands. Conidia are generally not airborne, but the fungus can become airborne on bits of infected plant debris or in dust.

In the presence of roots, chlamydospores or conidia germinate and penetrate susceptible plants. The fungus enters the xylem and grows upward, plugging the tissue and reducing the movement of water. Toxins are produced that cause the foliage to turn yellow.

Fusarium wilts are favored by high air and soil temperatures (75° to 86°F). Disease may not occur at low soil temperatures (below 68°F), or an infected plant may remain symptomless at lower temperatures. The fungus can be spread with infected cuttings or other forms of vegetative propagation taken from healthy appearing but infected plants.

MANAGEMENT

If seed is taken from infected plants, the seed itself is usually healthy, but the seed coat often becomes contaminated by microscopic pieces of infected tissue and by spores. Many important Fusarium wilt diseases are spread in this manner.

- Treat seed with a fungicide or heat to destroy the fungus on the seed and to protect the emerging seedlings from infection.
- Dip bulbs and corms in fungicide or hot water (or both) to reduce *Fusarium*.

Presence of pathogenic *Fusarium* in the soil can be reduced by heat treatments and chemical fumigation. These treatments are more effective in controlling the fungus in annual plantings than in perennial plantings. In general, however, Fusarium wilt diseases are best controlled by using resistant or tolerant cultivars, not by using soil applied fungicides. Liming soils and using nitrate nitrogen fertilizer have been effective for management of *F. oxysporum* on chrysanthemum, aster, gladiolus, cucumber, tomato, and

watermelon. In greenhouse production use steam from boilers and apply to raised field beds or raised benches to control soil borne diseases such as Fusarium wilt. In field production use long rotations or try to follow a fumigated crop like strawberry.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

SOIL FUMIGATION

A. CHLOROPICRIN* — Label rates — See label

COMMENTS: Inject into soil and cover immediately with plastic tarps. Fumigants are a source of volatile organic compounds (VOCs) but are not reactive with other air contaminants that form ozone. Fumigate only as a last resort when other management strategies have not been successful or are not available.

B. ***Sequential application of:***

(***Note:*** *Fumigants such as 1,3-dichloropropene and metam products are a source of volatile organic compounds (VOCs) but minimally reactive with other air contaminants that form ozone. Fumigate only as a last resort when other management strategies have not been successful or are not available.*)

CHLOROPICRIN*/1,3 DICHLOROPROPENE*

(Pic-Clor60) — 300–332 lb (shank) — See label

(Pic-Clor60 EC) — 200–300 lb — See label

COMMENTS: Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed control. For drip fumigation the use of VIF will improve both nematode and weed control. According to state permit conditions, the maximum application rate of 1,3-dichloropropene is 332 pounds active ingredient per acre. Pic-Clor60: One gallon of weighs 12.1 lb; Pic-Clor60 EC: One gallon of weighs 11.8 lb.

Following 5 to 7 days after fumigation:

METAM SODIUM*

(Vapam HL, Sectagon 42) — 37.5–75 gal — See label

COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 4.26 lb of metam sodium.

. . . or . . .

METAM POTASSIUM*

(K-Pam HL, Sectagon–K54) — 30–45 gal — See label

COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium.

. . . or . . .

DAZOMET*

(Basamid) — 200 lb — See label

COMMENTS: Powder incorporated into the soil, followed by irrigation or tarping. It decomposes to a gaseous fumigant (methyl isothiocyanate).

* Permit required from county agricultural commissioner for purchase or use.

Acceptable for use on organically grown ornamentals.

§ Do not exceed the maximum rates allowed under the California Code of Regulations Restricted Materials Use Requirements, which may be lower than maximum label rates.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

GRAY MOLD (11/20)

Botrytis cinerea

SYMPTOMS AND SIGNS

Gray mold is one of the most destructive plant pathogens and attacks a wide variety of plants. Flower petals and ripening fruits and vegetables are particularly susceptible to infection, but leaves and stem tissues may also get infected. Young seedlings of several crops can be killed if infected with gray mold. In high relative humidity, the fungus may sporulate on infected tissues and produce masses of characteristic gray or brownish spores that become airborne, which is primarily how the fungus is disseminated. Spores must have moisture to germinate and infect.

COMMENTS ON THE DISEASE

Botrytis does not invade healthy green tissue such as leaves and stems unless (a) an injured or dead area is present, or (b) it grows directly from a food base such as a fallen petal or leaf. The fungus will first colonize the food base and then attack healthy green tissues. However, flower petal tissue differs significantly from leaf and stem tissue, and *Botrytis* can directly invade petals of African violet, aster, begonia, carnation, chrysanthemum, cyclamen, cymbidium, gerbera, geranium, gladiolus, hydrangea, marigold, orchid, petunia, poinsettia, primrose, ranunculus, rose, snapdragon, zinnia, and others.

Although the fungus is capable of growth within a wide range of temperatures from about 28° to 90°F, growth is very slow at the extremes. Optimum temperature range for growth is 70° to 77°F. The fungus, which is more active below 70° than it is above 77°F, is particularly troublesome under conditions of moderate temperature and high humidity.

MANAGEMENT

Refrigeration at temperatures near 32°F will retard but not completely stop the development of gray mold; when infected tissue is warmed, decay can proceed rapidly.

Moisture often is more of a limiting factor than temperature. Free moisture is necessary for germination of *Botrytis* spores. Moisture is also necessary for growth within plant tissues, and low humidity may result in arrested growth of the fungus. However, growth can resume when moisture again becomes available.

Gray mold is most severe during times of the year when the humidity is high. In California, this is usually in the late fall and winter months, when rainfall is common. The worst time for disease development is from September to December, because there is an abundant amount of herbaceous vegetative material (crop refuse and dying summer plants) available for fungal colonization and, as a consequence, many spores are present in the air and on plant parts.

Cultural Control

Botrytis cinerea produces innumerable asexual spores (conidia) that are moved by air currents. Because spores may readily develop in decaying vegetation and old flowers, elimination or reduction of sources of the spores is an important part of any control program.

- Remove old flowers before they become infected and function as spore sources. The fungus can develop and sporulate at low temperatures, so do not overlook old flowers and foliage in refrigerators.
- Avoid condensation of water on susceptible plant parts, as free moisture is necessary for germination and infection
- Avoid overhead watering during blooming. If this is the only method of irrigation available, irrigate early in the day so that the foliage can dry as rapidly as possible.
- Maximize the period between irrigations to further enhance drying of foliage and flowers.
- Increase plant spacing to increase ventilation and minimize leaf wetness. This can help reduce both disease incidence and severity.

Chemical Control

Numerous fungicides are effective against *B. cinerea* but not all of them can be used on all crops. Some products can damage plants. To avoid damage and the development of fungal strains that are resistant to fungicides, growers should alternate different fungicides. The fungicides are preventives and must be applied before infection. In some crops, such as chrysanthemum, the lower foliage of crowded plants becomes infected and acts as a source of spores that then infect the flowers. In these crops, it is important to apply fungicides at an early stage when the lower foliage can be adequately covered by the chemical.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. AZOXYSTROBIN
(Heritage) — 4–8 oz/100 gal water — 4
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Apply as a broadcast or banded spray targeted at the foliage or crown of the plant. A locally systemic fungicide.

B. BOSCALID/PYRACLOSTROBIN
(Pageant) — 12–18 oz/100 gal — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Carboximide (7) and quinone outside inhibitor (11)

C. CHLOROTHALONIL
(Daconil WeatherStik) — 1.375 pt/100 gal water — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M 05)
COMMENTS: Do not apply to either green or variegated Pittosporum or to Schefflera. Effective for the control of *Botrytis* spp., *Alternaria* spp., *Rhizoctonia* spp., as well as other leaf-spotting fungi on many ornamentals.

D. CYPRODINIL/FLUDIOXONIL
(Palladium) — 4–6 oz/100 gal water — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Amino acids and protein synthesis (9) and signal transduction (12)

E. FENHEXAMID
(Decree 50 WDG) — 0.75-1.5 lb/100 gal water — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Hydroxyanilide (17)
COMMENTS: Apply as a spray; very effective and can be applied after infection.

F. FLUDIOXONIL
(Medallion WDG) — Label rates — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Phenylpyrroles (12)

G. FLUOXASTROBIN
(Disarm 480 SC) — 4–8 fl oz/100 gal — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Preventative application.

H. IPRODIONE
(Chipco 26019 N/G) — 6.5 oz/100 gal water — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Dicarboximide (2)

COMMENTS: Apply as a drench (1–2 pt/sq ft) at seeding or transplanting. Some resistance has been reported with this material. Effective against Rhizoctonia damping-off, *Sclerotinia*, and gray mold. Some iprodione is absorbed by plant parts.

I. MANCOZEB
(Dithane 75DF) 1–1.5 lb/100 gal water 24
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M 03)
COMMENTS: Protects against leaf spots, *Botrytis*, rusts, and blight. Not systemic so thorough coverage is important for control.

J. THIOPHANATE-METHYL
(Talaris 4.5 F) 20 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Methyl benzimidazole (1)
COMMENTS: Apply as a drench or heavy spray (1–2 pt/sq ft) after sowing. Some resistance has been reported with this material. Thiophanate-methyl is absorbed by plant parts exposed to the chemical. Roots may absorb the fungicide (or its breakdown product carbendazim), which moves in the xylem to transpiring leaves.

K. DICLORAN
(Botran 75-W) Label rates 12
MODE OF ACTION GROUP NAME (NUMBER[1]): AH-fungicides (14)

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‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

PHYTOPHTHORA ROOT AND CROWN ROTS (11/20)

Phytophthora spp.

SYMPTOMS AND SIGNS

Many, if not most, *Phytophthora* species can infect roots in the same manner as *Pythium* species. In addition, *Phytophthora* species infect crowns, stems, and larger roots, particularly in woody plants. Infection of the roots, crowns, and lower stems result in dark, discolored tissues. Tissues of diseased roots become soft and mushy and outer layers of the root may slough off. Plants with infected roots and crowns become stunted, are low in vigor, wilt, and appear as if they were water stressed. Foliage turns yellow, leaves fall off, and the plant may wilt and die.

Aerial plant parts, including branches and shoots, can also be infected by some species of *Phytophthora* under wet conditions if infested soil, water, or airborne spores contact these aboveground parts.

COMMENTS ON THE DISEASE

The pathogens that cause Phytophthora root and crown rots are related to *Pythium* species. *Pythium* and *Phytophthora* are sometimes collectively referred to as the water molds and are grouped in the family Pythiaceae. Root and crown rots are most common under wet or over-irrigated soil conditions. Ideal soil conditions for the growth of *Phytophthora* are wet soils with temperatures in the range of 59° to 74°F. Like *Pythium* spp., these fungi can be spread by fungus gnats and shore flies.

Phytophthora species have the same type of reproductive structures as *Pythium* species (i.e., oospores, sporangia, chlamydospores, and zoospores). Sporangia of some *Phytophthora* species (e.g., *P. infestans* and *P. nicotiana*) are airborne and aerial plant parts are the principal infection sites. ELISA test kits are available for detecting *Phytophthora*.

MANAGEMENT

Emphasis in control of Phytophthora diseases is placed on providing good drainage and water management. In addition, because aerial parts often are infected, propagative material can be a source of infection. Deep planting where soil covers the base of the stem encourages infection by *Phytophthora*. The same fungicides active against *Pythium* species also have activity against *Phytophthora* species. Copper-containing fungicides are also useful in protecting aerial parts of plants from infection by *Phytophthora* spp.

Both *Pythium* and *Phytophthora* species can be introduced to planting areas via contaminated surface water and soil. Aerial infections by *Phytophthora* species of a number of plants have been observed where overhead irrigation with water from streams is practiced or where untreated, recirculated water is used. For more information, see MANAGEMENT OF SOILBORNE PATHOGENS.

Steam (at 140°F for 30 minutes), solarize (double-tent at 160°F for 30 minutes or 140°F for 1 hour), or chemically treat growing medium. Sanitation is important because *Phytophthora* spp. can survive in dust, planting medium, or soil particles on greenhouse floors and in flats and pots. Remove and discard diseased plants. Use of properly composted pine bark as 20% of potting mix is reported to provide some control of *Pythium* and *Phytophthora* root rots. For flower production in open fields with warmer climates, solarization has successfully controlled most *Phytophthora* species in many crops. Care must be taken not to re-infest treated soil via contaminated plants, soil, media, or water. Solarization, steaming, and composting are acceptable for organic production.

Common name (Example trade name)	Amount to use	REI‡ (hours)
Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.		
A. AMETOCTRADIN/DIMETHOMORPH (Orvego)	11–14 fl oz/50–100 gal water	12

MODE OF ACTION GROUP NAME (NUMBER[1]): Mitochondrial respiration inhibitor (45) and cell wall synthesis inhibitor (40)

B. CYAZOFAMID
(Segway) 3.0–6.0 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Ubiquinone reductase, Qi site (21)
COMMENTS: Toxic to aquatic organisms.

C. FENAMIDONE
(Fenstop) 7–14 fl oz/50–100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Toxic to aquatic organisms.

D. FLUOPICOLIDE
(Adorn) 1–4 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Benzamides (43)
COMMENTS: Toxic to aquatic organisms.

E. FLUOXASTROBIN
(Disarm 480 SC) 0.15–0.60 fl oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)

F. SALTS OR ESTERS OF PHOSPHOROUS ACID
(Aliette WDG) 2.5–5 lb/100 gal water for foliar application 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Phosphonate (P 07)
COMMENTS: Foliar spray is more effective than the soil drench. When applied as a foliar spray it is absorbed by foliage and moves into roots.

G. MANDIPROPAMID
(Micora) 4–8 fl oz/100 gal 4
MODE OF ACTION GROUP NAME (NUMBER[1]): Carboxylic acid amides (40)

H. MEFENOXAM
(Subdue Maxx) 0.5–1.0 fl oz/100 gal water 48
MODE OF ACTION GROUP NAME (NUMBER[1]): Phenylamide (4)
COMMENTS: Applied at planting as a drench and periodically thereafter as needed. Available also in a granular formulation to use before planting. It is water-soluble and readily leached from soil. It is absorbed primarily through roots and is translocated in the plant through the xylem. Use of this material over a period of time may lead to resistance.

I. *REYNOUTRIA SACHALINENSIS*
(Regalia CG)# Label rates 4
MODE OF ACTION GROUP NAME (NUMBER[1]): anthraquinone elicitor (P 05)

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Acceptable for use on organically grown ornamentals.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

POWDERY MILDEW (11/20)

Powdery mildew: *Erysiphe* spp., *Golovinomyces* spp., *Leveillula (=Oidiopsis) taurica, Oidium* sp., *Podosphaera* spp.

SYMPTOMS AND SIGNS

Powdery mildew is the name given to diseases resulting from infection by fungi that produce a white to gray, powdery growth on the surfaces of leaves and sometimes other plant parts. Leaves may yellow, then brown and die. Infected tissues may be distorted and misshapen.

COMMENTS ON THE DISEASE

There are many kinds of powdery mildew fungi, and most are highly specialized. For example, the powdery mildew that infects squash plants will infect some other plants in the cucurbit family but will not infect roses, and the powdery mildew from roses will not attack zinnias (and vice versa), although the fungus that infects zinnias also infects many other members of the composite family. Powdery mildew fungi are obligate parasites; that is, they can grow only on living plant tissue. When the mildew-infected plant part dies, so does the mildew unless chasmothecia (spherical, resting stages of the fungus) are formed.

Most powdery mildew fungi grow over the surface of the leaf, sending short food-absorbing projections (haustoria) into the epidermal cells. The fungi produce masses of spores (conidia), which become airborne and spread to other plants. Powdery mildew spores require no external moisture for germination, while most other fungi require free water in the form of dew, guttation, rain, or water from overhead irrigation for germination and infection. Conidia of powdery mildew (except those that infect grasses) die in water. Spores may be dispersed, however, by splashing water.

The fungus survives in the absence of susceptible host tissues by forming a sexual stage (chasmothecia) resistant to drying and other adverse environmental conditions. With many perennial plants, such as rose, the fungus survives as mycelium in dormant buds or actively on plant tissues. Powdery mildews are particularly severe in semiarid regions, such as most of California, and are less troublesome in high rainfall areas.

Powdery mildews are favored by warm days and cool nights and moderate temperatures (68° to 86°F). At leaf temperatures above 90°F, some mildew spores and colonies are killed. Shade or low light intensities as well as high relative humidity (greater than 95%) favor powdery mildew fungi. Greenhouse conditions are often ideal for development of the disease.

MANAGEMENT

The best control is through the use of resistant cultivars. However, little attention has been paid to the development of resistant cultivars in flower and nursery crops. Increased air movement around the plants in the greenhouse tends to reduce infection potential of mildews. Plants that have been treated with antitranspirants are less likely to develop powdery mildew infections

Monitoring and Treatment Decisions

In general, there are two types of fungicidal control: eradication of existing infections and protection of healthy tissues. In practice, some products provide both protection and eradication, especially when good wetting of the plant is achieved. To achieve good wetting, some of these products may require the addition of surfactants.

The fungus has developed resistance to some of these fungicides. Rotate the different fungicides to help slow down the development of fungicide resistance within fungal strains.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing

a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

PROTECTANTS (Must be applied to healthy tissues before infection takes place)

A. TEBUCONAZOLE
(Torque) 4–10 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)
COMMENTS: A systemic fungicide applied as a foliar spray; both a protectant and eradicant.

B. CYPRODINIL/FLUDIOXONIL
(Palladium) 4–6 oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Amino acids and protein synthesis (9) and signal transduction (12)

C. BOSCALID/PYRACLOSTROBIN
(Pageant) 6–12 oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Carboximide (7) and quinone outside inhibitor (11)

D. FLUOXASTROBIN
(Disarm 480 SC) 1–4 fl oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)

E. WETTABLE SULFUR# 3 lb/100 gal water 24
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M 02)
COMMENTS: Use a wetting agent. Effectiveness of sulfur increases with increasing temperature, but the likelihood of plant injury increases also. Plant damage may result if sulfur is applied at temperatures exceeding 90°F. Some plants, such as melons, are sensitive to sulfur. Sulfur can be applied as a dust or as a spray. Repeated applications are generally necessary to protect new growth and also to renew deposits removed by rain or irrigation.

F. MYCLOBUTANIL
(Rally 40WSP) 3 oz/50 gal water 24
MODE OF ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)
COMMENTS: A systemic fungicide applied as a foliar spray; both a protectant and eradicant of rusts or powdery mildew on carnations, crape myrtle, gerbera, roses, and snapdragons.

G. AZOXYSTROBIN
(Heritage) 1–4 oz/100 gal water 4
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Acts as a protectant but has some eradicant properties. A locally systemic fungicide that is an eradicant and protectant against some powdery mildews.

H. TRIADIMEFON
(Bayleton Flo) Label rates 12
MODE OF ACTION GROUP NAME (NUMBER[1]): DMI (Group 3)[1] triazole fungicide
COMMENTS: A long-lasting systemic fungicide that provides for general control of some powdery mildews, some rusts, and leaf blight and spots in greenhouses and commercial nurseries.

I. THIOPHANATE-METHYL
(Talaris 4.5 F) 10–20 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Methyl benzimidazole (1)

COMMENTS: Not as effective against powdery mildew as other materials. Thiophanate-methyl is absorbed by plant parts exposed to the chemical. Roots may absorb the fungicide (or its breakdown product carbendazim), which moves in the xylem to transpiring leaves.

J. PROPICONAZOLE
(Banner Maxx II) Label rates 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)
COMMENTS: A preventive fungicide.

K. *REYNOUTRIA SACHALINENSIS*#
(Regalia CG) Label rates 4
MODE OF ACTION GROUP NAME (NUMBER[1]): Anthraquinone elicitor (P 05)

L. POTASSIUM BICARBONATE
(Kaligreen)# 1–3 lb/100 gal water/acre 4
MODE OF ACTION GROUP NAME (NUMBER[1]): Inorganic salt (NC)
COMMENTS: Primarily a protectant but it eradicates some existing infections with thorough coverage. Apply at first signs of infection. Thorough coverage is essential for good protection. Labeled for use on roses, field ornamentals, and greenhouse ornamentals.

ERADICANTS

A. LIME SULFUR 28%
(Rex lime sulfur solution)# 0.5 gal/100 gal water 48
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M 02)[1]
COMMENTS: Primarily an eradicant but has some protectant properties. Plant damage may result if applied when temperatures exceed 80°F. Not as effective against powdery mildew as other materials. Not for use in greenhouses.

B. NEEM OIL
(Triact 70)# Label rates 4
MODE OF ACTION GROUP NAME (NUMBER[1]): (NC)
COMMENTS: A broad-spectrum botanical pesticide derived from the neem tree that is effective against various fungal diseases including black spot on roses, powdery mildew, downy mildew, anthracnose, and leaf spot. Registered for landscape and nursery ornamentals; oils work best as eradicants but also have some protectant activity. When using as a protectant, apply on a 14-day schedule; as an eradicant, apply on a 7-day schedule. Do not repeat oil applications frequently as multiple applications may burn leaves and flowers. Never apply any oil within 2 weeks of a sulfur spray or plants may be injured.

C. PIPERALIN
(Pipron) 4–8 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Amine (morpholine) (5)[1]
COMMENTS: Requires thorough coverage. For use in greenhouses only. A foliar spray that eradicates powdery mildew on rose, lilac, dahlia, phlox, zinnia, chrysanthemum, and catalpa.

D. STYLET OIL
(Organic JMS Stylet Oil)# 1 oz/gal water 4
MODE OF ACTION GROUP NAME (NUMBER[1]): (NC)
COMMENTS: A good eradicant for mild to moderate powdery mildew infections; oils work best as eradicants but also have some protectant activity. Registered for use on chrysanthemum, dieffenbachia, philodendron, poinsettia, and roses. May be phytotoxic, especially on greenhouse roses. Do not repeat oil applications frequently as multiple applications may burn leaves and flowers. Do not apply to plants suffering from heat or moisture stress. Never apply any oil within 2 weeks of a sulfur spray or plants may be injured.

E. TEBUCONAZOLE

(Torque)	4–10 fl oz/100 gal water	12

MODE OF ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)

COMMENTS: A systemic fungicide applied as a foliar spray; both a protectant and eradicant.

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action group number; for fungicides with other group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action group number.

Acceptable for use on organically grown ornamentals.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

PYTHIUM ROOT ROT (11/20)

Pythium spp.

SYMPTOMS AND SIGNS

Pythium attacks juvenile tissues such as the root tip and newly germinated seedlings. After gaining entrance to the root the fungus may cause a rapid, brown to black rot of the entire primary root and may even move up into the stem tissue. As the soil dries, new roots may be produced and the plant may recover or never show symptoms of disease. Under wet conditions brought about by poor soil drainage or excess irrigation, more and more roots are killed and the plant may wilt, stop growing, or even collapse and die. Bulbs of susceptible plants turn brown to black, gradually desiccate, and form a hard mummy.

COMMENTS ON THE DISEASE

The pathogens that are responsible for Pythium root rot, also known as water molds, are present in practically all cultivated soils and attack plant roots under wet conditions. These fungi can be spread by fungus gnats and shore flies and end up contaminating potting mixes in containers. There are many species of *Pythium*; a few of these species are beneficial in that they compete with or parasitize the pathogenic species. Of the many pathogenic species, some have limited host ranges while others, such as *Pythium ultimum*, have very wide host ranges.

Some *Pythium* species, such as *P. aphanidermatum*, are pathogens only at high temperatures (above 77°F), and some are active only at low soil temperatures. Soil moisture conditions of 70% or higher of available water capacity are conducive to infection by *Pythium*. It is likely that soil from a field contains several pathogenic *Pythium* species.

Pythium species form several types of spores, but not all species form all types. Zoospores, which are produced in sporangia, are motile in water. Oospores, which result from a sexual process, usually undergo a period of dormancy and can withstand long periods of drying. Some species also form chlamydospores, which are asexual and have thick cell walls. These structures can serve as survival or overwintering structures. Sporangia and zoospores in general do not survive in air or dry soil for long periods of time.

MANAGEMENT

In the control of *Pythium* diseases, emphasis is placed on providing good drainage and water management.

- Steam (at 140°F for 30 minutes), solarize (double-tent at 160°F for 30 minutes or 140°F at 1 hour), or chemically treat the growing medium.
- Sanitize well because *Pythium* spp. can survive in dust, planting medium, or soil particles on greenhouse floors and in flats and pots.
- Remove and discard diseased plants.
- Use of properly composted pine bark as 20% of a potting mixture is reported to provide some control of Pythium and Phytophthora root rots. Additionally, the mycoparasite *Gliocladium virens* is used as a *Pythium* biocontrol agent.

For flower production in outside fields, solarization has been successful for control of damping–off in many crops that are grown in warmer climates. There are reports of inadequate control of some high temperature species (e.g. *P. aphanidermatum*). Solarization and steaming are acceptable for organic production.

Common name (Example trade name)	Amount to use	REI‡ (hours)
Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.		
A. FLUOPICOLIDE (Adorn)	1–4 fl oz/100 gal water	12

MODE OF ACTION GROUP NAME (NUMBER[1]): Benzamides (43)
COMMENTS: Toxic to aquatic organisms.

B. CYAZOFAMID
(Segway) 1.5–3.0 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Ubiquinone reductase, Qi site (21)
COMMENTS: Toxic to aquatic organisms.

C. FENAMIDONE
(Fenstop) 7–14 fl oz/50–100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Toxic to aquatic organisms.

D. BOSCALID/PYRACLOSTROBIN
(Pageant) 12–18 oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Carboximide (7) and quinone outside inhibitor (11)

E. *REYNOUTRIA SACHALINENSIS*#
(Regalia CG) Label rates 4
MODE OF ACTION GROUP NAME (NUMBER[1]): Anthraquinone elicitor (P 05)

F. MEFENOXAM
(Subdue Maxx) 0.5–1.0 fl oz/100 gal water 48
MODE OF ACTION GROUP NAME (NUMBER[1]): Phenylamide (4)
COMMENTS: Applied at planting as a drench and periodically thereafter as needed. Available also in a granular formulation to use before planting. It is water-soluble and readily leached from soil. It is absorbed primarily through roots and may be translocated in the plant through the xylem. Use of this material over a period of time may lead to resistance.

G. SALTS OR ESTERS OF PHOSPHOROUS ACID
(Aliette WDG) 2.5–5 lb/100 gal water for foliar application 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Phosphonate (P 07)
COMMENTS: When applied as a foliar spray, it is absorbed by foliage and moves into roots. Soil drench is less effective than a foliar application.

H. ETRIDIAZOLE
(Terrazole CA) 4–6 oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Heteroaromatics (14)

I. GLIOCLADIUM VIRENS#
(SoilGard) Label rates 4
MODE OF ACTION GROUP NAME (NUMBER[1]): Microbial (BM 02)

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Acceptable for use on organically grown ornamentals.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

RUST (11/20)

Rust: *Phragmidium* spp., *Puccinia* spp., and others

SYMPTOMS AND SIGNS

Rust pustules appear as powdery masses of yellow, orange, purple, black, or brown spores on leaves and sometimes on stems. Depending on the particular plant host, pustules can be found on either side of leaves. Severe rust can result in dried, dead foliage. The most significant impact of rust disease is the reduction of quality and marketability of the commodity.

COMMENTS ON THE DISEASE

The rust fungi are obligate parasites in the order Uredinales. Some have complicated life cycles that include up to five different spore stages and two distinctly different hosts. Other rusts produce less than five or sometimes only one type of spore and infect only one kind of plant. Stem rust (*Puccinia graminis*) of wheat alternates between barberry (*Berberis* spp.) and wheat (*Triticum vulgare*) and all five spore stages are produced. Rose rust produces four spore stages but only roses (*Rosa* spp.) are infected.

Urediniospores ("repeating" spores) are produced in pustules that appear yellow, orange, or brown as a result of masses of spores. These spores can re-infect the same host that produces them, making them the damaging phase of most rust diseases. Urediniospores are windborne and infect the plant through stomata. Water is required for short periods (6–8 hours or less) for germination and infection. Heavy dew is often sufficient. Once infection has occurred, water is no longer needed for continued development, and the infection and spore production will continue for the life of the leaf.

Some rusts, including rose (*Phragmidium tuberculatum*) may survive the winter on leaves that do not fall off the plant. Rose rust also survives as teliospores (dark, thick–walled, overwintering spores) that form in fall. These spores survive in a dormant stage on fallen leaves.

MANAGEMENT

Rust diseases are favored by moderate temperatures that favor the growth of the host. Rust spores can be killed by high temperatures. Some rust infections, such as geranium rust (*Puccinia pelargonii-zonalis*), can be eradicated by hot water treatment of cuttings, although some damage to the host can occur.

Because water is necessary for infection, overhead irrigation should be avoided when rust is a problem. Eliminate alternate hosts.

Chrysanthemum white rust, caused by *Puccinia horiana*, and Gladiolus rust, caused by *Uromyces transversalis*, are under an eradication program in California. Gladiolus rust also causes disease on other members of the iris family such as *Crocosmia, Tritonia*, and *Watsonia*. See specific guidelines under the DISEASE CONTROL OUTLINE FOR CHRYSANTHEMUM and DISEASE CONTROL OUTLINE FOR GLADIOLUS.

There are several fungicides that can be used to protect plants from infection. Mancozeb as a protectant and myclobutanil as an eradicant are generally effective against all rusts while triadimefon is effective against only specific rusts.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. TEBUCONAZOLE

(Torque) 4–10 fl oz/100 gal water 12

MODE OF ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)

COMMENTS: A systemic fungicide applied as a foliar spray; both a protectant and eradicant.

B. MANCOZEB
(Dithane 75 DF) 1–1.5 lb/100 gal water 24
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M 03)
COMMENTS: Provides protection only; must be applied before infection. Protects against leaf spots, *Botrytis*, rusts, and blight. Thorough coverage is important for control.

C. MYCLOBUTANIL
(Rally 40WSP) 3 oz/50 gal water 24
MODE OF ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)
COMMENTS: A systemic fungicide applied as a foliar spray; both a protectant and eradicant of rusts or powdery mildew on carnations, crape myrtle, gerbera, roses, and snapdragons.

D. BOSCALID/PYRACLOSTROBIN
(Pageant) Label rates 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Carboximide (7) and quinone outside inhibitor (11)

E. FLUOXASTROBIN
(Disarm 480 SC) 1–4 fl oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)

F. TRIADIMEFON
(Bayleton Flo) Label rates 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)
COMMENTS: A long-lasting systemic fungicide that provides for general control of some powdery mildews, some rusts, and leaf blight and spots in greenhouses and commercial nurseries. Because this material is closely related to growth retardant materials, it can have a toxic effect on certain plants, such as greenhouse roses.

G. AZOXYSTROBIN
(Heritage) 1–4 oz/100 gal water 4
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Apply as a broadcast or banded spray targeted at the foliage or crown of the plant. A locally systemic fungicide that is effective against rusts.

H. *REYNOUTRIA SACHALINENSIS*#
(Regalia CG) Label rates 4
MODE OF ACTION GROUP NAME (NUMBER[1]): Anthraquinone elicitor (P 05)

I. WETTABLE SULFUR# 1–3 lb/100 gal water 24
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M 02)
COMMENTS: Use a wetting agent. Not as effective as other materials. Apply this material with caution when temperatures exceed 85°F.

J. CHLOROTHALONIL
(Chlorothalonil 720 SFT) 1.375 pt/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Multi-site contact (M 05)
COMMENTS: Provides protection only; must be applied before infection.

K. PROPICONAZOLE
(Banner Maxx II) 2–16 fl oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)
COMMENTS: Controls white rust of chrysanthemums but may cause phytotoxic symptoms on some cultivars.

L. NEEM OIL
(Triact 70)# Label rates 4
MODE OF ACTION GROUP NAME (NUMBER[1]): (NC)

COMMENTS: Registered for landscape and nursery ornamentals, neem has some protectant properties against rust, but is not effective for rust on rose. Apply on a 14-day schedule.

* Permit required from county agricultural commissioner for purchase or use.

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Acceptable for use on organically grown ornamentals.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

SOUTHERN BLIGHT (11/20)

Sclerotium rolfsii

SYMPTOMS AND SIGNS

Southern blight, also called southern wilt, southern stem rot, southern root rot and other names, results from infection by the soilborne fungus *Sclerotium rolfsii*. The fungus survives in the soil as small (0.04–0.08 inch), tan to brown, round sclerotia. The sclerotia resemble mustard seeds in size and color and the fungus is sometimes referred to as the "mustard seed fungus." Plants are attacked at the soil line or below ground. The fungus produces abundant white hyphae or mycelia around infected parts and in and on the soil. Sclerotia are formed by the mycelia on infected plant parts and in the soil; their presence is the main diagnostic feature of the disease. The initial symptoms are similar to those caused by other basal stem rots (cottony rot, Rhizoctonia stem rot, etc.): discolored crown/stem lesion at the soil line, discoloration of lower leaves, wilting, plant collapse, and death.

COMMENTS ON THE DISEASE

The disease is favored by warm moist soil, hence it occurs in the summer months. The fungus has a wide host range and includes many field, vegetable, and ornamental crops. This pathogen is a regulated pest in California nurseries and must be eradicated. Contact your County Agricultural Commissioner for details.

MANAGEMENT

Steam (at 140°F for 30 minutes), solarize (double-tent at 160°F for 30 minutes or 140°F for 1 hour), or chemically treat growing medium for container-grown plants.

For outdoor field production, soil fumigation or soil solarization (in warmer climatic areas) is effective in killing soilborne sclerotia. Bulbs and other planting stock may carry the fungus. The fungus is killed by exposure to 122°F for 30 minutes and some plant materials such as caladium tubers, iris rhizomes, and gladiolus corms can be treated successfully with hot water. Use of heat treatment (steam, solarization, and/or hot water) is acceptable for organic production.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

SOIL FUMIGATION

A. CHLOROPICRIN* — Label rates — See label
COMMENTS: Inject into soil and cover immediately with plastic tarps. Fumigants are a source of volatile organic compounds (VOCs) but are not reactive with other air contaminants that form ozone. Fumigate only as a last resort when other management strategies have not been successful or are not available.

SOIL FUNGICIDE

A. TEBUCONAZOLE
(Torque) — 4–10 fl oz/100 gal water — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Demethylation inhibitor (3)
COMMENTS: A systemic fungicide applied as a foliar spray; both a protectant and eradicant.

B. CYPRODINIL/FLUDIOXONIL
(Palladium) — 2–4 oz/100 gal water — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Amino acids and protein synthesis (9) and signal transduction (12)

C. FLUTOLANIL
(Prostar 70 WG) — 3–6 oz/100 gal water — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Succinate-dehydrogenase inhibitor (7)

D. PCNB
(Terraclor 400) Label rates 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Aromatic hydrocarbon (14)
COMMENTS: Helpful in preventing infection when incorporated into top 2 inches of soil. Best available material for southern blight caused by *Sclerotium rolfsii.* Insoluble in water and must be thoroughly mixed with soil to reach its desired depth of control. Works through vapor action and has good residual action. Germination of some seeds may be inhibited and small plants may be stunted by this fungicide.

* Permit required from county agricultural commissioner for purchase or use.

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§ Do not exceed the maximum rates allowed under the California Code of Regulations Restricted Materials Use Requirements, which may be lower than maximum label rates.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

SUDDEN OAK DEATH AND RAMORUM BLIGHT (11/20)

Phytophthora ramorum

SYMPTOMS AND SIGNS

Although hosts of *P. ramorum* show a range of foliar symptoms, the disease is generally characterized by irregular, necrotic leaf lesions, instead of distinct leaf spots. Leaf infections can spread to the petiole and twigs, but diseased leaves often fall off before the lesion reaches the petiole. Sometimes infections occur initially on stems or develop into stems, where associated leaves eventually wilt, become necrotic, and die. On some hosts, a fairly distinct dark line can mark the advance of leaf infection, especially in cool and wet conditions.

Symptoms are most often found on leaf tissue where free water remains for long periods: leaf tips, leaves hanging down or located deep within the canopy, leaves near or touching the soil, or leaves that overlap or are cupped. Root infections are possible on some hosts, but the roots often appear more or less healthy. Root rot symptoms, typical of infections by other *Phytophthora* species, are not seen. The importance of these cryptic root infections in the spread of *P. ramorum* in the nursery trade is not yet clear.

While not commonly seen on nursery hosts, bark cankers on the trunks of woodland trees, such as oak and tanoak, are also associated with this disease. Cankers have red-brown to black discoloration, dark black to reddish colored sap, and often develop 3 to 6 feet above the ground, although they can be higher or lower. Symptoms caused by fertilizer burn, chemical injury, drought injury, freeze damage, sunburn, and root damage can sometimes look like *P. ramorum* foliar infection. However, these abiotic injuries are often found distributed over the entire plant, while lesions caused by *P. ramorum* are often only found initially on a few leaves or on one portion of the plant. There are many damaging species of *Phytophthora* other than *ramorum*, so diagnosis by a qualified lab is extremely important.

COMMENTS ON THE DISEASE

In the mid to late 1990s, portions of woodlands in Marin, Santa Cruz, and Monterey counties changed dramatically. Tree crowns turned brown within a few weeks, giving the impression of instantaneous mortality. Since then more than a million tanoaks, (*Notholithocarpus* [=*Lithocarpus*] *densiflorus*), California black oaks (*Quercus kelloggii*), coast live oaks (*Quercus agrifolia*), and other oak species have died as a result of *P. ramorum* infection in northern and central California. The pathogen also causes mortality in forested regions of southern Oregon. Additionally, it can be found in streams as well as the natural waterways of Washington.

A distinct European lineage of *P. ramorum* is causing similar diseases on ornamentals in some nurseries, botanic gardens, and landscapes in Europe. It has been infecting *Vaccinium* spp. in the heathlands of Scotland and Wales. Oak, and especially Japanese larch plantations, have been heavily impacted in the United Kingdom.

Camellias, rhododendrons, viburnums, *Pieris* spp., and other popular ornamental plants are susceptible to *P. ramorum* infection, and the pathogen can move long distances through shipments of infected nursery stock. Federal and state quarantines are in effect that require nursery inspections. If the pathogen is found, affected nursery stock must be destroyed. For a current host list and additional regulatory information, refer to the U.S. Department of Agriculture Animal and Plant Health Inspection Service's website on *P. ramorum*.

BIOLOGY

Phytophthora ramorum, while having many features in common with fungal organisms, is not a true fungus. *Phytophthora* species are Oomycetes or "water molds" and require a moist environment to actively grow and reproduce. *Phytophthora ramorum* produces several reproductive structures important for pathogen spread and survival, including sporangia, zoospores, and chlamydospores. Sporangia give rise to the zoospores, which can swim in water. Chlamydospores are resting spores that help the pathogen survive extreme temperatures, dryness, and other harsh conditions. *Phytophthora ramorum* can grow within a temperature range of 36° to 80° F with an optimum temperature of 68° F.

Spores can form on leaf surfaces of susceptible leaves and twigs following prolonged wetting. They are moved from plant to plant via windblown or splashed rain or by direct contact with infected leaves. Spores produced on infected plants can move to healthy plants in water runoff created by rain or sprinkler irrigation water. In California forests the pathogen sporulates prolifically on California bay laurel trees (*Umbellularia californica*), which serve as reservoirs for inoculum. Infected California bay laurel can also be an important source of inoculum when near the nursery stock.

MANAGEMENT

There are federal and state quarantines that require inspections for nursery stock in regulated California counties. If the pathogen is detected, the affected plants are destroyed and the pathogen is eradicated.

Disease symptoms may take weeks to several months to develop and become apparent, so infected plants may appear healthy at first. Fungicides that have activity on *Phytophthora* might prevent new infections and therefore interfere with detection of this pathogen; it is best not to apply fungicides while evaluating the disease status.

For most nurseries, the foremost objective of pest management programs is to prevent the introduction of the pathogen into the nursery via infected plant material. This can be partly accomplished by careful inspection of all incoming host propagative material and stock.

- Monitor new outside source stock at least biweekly in summer and at least weekly during rainy periods when environmental conditions are highly conducive to pathogen infection and development.

For nurseries surrounded by native host trees and shrubs and in the vicinity where *P. ramorum* is found, monitor areas surrounding the nursery, especially wet areas, near puddles, or rain runoff zones. It is very important to detect the pathogen early, while it is still at very low levels.

- Periodically inspect nearby native hosts for disease symptoms. Infected California bay laurel trees near the perimeter of nurseries may produce inoculum that can spread and cause infection of nearby host plants, so removal of these trees may be warranted.
- Consider building berms to prevent water and soil movement into production areas from hillsides surrounding the nursery that may contain infected hosts.
- Irrigation water pumped from streams and ponds in areas of infected native hosts may be contaminated with *P. ramorum*. Consider having this water periodically tested to detect *P. ramorum*. If it is found to be present, use alternative irrigation sources, such as well water or water disinfection treatments.

For more information on developing a detection and monitoring program, see *Nursery Guide for Diseases Caused by Phytophthora ramorum on Ornamentals: Diagnosis and Management*, UC ANR Publication 8156.

Cultural Practices

Cultural practices that can be useful to reduce disease risk:

- Avoid irrigation practices that leave foliage wet for prolonged periods. If sprinklers are used, irrigate in the morning to allow for thorough and quick drying of foliage.
- Monitor and maintain irrigation systems to insure the most uniform application of water to the crop. Correct low spots, areas of poor drainage, and clogged or leaking irrigation heads.
- Monitor irrigation-water sources, other than well water, for *P. ramorum*. Use disinfection systems if using recycled water.
- Wounded leaves (even tiny wounds or scratches) are much more susceptible to infection. Avoid handling host plants if they might be wounded when environmental conditions favor disease.
- Avoid splashing water from soil to foliage, as well as from foliage to soil or container soil. Use raised benches, gravel, or other means to elevate susceptible plants above soil. Transplants, even on gravel beds, appear to be very susceptible to disease because of the close proximity of foliage to soil, runoff water, or rain splash. Raised benches may be warranted for transplants.
- Remove plants or plant parts that are suffering from poor vigor, disorders, or other serious problems from production areas and destroy them. A small number of plants or plant parts could be

bagged and disposed. If a cull pile is needed temporarily, cover it with a clear polyethylene sheet until the culls can be destroyed or composted.
- Propagate cuttings only from disease-free hosts.
- Use only new or disinfested containers and soil. Place potting soil piles as far from infected native hosts or cull piles as possible and covered with clear polyethylene sheeting. Do not mix potting soil components on bare soil.

Monitoring and Treatment Decisions

Fungicides used to protect nursery stock from *P. ramorum* function as preventive treatments only. Currently, even the most active fungicides do not stop the development of *P. ramorum* once foliar lesions are present. The use of *Phytophthora*-specific fungicides may be warranted for high risk situations, such as where a nursery is exposed to local inoculum sources from surrounding infected native hosts or where *P. ramorum* has been detected previously in the nursery. Fungicides should only be used after other management strategies and preventive steps have been fully implemented.

When applying fungicides, good coverage over the foliage is important; add a wetting agent to prevent significant run-off and loss of fungicides on the hard-to-wet leaves of certain plant species. Apply treatments before environmental conditions favor pathogen infection; for example, spraying before a period of rainy weather will allow water to linger on leaf surfaces for many hours.

Some fungicides applied to the foliage move into leaves and are not washed off by rain or sprinkler irrigation, while others provide a protective layer of chemical on the leaf surface. Some can be applied to the soil, where they are absorbed and moved upward to the leaves, to protect them from infection. Some have residual activity that can last for several weeks after they are applied. Read fungicide labels and technical information provided by the fungicide manufacturer to learn how the fungicide can be used most effectively. See PHYTOPHTHORA ROOT AND CROWN ROTS and management in this section.

Resistance management.
To help reduce the potential for the development of resistance by *P. ramorum* to fungicides, alternate or tank mix fungicides with different mode-of-action group numbers. Fungicides active on *P. ramorum* may already be used in the nursery to control other foliar or soil-inhabiting *Phytophthora* species or related pathogens (such as downy mildews), and their use should be considered in planning the overall fungicide resistance management program.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

A. CYAZOFAMID
(Segway) — 3.0–6.0 fl oz/100 gal water — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Ubiquinone reductase, Qi site (21)
COMMENTS: Toxic to aquatic organisms.

B. DIMETHOMORPH
(Stature SC) — 12.25 fl oz/100 gal — 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Carboxylic acid amides (40)

C. MEFENOXAM
(Quali-Pro Mefenoxam 2 AQ) — Label rates — 48
MODE OF ACTION GROUP NAME (NUMBER[1]): Phenyl amides (4)
COMMENTS: The granular formulation may be applied preplant or the liquid formulation can be applied as a drench at planting. Mefenoxam is water-soluble and readily leached from soil. It is absorbed primarily through roots and may be translocated in the plant through the xylem.

D. MANDIPROPAMID
(Micora) — 4–8 fl oz/100 gal — 4

MODE OF ACTION GROUP NAME (NUMBER[1]): Carboxylic acid amides (40)

E. FLUOPICOLIDE
(Adorn) 1–4 fl oz/100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Benzamides (43)
COMMENTS: Toxic to aquatic organisms. Drench application.

F. FENAMIDONE
(Fenstop) 7–14 fl oz/50–100 gal water 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Quinone outside inhibitor (11)
COMMENTS: Toxic to aquatic organisms.

G. BOSCALID/PYRACLOSTROBIN
(Pageant) 12–18 oz/100 gal 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Carboximide (7) and quinone outside inhibitor (11)

H. SALTS OR ESTERS OF PHOSPHOROUS ACID
(Aliette WDG) Label rates 12
MODE OF ACTION GROUP NAME (NUMBER[1]): Phosphonate (P7)

1 Group numbers are assigned by the Fungicide Resistance Action Committee (FRAC) according to different modes of action. Fungicides with a different group number are suitable to alternate in a resistance management program. In California, make no more than one application of fungicides with mode of action Group numbers 1, 4, 9, 11, or 17 before rotating to a fungicide with a different mode of action group number; for fungicides with other Group numbers, make no more than two consecutive applications before rotating to fungicide with a different mode of action group number.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

VERTICILIUM WILT (11/20)

Verticillium wilt: *Verticillium albo-atrum*, *Verticillium dahliae*

SYMPTOMS AND SIGNS

Symptoms vary somewhat with the kind of plant and the environment, but some symptoms are common to most situations. The leaves may wilt and turn yellow, first at the margins and between the veins, then they turn tan or brown and die starting from the base to the tip of the plant or branch. Dead leaves can either fall off or remain attached to the plant. Woody plants often are affected first on one side, and affected branches usually die. The water-conducting tissues (xylem) of infected plants are often discolored with dark brown to black streaks. In some plants, including olive, ash, and roses, there is little or no discoloration.

COMMENTS ON THE DISEASE

Verticillium wilt, one of the most widespread and destructive soilborne diseases of plants, affects a large number of herbaceous and woody species throughout the world. The causal fungus, *Verticillium dahliae*, infects susceptible plants through the roots and plugs the water conducting tissues.

Susceptible flower crops include China aster, chrysanthemum, cineraria, dahlia, geranium, gerbera, heather, marigold, peony, pelargonium, rose, snapdragon, statice, stock, and strawflower. The *V. dahliae* fungus forms microscopic black resting structures (microsclerotia) capable of surviving in soil for many years in the absence of a susceptible plant. When a susceptible plant is planted in infested soil, the microsclerotia germinate and infect the plant. Long rotations with nonsusceptible plants are not effective in controlling the fungus.

The fungus also produces conidia that can be transported in irrigation water; however, they are not long-lived. The fungus can be disseminated by leaves dropping from infected plants and being blown around by the wind.

MANAGEMENT

Many horticultural crop plants have been selected or bred for resistance to the fungus. Use resistant cultivars and pathogen-free plants whenever possible.

Steam (at 140°F for 30 minutes), solarize (double-tent at 160°F for 30 minutes or 140°F for 1 hour), or chemically treat growing medium. For outdoor cut flower or nursery production, avoid fields previously used for susceptible crops (e.g., tomato, cotton, potatoes, strawberries, as well as the ornamentals listed above) unless disinfected. Soil fumigation or soil solarization (in warmer climatic areas) can be useful. During the growing season, remove and destroy any plants that exhibit symptoms of Verticillium wilt.

Common name (Example trade name)	Amount to use	REI‡ (hours)

Not all registered pesticides are listed. The following are ranked with the pesticides having the greatest IPM value listed first–the most effective and least likely to cause resistance are at the top of the table. When choosing a pesticide, consider information relating to the pesticide's properties and application timing, honey bees, and environmental impact. Always read the label of the product being used.

SOIL FUMIGATION

A.	CHLOROPICRIN*	Label rates	See label

Allowable for use under a Critical Use Exemption only. Fumigants are a source of volatile organic compounds (VOCs) but are not reactive with other air contaminants that form ozone. Fumigate only as a last resort when other management strategies have not been successful or are not available.

B. ***Sequential application of:***
(***Note:*** *Fumigants such as 1,3-dichloropropene and metam products are a source of volatile organic compounds (VOCs) but minimally reactive with other air contaminants that form ozone. Fumigate only as a last resort when other management strategies have not been successful or are not available.*)

CHLOROPICRIN*/1,3 DICHLOROPROPENE*		
(Pic-Clor60)	300–332 lb (shank)	See label
(Pic-Clor60 EC)	200–300 lb	See label

COMMENTS: Very effective for control of soilborne fungal pathogens and insects. Drip irrigation requires an emulsifier. For shank fumigation, using higher rates or plastic mulch, especially virtually impermeable film (VIF), improves weed control. For drip fumigation the use of VIF will improve both nematode and weed control. According to state permit conditions, the maximum application rate of 1,3-dichloropropene is 332 pounds active ingredient per acre. Pic-Clor60: One gallon of weighs 12.1 lb; Pic-Clor60 EC: One gallon of weighs 11.8 lb.

Following 5 to 7 days after fumigation:

METAM SODIUM*
(Vapam HL, Sectagon 42) 37.5–75 gal See label
COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 4.26 lb of metam sodium.

. . . or . . .

METAM POTASSIUM*
(K-Pam HL, Sectagon–K54) 30–45 gal See label
COMMENTS: Water-soluble liquid that decomposes to a gaseous fumigant (methyl isothiocyanate). Efficacy affected by soil texture, moisture, temperature, and percent organic matter. One gallon of product contains 5.8 lb of metam potassium.

C. DAZOMET*
(Basamid) 200 lb See label
COMMENTS: Powder incorporated into the soil, followed by irrigation or tarping. It decomposes to a gaseous fumigant (methyl isothiocyanate).

SOIL FUNGICIDES

A. *REYNOUTRIA SACHALINENSIS*
(Regalia CG)# Label rates 4
MODE OF ACTION GROUP NAME (NUMBER[1]): anthraquinone elicitor (P 05)

* Permit required from county agricultural commissioner for purchase or use.

§ Do not exceed the maximum rates allowed under the California Code of Regulations Restricted Materials Use Requirements, which may be lower than maximum label rates.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing.

VIRUSES AND VIROID DISEASES (11/20)

SYMPTOMS AND SIGNS

Virus diseases are recognized by several characteristic symptoms. Light and dark green mosaic patterns, mottles, ringspots, distortion of leaves and other plant parts, vein clearing, and vein enations are some of the symptoms seen in the leaves. Deformed, yellow, stunted growth, or overall stunting are other possible symptoms.

COMMENTS ON THE DISEASE

Viruses multiply only in living cells. They are too small to be seen with a light microscope and are therefore considered to be submicroscopic. Viruses are composed of a nucleic acid (most plant viruses contain ribonucleic acid [RNA]) and are enclosed in a protein coat. The nucleic acid of a few plant viruses (*Carnation etched ring virus*, *Dahlia mosaic virus*) is deoxyribonucleic acid (DNA). Viroids consist of low molecular weight RNA that lacks a protein coat. *Chrysanthemum stunt viroid* and *Chrysanthemum chlorotic mottle viroid* are examples of viroids.

Positive identification of virus infection involves several procedures, including visualization of virus particles with the electron microscope, serological techniques such as ELISA (enzyme-linked immunosorbance assay), sap inoculations of indicator plants, budding and grafting to indicator plants, microscopic examination for inclusion bodies (aggregates of virus particles or virus-induced protein structures), RNA and DNA hybridization, polymerase chain reactions (PCR), and gel electrophoresis.

Many viruses enter the host plant via the feeding activity of vectors that transmit the virus into plant cells. Insects, especially aphids, whiteflies, and leafhoppers, vector many viruses. Thrips vector *Tomato spotted wilt virus* and *Impatiens necrotic spot virus*. Mites, nematodes, and lower fungi also serve as vectors of a few viruses. See the Viruses With Wide Host Ranges table for a list of common plant viruses and their hosts, how they are spread, and links to photographs of their damage.

Most viruses are transmitted by vegetative propagation of new plant material from infected mother plants. Many plant viruses and viroids are spread by physical contact or by tools. Some orchid viruses are spread when healthy plants come in contact with diseased ones. Some viruses are pollenborne (*Cherry leaf roll virus*, *Prunus necrotic ringspot virus*). A few viruses are seedborne (*Squash mosaic virus* in muskmelons, *Tomato mosaic virus* in tomato, and others). Several viruses, including *Tobacco mosaic virus*, can survive in water run-off from infected plants, which, when recycled and used as irrigation water, can result in new infections.

MANAGEMENT

Control of virus diseases is a matter of prevention–the use of virus-free planting stock and resistant varieties. Once a plant is infected by a virus it usually remains infected for the life of the plant as there are no available pesticide treatments. Plants vegetatively propagated from infected mother stock are usually infected. However, virus-free plants can be obtained from infected plants by a combination of heat treatment and shoot tip (meristem) culture, and sometimes with the aid of chemical inhibitors of virus multiplication. Some viruses are transmitted from plant to plant by means of the feeding activity of insects. Once an insect has acquired a virus, it may retain it in a persistent (up to lifetime) or non-persistent (usually means minutes to hours) manner. Controlling insect vectors may help in reducing the spread of persistently transmitted viruses; however, with non-persistently transmitted viruses, insects can often spread the virus before they are inactivated by insecticides. Remove weeds and other plants that may harbor the virus and/or the vector.

Disinfection of pruning or propagation tools between cuts, or at least between different plant sets, varieties, or species, and the use of disposable gloves can help reduce the spread of virus diseases in a greenhouse operation. A solution of 1 part household bleach in 4 parts of water, applied for 5 minutes, acts as an effective disinfectant for virus-contaminated materials (tools, benches, etc.). Bleach solutions must be rinsed off with clean water to avoid toxicity to plants. (Note: Bleach treatments are corrosive to metal tools.) See MANAGEMENT OF SOILBORNE PATHOGENS section for more details.

Cultural Control

In outdoor field crop production, silver reflective mulch has been shown to repel aphids and whiteflies, thus reducing their numbers in and around plant canopies. In addition, virus transmission by these insects was greatly reduced. For best results, apply mulches at the time of planting or transplanting the crop. Apart from reducing aphid and virus incidence, silver reflective mulch increased cut flower production and reduced the crop requirement for irrigation water and fertilizer. This method is acceptable for organic production.

Viruses with wide host ranges.

Virus	Transmission	Ornamental hosts	Crop plant hosts	Weed and native plant hosts
Bean yellow mosaic (potyvirus group)	aphids; mechanically to an extent in gladiolus	gladiolus, sweet pea, violets	legumes, bean, clovers, fava bean, pea, soybean, sweet clover	legumes, *Chenopodium*, clovers, sweet clover
Beet curly top (geminivirus group)	leafhoppers	cosmos, coreopsis, geranium, nasturtium, petunia, strawflower, stock, viola, zinnia	bean, beets, borago, buckwheat, celery, clovers, cress, cucurbits, fava bean, fennel, flax, horseradish, pepper, potato, radish, rhubarb, tobacco, tomato, vetch	*Atriplex* spp., *Chenopodium* spp., clovers, *Polygonum* spp., *Rumex* spp., Russian thistle, shepherd's-purse
Cauliflower mosaic (caulimovirus group)	aphids	honesty (lunaria), stock	crucifers, broccoli, cabbage, cauliflower, Chinese cabbage, mustard	mustard, *Raphanus* spp., shepherd's-purse
Cucumber mosaic (cucumovirus group)	aphids; mechanically in many hosts	begonia, buddleia, calendula, China aster, columbine, dahlia, daphne, delphinium, geranium, gerbera, gladiolus ligustrum, lily, lobelia, nasturtium, passionvine, primula, snapdragon, vinca, viola, zinnia	buckwheat, carrot, celery, cucurbits, cowpea, pepper, potato, tobacco, tomato	commelina, lambsquarters, lupine, milkweed, nightshade, penstemon, pigweed, pokeweed, tree tobacco (*Nicotiana glauca*)
Prunus necrotic ringspot (ilarvirus group)	grafting; pollen	*Prunus* spp., rose	apple, hops, *Prunus* spp.	*Prunus* spp.
Tobacco mosaic (tobamovirus group)	mechanical; seeds may be externally contaminated, can be soilborne	delphinium, petunia, phlox, wisteria, flowering tobacco	beans, tobacco, tomato, peppers	*Emilia*, tree tobacco
Impatiens necrotic spot and tomato spotted wilt (tospovirus group)	thrips	amaryllis, aster, ageratum, begonia, calendula, calla, chrysanthemum, coreopsis, cosmos, dahlia, forget-me-not, gerbera, gladiolus, gloxinia, gypsophila, impatiens, kalanchoe, lily, nasturtium, nemesia, papaver, petunia, phlox, primula, ranunculus, salvia, stock, sweet pea, tagetes, verbena, zinnia, and others	artichoke, basil, bean, celery, clover, cowpea, endive, fava bean, lettuce, papaya, pea, peanut, pepper, pineapple, spinach, tobacco, tomato, and others	bindweed, chickweed, emilia, jimsonweed, knotweed, lupine, malva, *Mesembryanthemum*, miner's lettuce, physalis, pigweed, nightshade, shepherd's-purse, and others
Turnip mosaic (potyvirus group)	aphids	anemone, nasturtium, petunia, statice, stock, sweet william, wallflower, zinnia	Brussels sprouts, cabbage, cauliflower, cress, horseradish, lettuce, mustard, radish, rape, rhubarb, swede turnip	cruciferous weeds

Disease Control Outlines

ASTER, CHINA

Callistephus chinensis (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Fusarium wilt* (*Fusarium oxysporum* f. sp. *callistephi*)	Plants yellow and wilt, often on one side. Brown discoloration of vascular system develops. Disease also causes damping-off of young seedlings at soil temperatures of 75° to 80°F.	Commonly seedborne. In soil for many years. Disease is most severe when soil and/or air temperatures are high.	Use disease-free seed. Fumigate the seedbed with chloropicrin or a sequential application of chloropicrin/1,3 dichloropropene and metam sodium or solarize soil. Grow on clean land, or only once every 5 years on infested land. Treat seed with a fungicide.
Gray mold* (*Botrytis cinerea*)	Brown, water-soaked decay of flowers. Fuzzy gray fungus spores form on rotted tissues. Fungus also attacks base of plant.	In plant debris. Favored by cool, wet conditions.	Avoid overhead irrigation. Mist blooms with iprodione or fenhexamid.
Leaf spots (*Stemphylium callistephi*)	Circular, irregular, brown spots appear on lower leaves. Leaves may die.	In plant debris. Airborne spores require long (48 hrs), damp periods for infection.	Avoid low-lying areas where air movement is poor. Do not use overhead irrigation. Protect foliage with a fungicide such as mancozeb.
Root rot (*Pythium** and *Phytophthora* spp.*)	Plants wilt or suddenly collapse. Roots decay. Blackish discoloration of leaves, stems, and roots occurs. Also causes damping-off of seedlings.	In soil. Favored by heavy, waterlogged soils.	
Rust* (*Coleosporium asterum*)	Orange pustules of powdery spores form on undersides of leaves. On living plants and possibly from spores from alternate host (three-needle pines).	Favored by free moisture from rain, dew, or fog.	Avoid overhead irrigation. Treat at the first signs of rust and continue until conditions are no longer favorable for the disease. Grow seedlings away from main crop.
Cottony rot or Sclerotinia rot (*Sclerotinia sclerotiorum*)	Infection girdles stems. Cottony, white fungal growth and large, black sclerotia develop on and inside stems. Stems take on a bleached-white color.	Airborne spores produced by sclerotia in soil, but infection more common from growth of hyphae from sclerotia. Favored by wet weather.	Avoid overhead irrigation. Treat planting area with PCNB. Spray plants with iprodione or thiophanate-methyl before rainy periods and at 2- to 4-week intervals during wet weather. Remove plant debris from field.
Stem rot (*Rhizoctonia solani, Botrytis cinerea*)	A brown decay develops at the soil line and affects the basal leaves and stem.	Soilborne and in plant debris. Gray mold (*B. cinerea*) favored by cold, damp conditions. Disease development can be rapid under high temperature conditions.	Before planting or transplanting, mix PCNB or *Trichoderma* spp. into top inch of soil. Spray bases of seedlings with thiophanate-methyl, iprodione, or *Trichoderma* spp.
Verticillium wilt* (*Verticillium dahliae*)	Symptoms are almost identical to Fusarium wilt. Not a common disease of asters in California.	In soil for many years. Symptoms most severe during warm weather that follows a cool period.	Avoid planting in fields where fungus has occurred or fumigate soil as described for Fusarium wilt.

Virus or viruslike diseases	Symptoms	Host range and natural spread	Comments on control
Aster yellows* (*Aster yellows phytoplasma*)	Infected plants produce an upright basal rosette of yellow shoots. Sometimes one-sided. Flowers are deformed and remain green. Sporadic disease of asters in California.	*Aster yellows phytoplasma* has a wide host range. Vectored by leafhoppers.	Locate seedbed away from weedy areas. Control weeds and leafhoppers in noncropped areas.

AZALEA

Rhododendron spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Cutting rot and graft decay (*Rhizoctonia solani* and *Cylindrocladium scoparium*)	Basal rot of cuttings occurs. Under humid conditions, tops are rotted and covered with fungal strands (mycelium).	In soil and plant debris. Favored by moist conditions and temperatures of 75° to 80°F.	Steam or chemically treat propagating media, flats, etc. Grow stock plants in treated media and observe strict sanitation. Spray or drench cuttings in rooting media with thiophanate-methyl or iprodione. *Cylindrocladium* is difficult to control with fungicides; triflumizole can be used in enclosed commercial structures.
Flower blight (*Ovulinia azaleae*)	Small, round spots rapidly enlarge and cause entire flower to collapse. Rotted flower becomes soft and clings to leaves or stems.	Black fungal structures (sclerotia) produced in diseased flowers and survive in soil. Favored by cool, rainy weather and by moisture on flowers. Spores are airborne.	Avoid overhead irrigation. Remove and burn diseased blossoms. Mulch soil with 4-inch layer. Treat soil with PCNB several weeks before plants bloom. Protect blossoms with thiophanate-methyl or triadimefon.
Leaf gall (*Exobasidium vaccinii*)	All or part of leaf becomes greatly thickened, distorted, and crisp. Also affects flowers. Infected parts are covered with a white or pinkish bloom of fungal spores.	On living plants. Airborne spores produced only during wet weather.	Hand-pick galls where practical before they turn white. Avoid overhead irrigation. Protect foliage with a fungicide, such as mancozeb, during wet weather.
Ramorum blight* (*Phytophthora ramorum*)	Leaf lesions that vary in size from 0.2 inches to covering nearly half the leaf. Lesions primarily at leaf tip or edge; can be surrounded by diffuse margins or thick black zone line. Infected leaves drop prematurely and lower part of plant can defoliate. Symptoms may be confused with leaf scorch in areas of high heat/sun.	Spore structures commonly form on leaf surfaces and twigs, following prolonged wetting. They are moved in contaminated soil, from plant to plant via windblown rain, or by direct contact with infected leaves.	Monitor incoming stock and areas surrounding the nursery for symptoms, follow good cultural and sanitation practices, and use preventive treatments before environmental conditions favor development of the pathogen.
Root rot (*Pythium** and *Phytophthora* spp.*)	Plants are low in vigor. Leaves wilt and turn dull green and fall prematurely, so only a few terminal leaves remain on the plant. Plants frequently die. Wood under bark at soil line is discolored. Roots become discolored and rotten (*Pythium*). Root and basal stem rot (*Phytophthora*).	Water molds occur in soil. Favored by overwatering, poor drainage, and other factors that weaken plants.	Treat growing media with chloropicrin or other recommended fumigants. Select cuttings from high on stock plants. Drench plants with oomycete (water mold) specific fungicide, or spray with fosetyl-Al.
Septoria leaf spot or leaf scorch (*Septoria azaleae*)	Dark, reddish brown, angular spots appear on leaves, which fall prematurely. Leaves yellow on some cultivars.	On living and dead leaves. Favored by wet weather. Fungal spores spread in splashing water.	Avoid overhead irrigation. Protect foliage with a fungicide such as mancozeb or thiophanate-methyl.

Azaleas are also susceptible to crown gall* (*Agrobacterium tumefaciens*), gray mold* (*Botrytis cinerea*), powdery mildew* (*Erysiphe* sp.), and web blight (*Rhizoctonia solani*).

* For additional information, see section on Key Diseases.

BEGONIA

Begonia spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Bacterial leaf spot (*Xanthomonas campestris* pv. *begoniae*)	Circular, necrotic spots start as small, water-soaked, blisterlike spots. Premature abscission occurs when spots are numerous.	Systemic as well as in dead begonia leaves. Favored by splashing water or overhead irrigation and high temperatures (80° to 90°F).	Keep humidity low. Avoid wetting foliage. Do not crowd plants. Remove and destroy infected plants.
Gray mold* (*Botrytis cinerea*)	Soft, brown rot of leaves, stem, and flowers occurs. Fuzzy gray fungal spores form on decayed tissues. Fungus is common on weakened plants. *Botrytis* may also start in powdery mildew spots, sunburned tissues, tissues injured by other means, or in ligules.	In plant debris; common on any dead plant material on soil if moist. Resting sclerotia favored by high moisture conditions and low temperatures.	Control root rots and powdery mildew*. Pick up dead flowers and leaves. Keep humidity low. Protect plants with fungicide such as fenhexamide. Avoid overhead irrigation.
Powdery mildew* (*Erysiphe begoniicola*, *Golovinomyces orontii*)	White, powdery spots develop on upper and lower leaf surfaces and small, greasy spots occur on undersides of leaves. Also may appear on flowers of some fibrous begonias.	On living begonia leaves; rarely as resistant fungal structures (chasmothecia). Spores are airborne as well as spread in water, but do not survive in free water. Favored by moderate temperatures and shade. Common on plants as they senesce in fall.	Increase air movement; some resistant cultivars available. Spray at the first sign of mildew and at 2- to 3-week intervals thereafter. Use myclobutanil, or triadimefon. Triadimefon is very effective but expect stunting of some plants.
Root and stem rot* (*Pythium* spp.)	Plants are stunted, unthrifty, and may die. Root system is small and discolored. Also invades tubers of tuberous begonias. Stem rot phase: stems become water soaked and discolored, and collapse. Disease also causes damping-off of seedlings. Plants are predisposed to sunburning.	In soil. Spores spread in water and when infested soil is moved to uninfested areas. Favored by excess water.	Steam or chemically treat soil. Observe strict sanitary measures. Drench plants with oomycete (water mold) specific fungicide. Do not drench very young seedlings.

Virus or viruslike diseases	Symptoms	Host range and natural spread	Comments on control
Spotted wilt (*Tomato spotted wilt virus*)	Rings or zoned spots develop on leaves. Plants are stunted; flowers are of poor quality.	Infects begonias, nasturtiums, callas, dahlias, and some weeds. Transmitted by thrips.	Eliminate nearby weeds and susceptible ornamental plants. Control thrips.

Begonias are also susceptible to Armillaria root rot (*Armillaria mellea*), anthracnose (*Gloeosporium* sp.), black root rot (*Thielaviopsis basicola*), cottony rot* (*Sclerotinia sclerotiorum*), crown gall* (*Agrobacterium tumefaciens*), foliar nematode** (*Aphelenchoides olesistis*), leaf spot (*Phyllosticta* sp.), Rhizoctonia stem rot (*Rhizoctonia solani*), root knot nematode** (*Meloidogyne* spp.), soft rot (*Pectobacterium* (=*Erwinia) carotovorum*), and Verticillium wilt* (*Verticillium dahliae*).

* For additional information, see section on Key Diseases.
** For additional information, see section on Nematodes.

CALLA

Zantedeschia spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Crown rot (*Rhizoctonia solani*)	Base of stems of callas are infected at or below the soil line, causing a general chlorosis of foliage.	Favored by warm, moist conditions. Fungus is present in most field soils.	Avoid deep planting and overwatering. Treat soil with PCNB before planting.
Pythium rot* (*Pythium ultimum*)	Roots may rot first. Pink and yellow corms develop irregular-shaped, shallow, water-soaked lesions that may coalesce. Infection spreads into interior tissues of root structures, producing irregular-shaped gray lesions that are sharply delimited.	Pathogen enters root structures through wounds. It is present in many field soils and has a wide host range. Disease is favored by warm, moist conditions, heavy soils, and poor drainage.	Avoid injuries to the rhizomes. Clean and dry root structures soon after digging. Store below 50°F. Some of the water mold fungicides would probably be effective in controlling the disease.
Phytophthora root rot* (*Phytophthora cryptogea*)	Yellowing of leaf margins of outer leaves followed by general yellowing and wilting. Feeder rootlets are rotted.	Pathogen is present in some field soils. Several other types of plants may be infected. Favored by wet soil conditions.	Grow on raised beds and provide good drainage. Do not overirrigate. Treat with oomycete (water mold) specific fungicide.
Soft rot (*Pectobacterium* (=*Erwinia*) *carotovorum*)	A soft rot of the rhizomes. Plants may rot off at the soil line. Bacterium is a common secondary invader of succulent plant parts and generally requires some sort of injury to cause disease. Has odor.	Bacterium is present in some field soils. Favored by warm, moist conditions and plant parts attacked by other organisms.	Avoid injuries to the rhizomes. Do not overwater. Yellow callas are more susceptible than others, but there are new yellow cultivars that are more resistant.

Virus or viruslike diseases	Symptoms	Host range and natural spread	Comments on control
Dasheen mosaic (*Dasheen mosaic virus*)	Mosaic patterns in leaves, which may be severely distorted. Infects plants low in vigor.	Common because callas frequently propagated vegetatively, which spreads the virus. Virus is spread by aphids. Spread in a planting can be rapid. Can be transmitted by sap but not by seed.	Obtain or develop virus-free plants by heat treatment and tissue culture. Control aphids. Remove infected plants.
Spotted wilt (*Tomato spotted wilt virus* and *Impatiens necrotic spot virus*)	Foliage, petioles, and flower stalks are streaked or spotted by whitish or yellowish areas, and sometimes by small, concentric rings. Necrotic areas that develop in leaves may be colonized by secondary fungi. Sometimes the necrotic areas are attributed to fungi, but usually they are secondary invaders.	Common because callas frequently propagated vegetatively, which spreads the disease. Both viruses are also transmitted by several thrips species. Virus is acquired by nymphal stage and transmitted by adult throughout its life. The virus has a very wide host range including many weeds and ornamental plants.	Control weeds and thrips. Destroy infected callas.

Callas are also susceptible to leaf spots (*Gloeosporium callae*, *Coniothecium richardiae*, and *Cercospora richardiae*), powdery mildew* (*Oidiopsis taurica*), Armillaria root rot* (*Armillaria mellea*), gray mold* (*Botrytis cinerea*), *Phytophthora* spp., seedling rot (*Rhizoctonia solani*), southern blight* (*Sclerotium rolfsii*), and root knot nematode** (*Meloidogyne* spp.)

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

CAMELLIA

Camellia spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Dieback (*Glomerella cingulata*)	Wilting and dying of branches. Leaves darken and often remain attached. Branch is girdled by fungus that enters through injuries, including leaf scars.	Found in warmer areas of California. Favored by wet, warm conditions, weakened plants, and injuries. Fungus spores (conidia) are spread by splashing water. Fungus has a wide host range.	Prune diseased tissues and protect wounds with a fungicide such as captan. Avoid overwatering.
Flower blight (*Ciborinia camelliae*)	Flowers have dry rot with accented veins. Only petal tissues are infected. First symptoms are small tan or brown necrotic spots in the center of the flower that enlarge and move rapidly to the base of flower. Rotted flowers are heavy and easily fall to ground. The fungus continues to develop, forming sclerotia in the calyxes of infected flowers.	Sclerotia survive on or in soil and germinate for several years producing fruiting bodies (apothecia) that discharge spores (ascospores) forcibly into the air.	Where practical, pick up all blossoms because fallen blossoms either may be infected or may become infected while on the ground. Prevent sclerotia from germinating by spraying ground with PCNB annually. Thiophanate-methyl will protect petals from infection but sprays must be applied frequently as new flowers open. Mulches 4 inches or more deep will help prevent apothecia from reaching the surface.
Gray mold* (*Botrytis cinerea*)	Necrotic, brown spots. Rot does not move to the base of the flower as rapidly as the flower blight fungus. Fuzzy gray fungus spores form on decayed blossoms under high humidity.	Favored by cool wet weather. Spores are airborne. Fungus survives on and in old flowers.	Avoid overhead irrigation. Clean up plant debris, especially floral tissues. Protect flowers with a fungicide effective against *Botrytis* such as fenhexamid.
Phytophthora root rot* (*Phytophthora* spp.)	Plants stunted and low in vigor. Foliage yellows, plant wilts and dies. Roots rotted. When plants collapse, the stem is girdled at or below the soil line. *Phytophthora cinnamomi* is often involved but other species also infect camellias.	*Phytophthora* spp. survive in soil as resting spores. They are common in stream and ditch water. Infective spores (zoospores) swim very short distances in soil water. Disease is favored by poor drainage, long wet periods, and standing water.	Heat or chemically treat propagation and growing media. Drench plants on a preventative basis with oomycete (water mold) specific fungicide.
Ramorum blight[1] (*Phytophthora ramorum*)	Leaf lesions that vary in size from 0.2 inches to covering nearly half the leaf. Lesions primarily at leaf tip or edge; can be surrounded by diffuse margins or thick black zone line. Infected leaves drop prematurely and lower part of plant can defoliate. Symptoms may be confused with leaf scorch in areas of high heat/sun.	Spore structures commonly form on leaf surfaces of susceptible leaves and twigs following prolonged wetting. They are moved in contaminated soil, from plant to plant via windblown rain, or by direct contact of infected leaves.	Monitor incoming stock and areas surrounding the nursery for symptoms, follow good cultural and sanitation practices, and use preventive treatments before environmental conditions favor development of the pathogen.

Camellias are also susceptible to several viruses and viroids such as color break virus and golden ring spot complex.*

* For additional information, see section on Key Diseases.

[1] *Phytophthora ramorum* was isolated from the following *C. japonica* cultivars on two or more occasions: Bob Hope, Mrs. Charles Cobb, Daikagura var. Debutante, Elegans Splendor, Glen 40, Kumasaka, Kramer's Supreme, Mathotiana Supreme, Nuccio's Gem, Nuccio's Pearl, Silver Waves, Shiro Chan, Tom Knudsen, *P. ramorum* was isolated from the following *C. sasanqua* cultivars on two or more occasions: Apple Blossom, Cleopatra, Hana Jiman, Jean May, Kanjiro, Setsugekka, Yuletide. *P. ramorum* was isolated from the following *C. oleifera* cultivar on two or more occasions: Winter's Fire.

CARNATION

Dianthus caryophyllus (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Alternaria leaf spot* and branch rot (*Alternaria saponariae*)	Gray-brown leaf or petal spots with purple margins. Black spore masses form in spots. Branch rot starts at nodes and girdles stem.	In infected plants and debris. Airborne spores. Moist conditions for 8 to 10 hours required for infection.	Provide good air circulation and keep humidity low. Irrigate in early morning. Do not wet foliage with irrigation water. During periods of high humidity, protect plants with iprodione, mancozeb, or chlorothalonil.
Bacterial wilt* (*Pseudomonas caryophylli*)	Sudden wilting of tops or individual branches. Basal stem cracks. Roots may be rotted. Vascular discoloration in stems is yellowish to brown. The outer layer (epidermis) separates easily from stem, which is sticky to the touch.	Infected plants and debris. Bacteria spread in water. Favored by high temperatures.	Use disease-free cuttings and treat soil as above. Bacteria can spread quickly. Avoid use of cutting dips and avoid splashing water. Break cuttings from stock plants. Disinfect tools.
Calyx rot (*Stemphylium botryosum*)	Rot starts at tip of calyx and progresses towards base.	In old leaves, stems, and debris. Favored by high humidity.	Same as Greasy blotch. Harvest regularly.
Fairy-ring leaf spot (*Cladosporium echinulatum*)	Conspicuous tan spots with concentric rings. Margin of spot may be red. Dark spores form in spots.	Infected plants and debris. Airborne spores. Favored by wet weather.	Provide good air circulation and keep humidity low. Irrigate in early morning. Do not wet foliage with irrigation water. Protect foliage with mancozeb.
Fusarium bud rot (*Fusarium tricinctum*)	Outwardly normal buds are brown and decayed inside. Cottony white growth and plump white mites may be visible.	Fungus carried by grass mite, *Pediculopsis graminum*.	Destroy infected buds. Control mites. Do not bring field-grown carnations into greenhouse. Control weeds outside growing area.
Fusarium stem rot (*Fusarium avenaceum*, *F. culmorum*, *F. graminearum*)	Stem rotted at soil line and high up on plant. Roots and base of stem rotted. Tops wilt and die. Pink cushions of spores may form at base of plant on decayed tissues. Common as a cutting rot.	In soil and plant debris. Spores spread in water. Also favored by warm, humid conditions. Also favored by high N fertilization and high N:K ratio.	Use clean cuttings and rooting medium. Spray cuttings in rooting medium with thiophanate-methyl.
Fusarium wilt* (*Fusarium oxysporum* f. sp. *dianthi*)	Yellow, wilted branches frequently occur on one side at first. Vascular discoloration is dark brown. Root system usually remains intact. In late stages, stem develops a dry, shredded rot. Infected parts die.	Soil and infected plants. Spores spread in water. Favored by soil temperatures 75°F and above. Restricted below 60°F.	Plant resistant cultivars. Use disease-free cuttings planted in treated soil. Steam soil in raised beds at 140°F for at least 30 minutes. Solarize soil or fumigate with chloropicrin. Adjust soil pH to 6.5 to 7.0.
Moderately resistant:	Ace, Apache, Barsemi Yasmino, Big Red, Comanche, Corona, Exquisite Select, Felicia, Fiesta, Georgia Ann, Jolievette, Lucy Carrier, Maman, Mei-Sciang, Orchid Beauty, Pallas, Shiro, Silvery Pink, Sweetheart, White Elegance		
Highly resistant:	Barbi, Candy Maj, Capello, Carbasio, Improved Lilac, Juanita, Lady Di, Light Pink Marble, Maiko, Maj Pink, Meiling, Melody, Moonlight, Picotee Orange, Scarlett Elegance, Siri #1, White Melody		
Gray mold* (*Botrytis cinerea*)	Fuzzy gray fungal spores form on soft, brown, decayed blossoms and can move into plant parts wherever blossoms touch them.	In plant debris. Airborne spores. Favored by high moisture conditions and low temperatures.	Remove old flowers from growing area. Maintain horizontal air movement. Lower humidity where possible. Mist blooms with iprodione or fenhexamid.

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Carnation, continued

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Greasy blotch (*Zygophiala jamaicensis*)	Greasy-appearing spots on leaves with radiating weblike margins. Pimpling of infected areas.	In infected plants and debris. Favored by high humidity. Not too common.	Provide good air circulation and keep humidity low. Irrigate in early morning. Do not wet foliage with irrigation water.
Phialophora wilt (*Phialophora cinerescens*)	Gradual wilting of plants; leaves become straw colored. Not one-sided as Fusarium wilt may be. Brown discoloration of vascular system. Little or no tissue rotting in late stages. Uncommon.	Soil and infected plants. Spores spread in water. Favored by cool soil temperatures.	Use disease-free cuttings and treat soil as above.
Phytophthora stem rot* (*Phytophthora parasitica*)	Stem rotted at soil line. May be mistaken for Rhizoctonia stem rot.	In soil and plant debris. Favored by warm, moist soil and poor drainage.	Steam or fumigate soil. Drench at planting with oomycete (water mold) specific fungicide.
Pythium root rot* (*Pythium* spp.)	Plants are stunted, particularly in lower, poorly drained areas. Rootlets rotted.	Soilborne. Common in most soils. Favored by poor drainage, low spots, excessive irrigation.	Steam or fumigate soil (see Fusarium wilt). Drench plants with oomycete (water mold) specific fungicide periodically, depending on severity of disease. Make first application at planting.
Rhizoctonia stem rot (*Rhizoctonia solani*)	Stem rotted at soil line. Rot progresses from the outside. Entire plant wilts and dies. Dark fungal strands and sclerotia may be visible with a hand lens.	Soilborne; plant debris. Favored by warm, moist conditions.	Steam rooting medium and soil. Use PCNB before transplanting, or spray base of transplant with iprodione.
Rust* (*Uromyces dianthi*)	Small pustules of powdery brown spores. Spores are airborne.	Carried over only on living plants. Favored by moist conditions.	Use resistant cultivars or protect plants in problem areas with myclobutanil or mancozeb.

Virus or viruslike diseases	Symptoms	Host range and natural spread	Comments on control
Mottle (*Carnation mottle virus*)	Faint leaf mottle or no symptoms. Common in virtually all carnation cultivars.	Handling and cutting knife. Not transmitted by insects. May be spread in drainage water.	Reduce spread of mottle by disinfecting tools between blocks of plants and several times a day. Obtain virus-free plants.
Etched ring	Rings usually oval or elongated; rarely concentric on older leaves and stems. Symptoms may be slight in young cuttings. No obvious effect on plant vigor.	Aphids. Not spread by handling.	Obtain virus-free plants. Control aphids.
Necrotic fleck	Reddish purple necrotic flecks, streaks, or spots appear in leaves. Symptoms are masked at low temperatures.	Aphids.	Obtain virus-free plants. Control aphids.
Ring spot	Small 0.5- to 1-inch rings; sometimes concentric. Chlorosis, mottling, and distortion of young leaves. Plants obviously stunted.	Cutting knife and handling. Insect vectors unknown.	Same as for mottle.
Vein mottle (not common in California)	Young leaves exhibit a vein clearing, which develops into chlorotic spots and patterns that mostly follow veins. Symptoms tend to disappear on old leaves.	Aphids. Not spread by handling or cutting knife.	Obtain virus-free plants. Control aphids.

* For additional information, see section on Key Diseases.

CATTLEYA

Cattleya spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Bacterial soft rot (*Dickeya* (=*Erwinia*) *chrysanthemi*)	Soft, watery rot of leaves; often foul smelling. Starts as small water-soaked area. Infection is through wounds. Often kills cattleya plants.	In soil and decaying plant debris. Bacteria spread in water. Favored by warm, moist conditions.	Avoid overhead watering, wounding plants, and provide horizontal air movement and good aeration. Observe strict sanitation. Disinfect knives between cuts.
Black rot and seedling damping-off (*Pythium ultimum**, *Phytophthora cactorum**)	Starts as small, water-soaked leaf spots and root rot. Decay may progress rapidly. Affected tissues turn black and are sometimes soft.	Soilborne fungi. Spores spread in water. Favored by warm moist conditions (above 65°F).	Drench plants with oomycete (water mold) specific fungicide. Steam or chemically treat growing media and used pots. Remove badly infected plants.
Botrytis flower brown speck or rot (*Botrytis cinerea*)	Tiny, light-brown spots on blossoms may enlarge to rot entire flower. Fuzzy gray fungal spores develop on flowers if kept moist.	On plant debris. Spores airborne. Favored by cool, moist conditions.	Eliminate old flowers. Eliminate plant debris, both inside and outside growing area. Avoid getting flowers wet. Treat with fenhexamid.
Gloeosporium leaf spot (*Gloeosporium* spp.)	Prominent, sunken, reddish brown spots with definite margins. Spots may coalesce and kill entire leaf. Spots start as minute, dark areas, often at leaf tips.	In infected plants. Spores spread in water. Favored by moist conditions and unfavorable growing conditions.	Provide better growing conditions. Avoid wetting foliage. Remove infected tissues.
Rust (*Sphenospora kevorkianii*, *Uredo nigropuncta*)	Pustules of powdery, yellow or orange spores on undersides of leaves.	In infected plants. Spores airborne. Moisture needed for only short period. Not too common.	Avoid wetting leaves. Destroy infected leaves.

Virus or viruslike disease	Symptoms	Natural spread and host range	Comments on control
Blossom necrotic streak (a strain of *Cymbidium mosaic virus*)	Blossoms open without evidence of brown spots or streaks, which become visible after about 1 week or longer. Long, yellowish, irregular streaks may develop on leaves.	Can be spread on cutting tools.	Use clean cutting tools. Destroy infected plants.
Leaf necrosis (*Cymbidium mosaic virus*)	Irregular, elongated streaks of dead tissue on undersurface of older leaves. Some leaves may be killed or various patterns of sunken, black tissue may develop. Infected plants may show no symptoms.	Spread by pruning tools. *Cattleya* and its hybrids, *Cymbidium, Epidendrum, Zygopetalum, Angraceum, Laelia, Oncidium, Spathoglottis*.	Use clean and disinfected cutting tools.
Mild flower break (*Odontoglossum ringspot virus*)	Flowers less variegated than above and without distortion. Leaves show only mild, hard-to-detect mosaic symptoms. Spots and streaks of increased pigment intensity.	Unknown, but can be transmitted by juice inoculations. *Cattleya* and its hybrids, *Cymbidium, Odontoglossum, Phalaenopsis*.	Isolate or destroy infected plants. Disinfect tools between cuts with a quaternary ammonium disinfectant.
Severe flower break	Variegation of flower color. May also distort sepals and petals. Leaves mottled with streaks of light and dark green tissue. Dark green areas somewhat raised, producing ridges and bumps.	Spread by green peach aphid. *Cattleya* and its hybrids, *Cymbidium*.	Same control for all viruses.
Virus or viruslike disease	**Symptoms**	**Natural spread and host range**	**Comments on control**
Symmetrical flower break	A symmetrical variegation in which pigment occurs along sepal margins and over most of petals, except in middle	Unknown, but can be transmitted by juice inoculations. *Cattleya*.	Use clean and disinfected cutting tools.

areas that have little or no pigment. Leaves may develop an inconspicuous mosaic mottle.

* For additional information, see section on Key Diseases.

CHRYSANTHEMUM

Chrysanthemum grandiflora (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Bacterial blight* (*Dickeya chrysanthemi*)	Water-soaked lesions; pith becomes jellylike; tops turn black and exude drops of liquid. Stem may break or split.	In plant debris. Favored by high temperatures (80° to 90°F), absence of free water, and high humidity.	Use disease-free cuttings. Reduce humidity in growing areas. Dip cuttings in streptomycin.
Cottony rot* (*Sclerotinia sclerotiorum*)	Stems rotted; flower rot is similar to gray mold. Cottony, white fungal mass may occur on rotted tissues. Black sclerotia may form inside or outside stems.	Sclerotia in soil. Spores produced from sclerotia are airborne but infect only through flowers and dead tissues. Favored by high humidity.	Same as for gray mold. Also, treat soil with PCNB before planting and spray foliage with iprodione or thiophanate-methyl.
Crown gall (*Agrobacterium tumefaciens*)	Irregular or round galls on stems and sometimes leaves.	Soil and galls. Infection favored by moist conditions.	Destroy infected plants.
Foliar nematode (*Aphelenchoides ritzemabosi*)	Dark green, angular spots in leaves develop progressively upward from base of plant. Leaves turn yellow. These nematodes are rarely important in California.	Adults can survive up to 3 years in dead leaves. Spread by splashing water. Leaves need to be wet for infection to take place.	Use disease-free plants. Discard infected plants. Avoid overhead irrigation. Control weeds. Submerge infected plants in hot water (115°F) for 10 minutes.**
Fusarium wilt* (*Fusarium oxysporum* f. sp. *chrysanthemi* and f. sp. *tracheiphilum*)	Unilateral chlorosis of one or more leaves near the apex, followed by curvature of the stem towards the affected side. As the disease progresses, there is a general chlorosis and wilt and stunting of leaves. The vascular system becomes a reddish brown.	Soilborne and carried in cuttings. Favored by high soil temperatures (80°F).	Use disease-free cuttings in clean soil. Treat soil (see Verticillium wilt). Adjust pH of soil to 6.5 to 7.0 and use nitrate nitrogen. Avoid planting highly susceptible cultivars (Bravo, Cirbronze, Illini Trophy, Orange Bowl, Royal Trophy, Yellow Delaware)
Gray mold* (*Botrytis cinerea*)	Brown, water-soaked spots on petals. Fuzzy gray fungal spores form on decayed tissues. Rotting of lower leaves. Fungus may enter and girdle stem.	In plant debris. Favored by high humidity, low temperatures (50° to 60°F), and water on plant.	Keep humidity low; avoid overhead irrigation. Protect foliage with a fungicide, especially lower-dense foliage. Mist blooms with chlorothalonil, iprodione, or fenhexamid.
Hollow stem (*Pectobacterium* (=*Erwinia*) *carotovorum*)	Pith of rooting cuttings deteriorates and collapses. Affected tissues are brown. Surviving plants do not grow satisfactorily and pith collapse may extend upward involving several internodes. Red Torch, Tempo, and Tempter are very susceptible cultivars.	Bacteria may be present in vascular bundles of symptomless chrysanthemums. Bacteria also present in undecomposed debris. Favored by high temperatures and high moisture.	Use disease-free cuttings. Reduce humidity in growing areas. Streptomycin dips may be helpful.
Powdery mildew* (*Golovinomyces cichoracearum*)	White powdery growth on leaves and stems. Found mainly on older leaves.	Airborne spores produced only on living plants. Favored by high humidity, crowding of plants, and cool weather.	Spray with piperalin to eradicate existing infections. Protect foliage with myclobutanil or triadimefon.
Pythium root rot and basal stem rot* (*Pythium* spp.)	Girdling black lesions occur near soil line. Plants stunted because of reduced root system caused by root rot. Plants may die.	Soilborne pathogen. Spores spread in water or in soil. Favored by excess soil moisture and poor drainage.	Treat soil as for Verticillium wilt. Drench plants with oomycete (water mold) specific fungicide.
Ray blight (*Phoma chrysanthemi*)	Basal leaf and stem rot. Below ground stem infection may cause a one-sided distortion and necrosis of foliage. Blackish rot of petals (ray blight) may extend into flower stalk.	In chrysanthemum refuse. Waterborne spores. Favored by rainy weather.	Use disease-free cuttings. Avoid wetting foliage and keep humidity low. Protect foliage with chlorothalonil.

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Chrysanthemum, continued

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Rhizoctonia stem rot (*Rhizoctonia solani*)	Stem rotted at soil line. Plants stunted. Dark fungal strands may be visible with hand lens. May kill plants.	Soilborne fungus. Favored by warm, moist conditions.	Avoid deep planting. Spray base of transplants with thiophanate-methyl, chlorothalonil, or iprodione after planting, or treat soil with PCNB before planting.
Rust* (*Puccinia tanaceti*)	Small pustules of powdery, chocolate-brown spores on undersides of leaves and on stems.	Airborne spores produced only on living plants. Free moisture necessary for infection. Principally a field disease.	Use resistant cultivars. Protect foliage with triadimefon or mancozeb before rust starts to build up. Avoid wetting foliage. Keep humidity low.
Septoria leafspot (*Septoria obesa*, *S. chrysanthemi*)	Irregular or circular, brown or black dead spots develop progressively upward from base of plant. Tiny black fungal fruiting bodies in centers of spots.	In plant debris and in soil debris for 2 years. Spores spread in splashing water. Favored by wet weather.	Protect foliage with a fungicide at first sign of disease. Greenhouse: avoid wetting foliage. Keep humidity low.
Verticillium wilt* (*Verticillium dahliae*)	Yellowing and wilting of foliage, may be one-sided. Leaves die and dry upward from the base of the plant. Vascular tissue may be discolored.	Soilborne for many years. Carried in cuttings and root divisions. Favored by cool weather followed by hot weather during flowering.	Use resistant cultivars and pathogen-free plants. Fumigate with chloropicrin or other chloropicrin combinations. In sunny climates, soil solarization might be considered.
White rust (*Puccinia horiana*)	Whitish pustules on the lower leaf surface. On the upper surface the infection is evident as pale-green to yellow spots up to 4 mm in diameter. Raised, waxy, pink-colored pustules are formed on lower leaf surface and can coalesce into large areas covering the leaf, Pustules found on stems and sometimes flowers. As they mature and produce spores, they turn whitish in color.	This microcyclic rust survives on living chrysanthemum foliage. Teliospores in the leaf pustules germinate in place producing basidiospores that are airborne and infect by direct penetration. Favored by the same conditions as ordinary rust (cool, damp weather), except that direct sunlight destroys airborne basidiospores. Principally a greenhouse disease.	White rust is widespread throughout many areas of the world but is not confirmed as established in the United States. Any offshore introduction of this pathogen is a significant threat to the United States floriculture industry. It spreads rapidly in greenhouse and nursery environments, resulting in severe losses. As a quarantine pest, detection leads to federal and state regulatory action. See USDA Plant Pest Program for Chrysanthemum White Rust.

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Chrysanthemum, continued

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Aspermy (*Tomato aspermy virus*)	Flower distortion and reduction in flower size. Color break in florets of red, bronze, and pink cultivars. Foliar symptoms not apparent. Some cultivars are symptomless.	Transmitted by handling, cutting tools, and vegetative propagation. Also transmitted by aphids.	Use disease-free cuttings. Control aphids; remove infected plants.
Chlorotic mottle (*Chrysanthemum chlorotic mottle viroid*)	Mottling followed by complete chlorosis. May be confused with nutritional problems. Symptoms somewhat masked under low light and cool temperature conditions below 70°F.	Spread by handling, cutting tools, and vegetative propagation.	Use disease-free cuttings. Remove infected plants.
Spotted wilt (*Tomato spotted wilt virus, Impatiens necrotic spot virus*)	Frequently one-sided in plant. Ring patterns on leaves of some cultivars. Leaf distortion and necrosis. Dark necrotic streaks on stems. Flowers may be distorted and with some necrosis.	Thrips-transmitted; not spread by cutting knife, but can be spread by vegetative propagation. Many weeds and perennial ornamental plants act as reservoirs of virus (dahlia, calla, nasturtium, mallow, knotweed, plantain, and others).	Eliminate nearby susceptible ornamental plants and weeds. Control thrips inside and outside growing areas. Use virus-free cuttings.
Stunt (*Chrysanthemum stunt viroid*)	General stunting of plants. Foliage may be pale with upright, young leaves. Flowers are smaller than normal and some cultivars may flower 7 to 10 days early.	Viroid is easily transmitted by handling, cutting knives, vegetative propagation, etc. Not spread by insects. Viroid has a wide host range. Symptomless in some plants.	Obtain disease-free plants from a propagation specialist using an indexing program.

Chrysanthemums are also susceptible to Ascochyta blight (*Mycosphaerella ligulicola*, *Ascochyta chrysanthemi*), aster yellows* (aster yellows phytoplasma), charcoal rot (*Macrophomina phaseolina*), and southern blight* (*Sclerotium rolfsii*).

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

CYCLAMEN

Cyclamen spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Anthracnose (*Cryptocline* [=*Gloeosporium*] *cyclaminis*)	Distinctly zonate, pale green and circular spots. Orange to pink-colored spores on stems and leaves.		
Gray mold* (*Botrytis cinerea*)	Spotting of flowers. Decay of emerging flower stems and leaf petioles under leaf canopy. Fuzzy gray fungal spores form on rotted tissues.	In plant debris, especially flowers. Common saprophytic fungus. Favored by cool, wet weather. Water necessary for spore germination.	Avoid overhead watering. Remove old flowers. Improve air circulation. Control humidity to avoid moisture condensation. Treat with iprodione or fenhexamid.
Soft rot (*Dickeya* (=*Erwinia*) *chrysanthemi*)	Plants collapse suddenly. Tuber is mushy.	Infected plants and debris. Disease is favored by high temperatures (75°F and above). Bacteria are spread by splashing water and handling.	Discard infected plants. Avoid excessive water splashing. Maintain sanitary conditions. Keep greenhouse cool.
Root rot (*Pythium** and *Phytophthora* spp.*)	Plants are stunted. Roots are discolored and rotten, lower leaves wilt and may turn yellow.	Pathogens are normal inhabitants of natural soil. Disease is favored by poor drainage and overwatering.	Heat-treat growing medium at 140°F for 30 minutes or fumigate. Drench plants with oomycete (water mold) specific fungicide.
Fusarium wilt* (*Fusarium oxysporum* f. sp. *cyclaminis*)	A progressive yellowing and wilting of leaves starts with oldest. Brown discoloration of the vascular tissues in tubers. Tuber remains firm unless secondary bacteria are introduced.	Survives as resting spores (chlamydospores) in soil. No other plants are infected. Disease is favored by temperatures above 70°F. May be seedborne.	Discard infected plants and soil; don't save seed from infected plants. Good sanitation generally provides adequate control. Thiophanate-methyl drenches during early growth period should be helpful. Adjust soil pH to 6.5 to 7.0. Treat seed with a fungicide.
Leaf spots* (*Phyllosticta cyclaminis*)	Yellowish-to-brownish spots near leaf margins.	On diseased plants and plant debris. Favored by wet conditions. Dissemination of spores is by splashing water.	Control is same as for gray mold. Protect foliage with a fungicide.
Septoria leaf spot (*Septoria cyclaminis*)	Red concentric spots turn gray with red borders.		
Stunt (*Ramularia cyclamanicola*)	Conspicuous stunt. Flower peduncles shortened so that flowers open below surrounding leaves. Reddish brown necrosis in tuber. Brown irregular leaf spots. Frosty appearance on underside of lower yellowed leaves.	Infected plants and debris. Spores are airborne. Favored by warm, moist conditions.	Dispose of infected plants, keep humidity low. Keep seedlings away from older plants. Protect plants with thiophanate-methyl.

Cyclamen are also susceptible to black root rot (*Thielaviopsis basicola*) and Cylindrocladiella disease (*Cylindrocladiella peruviana*).

* For additional information, see section on Key Diseases.

CYMBIDIUM ORCHID

Cymbidium spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Black rot* (*Pythium ultimum*)	Rapid, black rot of pseudobulb and rotting of roots. Bulb, usually firm at first, gradually desiccates, forming a hard mummy.	Soilborne pathogen. Spores spread in water. Favored by poor drainage and excess water.	Provide better drainage. Avoid excess irrigation. Drench plants with oomycete (water mold) specific fungicide. Steam or chemically treat growing medium.
Flower spotting (*Botrytis cinerea*)	Small black, brown, or colorless spots often surrounded by water-soaked areas.	In plant debris. Spores airborne. Favored by cool (45° to 60°F), moist conditions and condensed moisture on flowers.	Avoid wetting flowers. Keep humidity as low as possible. Eliminate old flowers and plant debris both inside and outside growing area.
Sclerotium or collar rot (*Sclerotium rolfsii*)	Rapid rotting and collapse of the leaf bases and stem. White fungus growth and small resting structures (sclerotia) that resemble mustard seeds usually present on plant and planting medium.	Sclerotia survive in soil for many years. No spores form. Favored by warm, moist soil. Fungus has a wide host range.	Destroy infected plants. Heat-treat soil, fumigate with chloropicrin or another chloropicrin combination, or mix granular PCNB with planting medium before planting.

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Bar mottle (*Cattleya severe flower break virus*)	Yellow bar-shaped streaks and blotches on leaves.	Green peach aphid. *Cymbidium*, *Cattleya,* and its hybrids.	Same as for mosaic. Also, control insects.
Diamond mottle (*Odontoglossum ringspot virus*) (*Tobacco mosaic virus,* orchid strain)	Elongated chlorotic areas are sometimes diamond-shaped. Older leaves sometimes develop brown-to-black flecks and streaks.	Can be transmitted by juice inoculations. *Cymbidium*, *Cattleya*, *Odontoglossum*, *Phalaenopsis.*	Same as for mosaic.
Mosaic (*Cymbidium mosaic virus*)	Symptoms vary in pattern and severity. Small, elongate pale areas in young leaves may later develop into dead, dark spots or streaks. Mottling of young leaves, sometimes becomes inconspicuous in old leaves. No flower variegation.	Transmitted by pruning tools. *Cymbidium*, *Cattleya*, *Epidendrum*, *Zygopetalum*, *Angraceum*, *Laelia*, *Oncidium*, *Spathoglottis.*	All virus diseases are propagated with plant. Once infected, plant remains so for life. Destroy infected plants. Disinfect tools between cuts or heat-sterilize in a flame.
Ringspot virus (*Cymbidium ringspot virus*)	Necrotic ringspot patterns on young and old leaves. Plants severely stunted. Can be lethal.	Can be transmitted by juice inoculations. *Cymbidium*, *Cattleya*, *Spathoglottis*, *Trichosoma.*	Same as for mosaic.

* For additional information, see section on Key Diseases.

DAHLIA

Dahlia spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Crown gall* (*Agrobacterium tumefaciens*)	Overgrowths or galls occur on stems and roots.	In soil for as long as 3 years; bacteria enter through wounds and can survive on infected roots. Gall development favored by rapidly growing host.	Avoid wounding plants. Do not grow plants in infested soil for 3 years, or fumigate soil. Discard infected roots. Rotate with non-woody crops, such as cereals and legumes.
Fusarium wilt* (*Fusarium oxysporum*)	Symptoms are almost identical to those of Verticillium wilt. Not common in California.	Soilborne for many years. Disease most severe when soil temperatures are high.	Destroy infected plants. Grow plants in new areas or fumigate soil; see below for control of Verticillium wilt.
Gray mold* (*Botrytis cinerea*)	Brown, water-soaked spots appear on petals. Fuzzy gray fungus spores form on soft, brown, decayed tissues; fungus may invade plant tissue that touches infected petals.	Plant debris. Favored by cool, wet conditions and condensed moisture on plants.	Remove withered or diseased flowers promptly. During cool, wet weather, spray with iprodione, mancozeb, or fenhexamid.
Powdery mildew* (*Golovinomyces cichoracearum*)	White, powdery fungus principally grows on older leaves and stems. Severely affected leaves dry up and may fall.	On living dahlia leaves and as small, dark, resting structures (chasmothecia) on old leaves. Free water is not necessary for infection.	Protect foliage with myclobutanil or sulfur.
Root knot nematode** (*Meloidogyne* spp.)	Knots or small swellings, caused by root knot nematodes, occur on feeder and fleshy roots.	In soil and on the roots of many plants. Favored by warm, sandy soils.	Use a nematicide to treat infested soil before planting or solarize soil. Destroy infected roots.
Sclerotinia or cottony rot* (*Sclerotinia sclerotiorum*)	Plants wilt and die suddenly. Water-soaked stem cankers appear near the soil line. Cottony, white fungal growth; later, large black sclerotia are found on insides and outsides of stems.	In soil as sclerotia, which produce airborne spores that infect only inactive or weak tissues. Sclerotia also produce hyphae, which infect plant tissue. Favored by cool, moist conditions.	Avoid soil where disease has occurred (common disease of many vegetable crops). Treat soil with PCNB before planting. Protect plants with iprodione or thiophanate-methyl.
Smut (*Entyloma dahliae*)	Yellowish, circular to irregular spots appear on leaves. Leaves later become brown and dry.	Plant debris. Favored by wet weather.	Do not use overhead irrigation. Mancozeb applied to control gray mold should help control smut.
Storage rots (*Botrytis cinerea*, *Pectobacterium* (=*Erwinia*) *carotovorum*, *Fusarium* spp.)	Roots rot in storage.	Plant debris. Favored by high temperature and humidity.	Avoid plant injuries. Maintain a storage temperature of 40°F and avoid high humidity. In mild climates, leave roots in soil.
Verticillium wilt* (*Verticillium dahliae*)	Basal leaves wilt and turn yellow. Frequently, only one branch is affected at first. Later, the entire plant dies. Dark discoloration of the vascular system occurs.	In soil for many years. Symptoms most severe during warm weather after a cool period. Fungus has a wide host range.	Destroy infected plants and roots. Fumigate soil with chloropicrin or a chloropicrin combination (tarped). Fumigation also controls most other fungi, bacteria, weeds, nematodes, and soil insects. Soil solarization might be considered in sunny climates.

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Dahlia, continued

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Dahlia mosaic (*Dahlia mosaic virus*)	The normal green color of leaves develops irregularly. Bands adjacent to the veins remain pale green (vein-clearing). Leaves may be distorted. Shortening of internodes (stunt) occurs in some cultivars. Flower color is usually normal.	Aphids. Spread vegetatively by cuttings and roots. In some cultivars, the virus is almost symptomless.	Destroy infected plants. Control aphids.
Mosaic (*Cucumber mosaic virus*)	Mild leaf mottle accompanied by little or no leaf distortion. Some varieties are symptomless carriers of the virus. Not common in California.	Aphids. Spread vegetatively by cuttings and roots. Many plants: cucurbits, tomato, pepper, legumes.	Destroy infected plants. Control aphids and weeds.
Ringspot (*Tomato spotted wilt virus*)	A well-defined mosaic mottle or irregular concentric rings or wavy lines in leaves. No leaf distortion or stunting occurs. Symptoms seen on older leaves.	Thrips. Spread vegetatively by cuttings and roots. Many plants.	Eliminate reservoir hosts and weeds. Destroy infected plants. Control thrips. Eliminate virus by taking small, stem-tip cuttings from rapidly growing plants.

Dahlias are also susceptible to southern blight* (*Sclerotium rolfsii*) and foliar nematodes (*Aphelenchoides* spp.).**

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

DELPHINIUM

Delphinium spp. and hybrids (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Black leaf spot* (*Pseudomonas syringae* pv. *delphinii*)	Irregular, tarlike, black spots in leaves. Petioles and stems also infected. Spots viewed from lower leaf surface appear brown.	Bacteria survive in plant debris from previous delphinium crop. Disease is favored by cool, wet weather. Bacteria are spread in splashing water.	Rotate field to a different crop. In perennial plantings, remove old leaves and stems from field. Avoid overhead irrigation.
Diplodina disease (*Diplodina delphinii*)	Brown to black stem cankers often at stem bases of older plants. Basal canker may girdle the stem, causing the tops to die and break over. Tiny, black fungus fruiting structures (pycnidia) may be visible in necrotic tissues. Uncommon.	Fungus survives on delphinium debris and in crowns of living plants. Spores are spread in splashing water.	Avoid overhead irrigation. Plant on raised beds. Do not replant fields for 2 or more years. In perennial plantings remove old stems and plant debris. Protective fungicidal sprays would probably be effective.
Downy mildew* (*Peronospora* spp., *Plasmopara* spp.)	Purplish red to dark brown, irregular angular spots on leaves. Lower surface covered with sparse, downy fungal growth that may be hard to see. Leaves turn yellow and fall.	Spores produced only on living plants. Resistant spores (oospores) carry fungus over unfavorable periods. Moist, humid conditions.	Protect foliage with mancozeb, fosetyl-Al, dimethomorph, or mefenoxam.
Powdery mildew* (*Erysiphe aquilegiae* and *Podosphaera delphinii*)	White powdery patches on surface of leaves and stems. Basal leaves yellow, then brown and die. Flowers may be deformed. Larkspur is particularly susceptible.	Fungus survives on living plants. Spores are airborne. Disease is favored by moderate temperatures, shade, crowding, and dry foliage.	Avoid overcrowding. Protect foliage with a powdery mildew fungicide.
Soft crown rot and black leg (*Pectobacterium* (=*Erwinia*) *atrosepticum*)	Stem bases are blackened and rotted, causing stems to fall over. New shoots may develop disease free under drying conditions or entire crown may rot. Rotted tissues usually have an offensive odor. Disease often appears at time of flowering.	Favored by warm, wet conditions. Bacteria survive in plant debris. Seeds may be contaminated by bacteria. Infection is through normal stem cracks and wounds. Bacteria are spread in water.	Avoid overhead irrigation, especially after flower spikes begin to elongate. Plant on raised beds and avoid wetting crowns. Heat treat or fumigate soil used to produce seedlings.
Water mold root rots (*Pythium** and *Phytophthora* spp.*)	Plants are stunted and yellow. Roots rotted. When *Phytophthora* spp. are involved, crown tissues may be rotted. Lower stems are sometimes infected.	Pathogens are soilborne and present in most agricultural soils. Spores (zoospores) are spread in water. Favored by wet weather, poor drainage, and overwatering.	Improve drainage. Grow on raised beds. Do not overirrigate. Fungicides used to control *Pythium* and *Phytophthora* should be useful.

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Aster yellows* (*Aster yellows phytoplasma*)	Flowers are converted to green leafy structures. Plants infected the preceding year produce many spindly, upright yellow shoots and no flowers.	Phytoplasma that has a wide host range and is spread by leafhoppers. Not spread by seed, other insects, or handling.	Do not plant seed beds downwind from delphinium, carrot, or celery fields. Control leafhoppers. Eliminate nearby weeds. Destroy infected plants.

Delphiniums are also susceptible to gray mold* (*Botrytis cinerea*), southern blight* (*Sclerotium rolfsii*), cottony rot* (*Sclerotinia sclerotiorum*), root knot nematode** (*Meloidogyne* spp.), Verticillium wilt* (*Verticillium dahliae*), damping-off* (*Rhizoctonia solani*, *Pythium* spp.), curly top (*Beet curly top virus*), various virus diseases (*Tobacco mosaic virus*, *Radish mosaic virus*, *Cucumber mosaic virus*), leaf spots (*Ascochyta aquilegiae*, *Cercospora delphinii*, *Ramularia delphinii*), white smut (*Entyloma winteri*), rust* (*Puccinia delphinii*), and Fusarium wilt* (*Fusarium oxysporum* f. sp. *delphinii*).

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

EASTER LILY

Lilium longiflorum (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Botrytis blight (*Botrytis elliptica*, *B. cinerea*)	Circular or oval orange or reddish brown spots usually appear on older leaves. Under damp conditions, fuzzy gray fungal spores form on spots. Brown spotting of blooms occurs. *Botrytis elliptica* infects healthy tissue whereas *B. cinerea* invades only dead or dying tissue.	In plant debris. Spores are airborne. Favored by cool, wet conditions and condensed moisture on plant parts.	Keep humidity below 85% by heating and ventilation. Do not use overhead irrigation. Mist blooms and foliage with iprodione, mancozeb, or fenhexamid.
Bulb rots (*Rhizopus* spp., *Penicillium* spp.)	Bulb rot may be soft and mushy (*Rhizopus* spp.) or dry and rotted (*Penicillium* spp.)	In plant debris. Spores are airborne. Favored by warm storage temperatures.	Do not injure bulbs. Store bulbs under cool and dry conditions. Thiabendazole bulb dips usually prevents *Penicillium* decay.
Fusarium bulb rot (*Fusarium oxysporum* f. sp. *lilii*)	Lower leaves become yellow or purple and die. Plants are stunted and of poor quality. Brown basal rot of bulb occurs, causing the scales to fall off.	In diseased bulbs and soil. Favored by warm temperatures.	Do not plant bulbs that show any signs of infection. Dip bulbs in thiabendazole. Plant deep in pot to force stem roots.
Leaf scorch (nonparasitic)	Semicircular brown areas develop along leaf margins. Leaf tips turn brown.	Most severe in high-acid and low-fertility soils.	Adjust soil pH to 6.5 or 7.0. Maintain adequate levels of nitrogen and calcium.
Root rots* (*Pythium* spp., *Rhizoctonia solani*)	Roots turn brown and rot. Plants are stunted with yellowing of lower leaves and leaf scorch. Buds are blasted, resulting in a reduced bud count.	In soil and on bulbs. Favored by overwatering and poor drainage.	Drench plants with mefenoxam in combination with thiophanate-methyl. Mefenoxam at high rates may cause yellowing of leaf margins of Easter lilies.
Shoot rot (*Phytophthora cactorum*)	Growing points of emerging plants are rotted. Stems of older plants are rotted, causing the plants to wilt and collapse. Roots are also frequently rotted.	Soilborne. Spores are spread in water. Favored by poorly drained soil and overwatering.	Steam or chemically treat soil. Oomycete (water mold) specific fungicide drenches also help control the fungus. (See root rot control, above.)

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Fleck (*Cucumber mosaic virus* and *Lily symptomless virus*)	Small, brown, elongated spots appear parallel to leaf veins mostly on older leaves. Flowers are smaller and fewer than on healthy plant	Many hosts; transmitted by aphids.	Remove infected plants and control aphids.
Mosaic (*Tulip breaking virus*)	Foliage shows a slight, dark and light green mottling. Plants are usually salable.	Spread by aphids.	Obtain virus-free bulbs, if possible. Control aphids. Destroy infected plants. Root rot is more severe on virus-infected plants.
Rosette (*Lily rosette virus*)	Leaves curl downward and are flat. Internodes are shortened, giving plants a flat rosette or cylindrical appearance in contrast to pyramid shape of a healthy plant. Flowers fail to open correctly.	Symptoms tend to be masked at high temperatures (above 75°F).	

Easter Lilies are also susceptible to foliar nematodes (*Aphelenchoides olesistis*)** that cause bunchy top and black scale rot (*Colletotrichum lilii*).

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

FUCHSIA

Fuchsia spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Fuchsia rust* (*Pucciniastrum epilobii*)	Initially, small brown areas appear on underside of leaves. Later, large circular areas of chlorosis occur and yellow-orange uredospores appear on the underside of leaves. Older leaves may have green tissue around infected areas. Eventually uredospores appear on both sides of leaf. Infected leaves usually drop.	Overwinters as teliospores on fireweed or as basidiospores on fir. Uredospores on fuchsia can reinfect fuchsia.	Remove fireweed and infected plants. Applications of mancozeb are effective. Avoid wetting leaves. Prune back to stems and remove cuttings.

Fuchsias are also susceptible to crown gall* (*Agrobacterium tumefaciens*), Verticillium wilt (*Verticillium dahliae*), Armillaria root rot* (*Armillaria mellea*), damping-off* (*Pythium rostratum, P. ultimum* and *Rhizoctonia* sp.), Phytophthora root and crown rots* (*Phytophthora* spp.), various viruses* (*Tomato spotted wilt virus*), eriophyid mites, and root knot nematodes** (*Meloidogyne hapla*).

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

GERANIUM

Pelargonium spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Alternaria leaf spot* (*Alternaria tenuis*)	Water-soaked areas occur on undersides of leaves. Spots enlarge to 0.25 to 0.5 inch and have a slightly sunken center surrounded by concentric rings of darker brown or red tissue. Common on *Pelargonium domesticum*.	In plant debris and leaf spots. Favored by cool wet conditions.	Protect foliage with mancozeb. Iprodione sprays applied for gray mold also may help.
Bacterial blight* (*Xanthomonas axonopodis* pv. *pelargonii*)	Round sunken leaf spots or angular dead areas appear and are followed by wilting and death of leaf. Systemic infection results in defoliation and frequently death of plant. Infected stems are blackened and shriveled. Black streaks may occur in nonrotted portions of stem. Older plants may not exhibit symptoms.	In infected cuttings and plants and in plant debris in soil for 1 year. Disease develops rapidly at high temperatures. Bacteria are spread in water and can be vectored by greenhouse whitefly from diseased to healthy geranium plants.	Use disease-free propagative material and observe strict sanitation. Steam or chemically treat rooting media. Disinfect cutting knives in a solution containing quaternary ammonia. Avoid overhead irrigation.
Bacterial leaf spot (*Pseudomonas cichorii*)	Dark brown to black, irregularly shaped spots (0.25 to 1 inch in diameter). Margins are water-soaked. Spots may develop tan centers and have a yellow halo.	Infected plants. Many kinds of plants are susceptible. Favored by warm temperatures, rain, and overhead irrigation.	Avoid overhead irrigation. Maintain sanitation.
Blackleg and root rot* (*Pythium* spp.)	Brown water-soaked bases of cuttings and young plants. Lesions enlarge rapidly, move up the stem, and turn black. Affected plants wilt and die.	Soilborne. Favored by overwatering and poor drainage.	Follow recommendations above. Drench plants with oomycete (water mold) specific fungicide. Remove and destroy infected plants.
Edema (nonparasitic)	Small, water-soaked, pimplelike spots appear on undersides of leaves and stems. Spots later become corky.	Favored by cloudy, cool weather. Actual cause unknown.	Do not overwater. Keep humidity low. Maintain higher temperatures.
Gray mold* (*Botrytis cinerea*)	Brown water-soaked decay of flowers occurs. Fuzzy gray fungal spores form on rotted tissues. When infected flower parts fall on leaves, they also rot. Disease may affect stems.	In plant debris, especially flowers. Favored by cool wet conditions and water on plant.	Protect plants with chlorothalonil, iprodione, or fenhexamid. Where practical, remove old blossoms and dead parts. Avoid overhead irrigation.
Rust* (*Puccinia pelargonii-zonalis*)	Pustules of orange-brown spores form on undersides of leaves.	On living leaves. Favored by moist conditions and water on plants. Spores are airborne.	Protect foliage with triadimefon and myclobutanil. Lower humidity to avoid condensation of water on leaves. Mancozeb also will help control rust.
Verticillium wilt* (*Verticillium dahliae*)	Lower and middle leaves wilt, yellow, die, and fall. Shoots die back. Plants are stunted. In later stages, water-conducting tissues (xylem) may be discolored.	Remains in soil for many years. Also spread by infected cuttings and plants. Fungus has wide host range (tomato, strawberry, chrysanthemum, nightshade, and many others). Favored by moderate temperatures. Symptoms most severe in warm weather.	Use pathogen-free cuttings. Steam treat or fumigate soil with chloropicrin or a chloropicrin combination. Avoid soil previously planted to tomatoes, strawberries, potatoes, chrysanthemums, or other susceptible crops.

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Geranium, continued

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Flower break (*Pelargonium flower break virus*) Leaf curl (*Pelargonium leaf curl virus*) Line pattern (*Pelargonium line pattern virus*) Mosaic (*Cucumber mosaic virus*) Ringspot (*Tomato ringspot virus* or *Tobacco ringspot virus* or both)	Symptoms vary depending on viruses present, cultivar, and growing conditions. Symptoms include light and dark green mottling of foliage, chlorotic spotting, ring spotting, leaf distortions, leaf breaking, vein clearing, and others.	In infected geranium plants. Symptoms of some are masked during warm weather.	Obtain virus-free cuttings. Do not propagate from plants that have shown symptoms of virus.

Geraniums are also susceptible to Armillaria root rot* (*Armillaria mellea*), crown gall* (*Agrobacterium tumefaciens*), bacterial fasciation (*Rhodococcus fascians*), and cottony rot* (*Sclerotinia sclerotiorum*).

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

GLADIOLUS

Gladiolus spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Botrytis disease* (Botrytis blight, Neck rot, Corm disease) (*Botrytis gladiolorum*, *B. cinerea*)	Tiny brown leaf spots develop; spots may expand or coalesce. Brown water-soaked spots appear on flower petals. Basal stem infections (neck rot) may penetrate corm; corm decay may continue in cold storage. Fuzzy gray fungus spores may form on decayed tissues. Black seedlike sclerotia may form on underground parts.	In corms and on crop refuse. Spores are airborne. Favored by moist conditions and low temperatures (50° to 70°F).	Complete control program essential in coastal areas: cure and treat corms as outlined at end of this section; protect foliage with chlorothalonil, iprodione, mancozeb, or thiophanate-methyl. After harvest and before packing, spray flower spikes with a fungicide.
Fusarium yellows (*Fusarium oxysporum* f. sp. *gladioli*)	Leaves tend to turn downward, yellow progressively, and die prematurely. Brown rot of corms begins in basal plate and core, and extends upward into the leaf bases via vascular strands. Corms may rot in ground or while in storage. Cultivars vary in symptoms and susceptibility. Infection without obvious symptoms is common.	In diseased corms and in infested soil for many years. Favored by temperatures of 70°F or above.	Plant disease-free corms in clean soil, or grow resistant cultivars. Hot water treatment of cormels eliminates the fungus from infected stocks. Cure and treat corms as outlined at end of this section. Fumigate infested soil with chloropicrin or a chloropicrin combination. Disease is less severe if soil pH is 6.6 to 7.0 and 80 to 90% of nitrogen is the nitrate form.
Penicillium corm rot (*Penicillium gladioli*)	A firm brown corm rot develops in storage; frequently in association with other corm rots. If conditions are moist, greenish blue spore masses appear over rotted areas.	On corms and corm debris and as spores on storage-room equipment. Rot develops rapidly when humidity is high.	Cure and treat corms as outlined at end of this section.
Rhizoctonia neck rot (*Rhizoctonia solani*)	Stem below ground and husks at harvest appear shredded. Brown fungus strands (mycelium) visible with a hand lens.	Common soilborne fungus with wide host range. Favored by warm, wet conditions.	Corm dips help control the fungus. Treat soil with PCNB before planting. Sprays of iprodione or thiophanate-methyl should reduce spread of the fungus down the row.
Rust (*Uromyces transversalis*)	First seen as small yellowish spots that later break out of leaves, stems, and sometimes flowers, forming pustules with yellow-orange spores. May also include yellowish-brown (uredinia) or blackish-brown (telia) pustules.	Besides *Gladiolus* species, other hosts include other members of the Iris family: *Crocosmia, Tritonia*, and *Watsonia*. Spores can contaminate corms, rhizomes and bulbs. Spores can be blown long distances by wind.	Only accept corms and plants from known clean sources. Prevent introduction into nursery by careful regular monitoring.
Scab (*Pseudomonas gladioli* pv. *gladioli*)	Mainly seen on corms as irregular or round sunken brown spots with a shiny, brittle, varnishlike material (bacterial exudate) on the surface.	On corms and in soil refuse for 2 years. Favored by heavy, wet soils and warm weather. Encouraged by heavy nitrogen fertilization.	Rotate every 3 years. Control measures for other diseases usually take care of scab. Control chewing insects in the soil.
Stemphylium leaf spot (*Stemphylium* spp.)	Small round or angular yellow spots with a red dot in the center appear on green parts of plants. Spots are larger on some cultivars. Cultivars differ in susceptibility.	Carried over on gladiolus foliage and refuse. Favored by warm, wet weather, especially sprinkler irrigation and rain.	Spray mancozeb at 10- to 14-day intervals. Plow under gladiolus crop residues.
Stromatinia rot (*Stromatinia gladioli*)	Leaves yellow and die. Leaf sheaths rot at soil level (neck rot). Rotted tissues appear shredded. Numerous, very small black fungus resting structures (sclerotia) are imbedded in dead tissue. Corm lesions are dark brown and sunken with raised margins.	On diseased corms and in soil for 10 years or more. Favored by wet soil.	Cure and treat corms as outlined at end of this section. Use uninfested or chemically treated land. Fumigate soil with chloropicrin or a chloropicrin combination.

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Grassy top (*Aster yellows phytoplasma**)	Current season infection results in early maturity, small corms, and arrested root development. Next year, the corms produce numerous thin, weak shoots—grassy top. Flowers produced by grassy top plants are green.	Leafhoppers. Many kinds of plants, including some weeds.	Destroy infected plants.
Mild mosaic (*Bean yellow mosaic virus*)	A faint leaf mottle and sometimes a pencil-stripe color break of blossoms. Disease is common in nearly all gladiolus cultivars but symptoms are more severe in some cultivars. Blossoms may fail to open all the way.	Aphids. Mechanically transmitted by harvesting tools. Legumes (beans, peas, vetch).	Propagate from selected disease-free plants grown in isolated areas.
Ringspot (*Tobacco ringspot virus, Tomato ringspot virus*)	Yellow or white ring patterns and blotches on leaves.	Nematodes. Mechanically transmitted by harvesting tools. Many kinds of plants, including weeds.	Destroy infected plants.
White break (*Cucumber mosaic virus*)	White streaking or flecking of leaves and a white blotch or color break in petals. Flowers sometimes fail to open completely or shrivel prematurely.	Aphids. Corm-propagated. Sometimes transmitted by harvesting tools. Cucurbits (melons, cucumber, squash), peppers, tomatoes, nandina, and hundreds of other hosts.	Propagate from selected disease-free plants grown in isolated areas. Rogue infected plants at flowering time or as soon as virus symptoms appears. Control aphids.

Gladiolus are also susceptible to Septoria leafspot (*Septoria gladioli*) and leaf smut (*Urocystis gladiolicola*), which are rare diseases in California. Curvularia leafspot (*Curvularia lunata*) appears occasionally as a neck rot, particularly in cormel stocks.

* For additional information, see section on Key Diseases.

CARING FOR CORMS

The major gladiolus pathogens can be carried on the surface of or inside corms. To control the pathogens, it is essential to correctly cure, store, and dip corms before planting.

Curing: Immediately after digging, place corms in shallow trays in storage rooms maintained at 95°F (35°C) and 80% relative humidity. Use fans to circulate air through and around corms. When old corms break off easily, usually after 6 to 8 days, clean the new corms. Return corms to storage at 95°F and 80% relative humidity for 4 more days.

Storage: Store cured corms at 40°F and 70 to 80% relative humidity. In mild climates, clean corms can be replanted if Fusarium yellows is not a problem.

Preplant dip: Before planting, dip corms in iprodione or thiabendazole plus 4 to 6 fluid ounces of wetting agent/100 gal water. The water should be at a temperature of 80° to 90°F. Allow corms to dry before planting.

Sanitation: Maintain sanitary storage facilities. Burn all gladiolus refuse. Steam treat or disinfect trays, tools, and the like.

Hot water treatment of cormels: (1) Select sound, hard, fully dormant corms grown in warm soil and harvested before cold weather. Cure as outlined. (2) Presoak corms for 2 days in water when the air temperature is 60° to 80°F. Discard any corms that float. (3) Immerse 30 minutes in water heated to 131°F. (4) Cool immediately with clean, cold water. (5) Dry thoroughly and quickly in warm air or sunshine. (6) Dust with a fungicide and store at 40°F and 70 to 80% relative humidity.

GYPSOPHILA

Gypsophila paniculata (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Bacterial gall (*Pantoea agglomerans* (formerly *Erwinia herbicola*))	Soft, light brown galls up to 2 inches (5 cm) in diameter develop at or below soil line. Galled plants are often stunted and some die.	Bacteria survive in galls and in aerial parts of the plant. Infection is favored by warm conditions.	Use pathogen-free stock developed through tissue culture. Avoid wounding plants when establishing field plantings. Maintain strict sanitation in propagation.
Flower blight (*Alternaria* sp.)	Infected flowers turn black.	Favored by moist conditions.	Avoid overhead irrigation during flowering. Protective sprays of iprodione or chlorothalonil may be helpful in severe situations.
Phytophthora crown rot* (*Phytophthora parasitica*)	Leaves wilt and turn light green. Entire plant may collapse and die. Crown tissue is discolored and a soft, wet decay develops. Secondary bacteria cause the diseased tissue to putrefy.	Pathogen is soilborne and may be present in many fields. Disease is favored by warm temperatures 90°F, moist conditions, and poor drainage.	Improve drainage by planting on raised beds. Do not moisture-stress plants, but do not overwater. Soil drenches of oomycete (water mold) specific fungicide are helpful in preventing the disease.
Root rot* (*Pythium* spp.)	Soft wet decay of seedlings and plants in propagation. Leaves of infected plants turn grey-green. In the field, roots are rotted and plants are stunted.	Several species of *Pythium* are involved. *Pythium aphanidermatum* is favored by warm or hot conditions while *P. ultimum* develops at lower temperatures. Both pathogens are present in many field soils. Disease is favored by overwatering and poor drainage.	An oomycete (water mold) specific fungicide is helpful when used in preventative programs.
Stem rot (*Rhizoctonia solani*)	All stages of growth may be affected. Stems are infected at or just beneath the soil line. Sunken dark lesions are dry in the early stages but later the decay becomes soft and wet.	Fungus occurs naturally in many soils. Favored by warm, wet conditions and deep planting.	Treat soil or planting medium with granular PCNB before planting. Avoid deep planting. Spray base of plants before or after planting with iprodione or PCNB. Keep PCNB off foliage.

Gypsophila is also susceptible to gray mold* (*Botrytis cinerea*), bacterial fasciation (*Rhodococcus fascians*), root knot nematode** (*Meloidogyne* spp.), cottony rot* (*Sclerotinia sclerotiorum*), southern blight* (*Sclerotium rolfsii*), crown gall* (*Agrobacterium tumefaciens*), and aster yellows* (*Aster yellows phytoplasma*).

* For additional information, see section on Key Diseases.
** For additional information, see section on Nematodes.

HEATHER

Calluna vulgaris, Erica spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Armillaria root rot* (*Armillaria mellea*)	Symptoms are similar to crown rot but distribution in the field is different. Examination of affected plants reveals white fungus plaques beneath the bark at or below soil line on main stem. *Erica canaliculata* and *E. hirtiflora* have been infected.	Fungus survives for long periods in infected roots buried in soil. Infection is favored by the same conditions that are favorable for plant growth.	Avoid fields just cleared of oaks or other susceptible woody plants. This is not a common disease of heather.
Chlorosis (Iron deficiency)	Foliage turns yellow and some turns almost white, especially new growth. Terminal growth may die and plants are stunted. Occurs if soil pH is too high.	Soils that are too basic as a result of too much calcium.	Spray plants with ferrous sulfate using 6 to 8 pounds/100 gal water. Thoroughly wet the plants using 100 to 150 gal/acre. Apply once a month starting in early spring as growth commences. If stems turn black, reduce dosage and frequency of treatment. Acidify soil.
Powdery mildew* (*Erysiphe azaleae*, *Golovinomyces orontii*)	Shoot tips are reddened, then yellow and turn brown and fall off. A side bud develops into the new terminal and successive killing of the tips causes crooked, twisted growth. The white powdery mildew growth is often difficult to find. Affected plants are stunted and bushy. *Erica persoluta* is damaged.	On living heather foliage. Fungus is favored by moderate temperatures, partial shade, and dry foliage.	Several fungicides are available to protect foliage from infection. Start applications in spring and after each irrigation. During very hot periods, sulfur may damage foliage and flowers; avoid excessive rates of application.
Root and crown rot (Pythium spp.*, *Phytophthora cinnamomi**)	Plants are stunted or may suddenly wilt and collapse. Roots are killed and the base of the stem (crown) is attacked, causing a complete or partial girdling. *Erica hirtiflora* (=*E. regerminans*) and *E. hyemalis* are very susceptible. *Erica canaliculata* (*E. melanthera*) is moderately resistant and *E. persoluta* is resistant.	Soilborne pathogens with wide host range. These organisms also survive in infected plants. Favored by excessive soil moisture, poor drainage, and warm temperatures.	Avoid introduction into new areas by growing or obtaining disease-free plants. Take cuttings from high on the plant and use heat-treated or fumigated propagative and growing medium. Prevent infection in the nursery by periodic treatments with an oomycete (water mold) specific fungicide. Careful water management will provide some relief in field plantings. Oomycete (water mold) specific fungicides applied as a drench also helps.
Rust* (*Uredo ericae*)	Small pustules of powdery orange spores occur on leaves. Infected leaves usually turn yellow and abscise. *Erica hirtiflora* and *E. persoluta* var. *alba* are infected.	On foliage. Spores are airborne and may be carried by the wind for many miles. Pathogen is favored by moderately low temperature and dew or rain.	Protect foliage with sulfur applied as a dust or spray. Start applications in late March and continue at 10- to 14-day intervals until rains stop. During very hot periods sulfur may cause damage to foliage and flowers; avoid excessive rates of application. Also avoid overhead watering.
Verticillium wilt* (*Verticillium dahliae*)	Wilting, yellowing, and defoliation occur frequently on only one side of the plant. Examination of crown and roots, which appear healthy, helps differentiate this disease from root and crown rot. Symptoms usually first appear in early summer. *Erica australis* and *E. persoluta* are affected.	Fungus is soilborne and has a wide host range. Fungus invades plant in the cool spring plugging the water-conducting tissues. Symptoms occur when plant is stressed for water, particularly during warm periods.	Avoid fields that have been in susceptible crops or weeds such as tomato, chrysanthemum, strawflowers, nightshade, and others. Propagate plants, using heat or chemically-treated medium. The fungus can be eliminated from field soil by fumigation with chloropicrin or a chloropicrin combination.

* For additional information, see section on Key Diseases.

IRIS (Bulbous) (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Bacterial blight* (*Xanthomonas campestris* pv. *tardicrescens*)	Elongated, water-soaked spots or lesions that usually occur near the base of leaves. Under moist conditions, lesions rapidly enlarge causing leaf to turn yellow and collapse. Flower stems may be infected.	Bacteria survive in infected bulb scales and tissues. Rhizomatous iris also is susceptible. Disease is favored by warm, moist conditions and by injuries and frost damage.	Avoid excessive overhead irrigation. Space plants wide enough to promote air circulation and rapid drying of foliage. Discard infected plants. Use pathogen-free planting stock. More info*
Basal rot (*Fusarium oxysporum* f. sp. *gladioli*)	Stunted, yellowed plants. Basal plate and scales are affected by a firm brown rot. Blue mold may develop as a secondary rot.	Fungus survives as chlamydospores in soil for several years. Spread by infected bulbs. Disease is favored by warm soils (above 57°F). Gladiolus, crocus, *Ixia, Tigridia, Tritoma*, and freesias are also attacked.	Do not plant in infested soil for 3 to 4 years or fumigate soil with chloropicrin or a chloropicrin combination. Dip bulbs in thiabendazole. *Fusarium oxysporum* f. sp. *gladioli* has shown some resistance to thiabendazole and to benzimidazole fungicides.
Black slime (*Sclerotinia bulborum*)	Plants yellow, wilt, and die or fail to emerge. Diseased plants tend to occur in clumps. Below ground shoots and bulbs are covered with a mass of gray fungus. Infected parts contain pockets of gray or white mycelium and black sclerotia.	Favored by cool weather. Fungus survives as sclerotia in soil for several years.	Rotate out of iris for 3 to 4 years. Include PCNB in bulb dip.
Blue mold (*Penicillium* spp.)	Plants are stunted, off-color, lack flowers, and prematurely die. Blue-green mold on rotted bulbs. Also common on stored bulbs.	Wounds caused by insects, harvesting, sunburn, etc. are necessary for infection. Late or early digging favors disease. Frequently starts on corms stored incorrectly.	Avoid very early or very late digging. Avoid injuries. Cure bulbs rapidly and provide good ventilation during storage. Heat cure bulbs within 5 days of digging. Dip bulbs in thiabendazole. Some *Penicillium* spp. have shown resistance to thiabendazole and other benzimidazole fungicides.
Fire (Leaf spot) (*Mycosphaerella macrospora* =*Didymellina macrospora*, conidial state *Heterosporium gracile*)	Oval to elliptical leaf spots with pale yellow or reddish brown borders. As the spots become old, centers turn tan. Spots are often near tips of leaves. Flower buds, stems, and bulbs may be infected. Dark green spores may be seen in the spots.	Disease is favored by mild temperatures (50° to 70°F) and wet conditions. Spores are airborne. Fungus also infects rhizomatous iris.	Dig bulbs annually. Protect foliage with myclobutanil, chlorothalonil, or mancozeb. Destroy old leaf tissues.
Ink spot (*Drechslera iridis*)	Dark reddish brown elongated spots with chlorotic margins. Older leaves develop gray centers. Dark spore masses may be visible on lesions. Usually older leaves are infected. Irregular inky-black stains occur on Iris reticulata bulbs. Disease may be severe on plants left in the ground for 2 years.	Disease is favored by mild (68° to 77°F), moist conditions. Fungus survives on infected bulbs and debris. Not common.	Dig bulbs every year. Remove and destroy all debris; rotate on a 3-year basis. Protect foliage with mancozeb.
Nematode** (*Ditylenchus destructor*)	Plants are stunted. Black streaks occur along veins of the outer husks. Outer husks become shredded at the base and the basal plate becomes honeycombed and grayish.	Nematodes survive in bulbs. Damage is worse in cool, moist climates. Other hosts include alfalfa, potato, sugarbeet, tulips, and some weeds and fungi.	Harvest bulbs 7 to 10 days earlier than normal. Treat dormant bulbs in hot water (110°F) for 3 hours. Cool and dry promptly. Disinfect tools, trays, etc. by heat treatment such as steam or hot water at 185°F. Do not replant infested fields for 2 years.

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Iris (*Bulbous*), *continued*

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Rust* (*Puccinia iridis*)	Reddish brown powdery pustules on leaves. Cultivars differ in susceptibility.	Fungus survives on living iris leaves. Spores are airborne. Favored by condensed moisture and overhead irrigation.	Irrigate so that water does not remain on leaves longer than a few hours. Chlorothalonil, myclobutanil, and mancozeb used to control leaf spot will help control rust. Remove and destroy old infected leaves.
Southern blight* (*Sclerotium rolfsii*)	This disease is also called crown rot or southern wilt. Outer leaves turn yellow. Eventually all leaves are affected. Leaf bases and bulb are affected by a soft rot. White mycelium is present on bulbs and in soil. Small, tan to reddish brown sclerotia are found in and on bulbs and soil.	Sclerotia survive in soil. Disease is favored by warm (77° to 95°F), moist soil. May be spread by infected bulbs and anything that moves infested soil.	PCNB mixed with soil before planting helps.

Bulbous irises are also susceptible to gray mold* (*Botrytis cinerea*), gray bulb rot (*Rhizoctonia tuliparum*), root rot* (*Pythium irregulare*), neck rot (*Rhizoctonia solani*), *Iris mosaic virus*, mosaics, and black storage molds (*Rhizopus* sp., *Aspergillus* sp.).

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

IRIS (Rhizomatous) (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Bacterial soft rot* (*Pseudomonas* spp.)	Wilting and dying of fans accompanied by a soft, wet, foul-smelling rot of rhizome. Fans separate easily from rotted rhizome or topple over.	In infected tissue. Favored by warm, wet weather, but rot may continue when conditions are dry. More serious when rhizomes are buried when planted.	Bacteria enter through wounds, so prevent injuries to plant. Remove infected plants, cut away rotted tissues, and allow cut surfaces to thoroughly dry before replanting. Plant high or on ridges so that the top of the rhizome is not covered.
Leaf spot* (*Mycosphaerella macrospora*, *Didymellina macrospora*, conidial state; *Heterosporium gracile*)	Circular to elongated spots 0.125 to 0.25 inch in diameter and up to 1 inch in length. At first, yellowish flecks appear. Spots later turn light brown and have a distinct red border. If severely infected, leaves of some cultivars die back. Dark green spores may be found in spots.	On living and dead leaves. Favored by wet weather. Fungus also infects bulbous iris and other iris species.	Collect and burn or bury dead leaves. Where practical, cut off infected parts of leaves. Protect foliage during wet weather with chlorothalonil, myclobutanil, mancozeb, or copper fungicides. Addition of a wetting agent may be necessary.
Rust* (*Puccinia iridis*)	Reddish brown, powdery pustules on leaves. Infected areas frequently surrounded by yellow tissues. Cultivars differ greatly in susceptibility to rust.	On living iris leaves. Spores are airborne. Favored by atmospheric moisture (rain, dew, overhead irrigation).	Irrigate so that the water does not remain on leaves longer than a few hours. Chlorothalonil, myclobutanil, and mancozeb used to control leaf spot will also help control rust.
Southern blight (*Sclerotium rolfsii*)	Rhizomes and leaf bases become rotted. The fungus is visible as a white, cottony growth on the surface and in the soil, and as small, brown resting structures (sclerotia).	In soil as sclerotia. Favored by high temperatures and wet soil.	Attacks many other plants. Avoid planting in infested soils. Fumigate soil before planting. To prevent spread, drench infested areas with PCNB or mix granular form with planting medium before planting.

Virus or viruslike disease	**Symptoms**	**Host range and natural spread**	**Comments on control**
Mosaic (*Iris virus 1*)	Light and dark green mottling and yellow stippling of foliage. Mottling and stippling are especially prominent on young leaves. Mosaic is most severe on bulbous iris and some rhizomatous species. *Iris germanica* and its hybrids are only slightly stunted and sometimes exhibit no symptoms.	Iris family (Iridaceae). Transmitted by aphids. Oncocyclus iris and their hybrids can be severely damaged. Serious on *Tigridia*.	Rogue infected plants. Control aphids.

Rhizomatous irises are also susceptible to root knot nematode** (*Meloidogyne hapla*). Rhizome rot caused by *Sclerotinia convoluta* and bacterial leaf blight caused by *Xanthomonas tardicrescens,* do not occur or are rare in California.

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

MARGUERITE DAISY

Chrysanthemum (=*Argyranthemum*) *frutescens* (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Cottony rot* (*Sclerotinia sclerotiorum*)	Plants wilt and die. Basal stem rot. Cottony, white mycelium present in and on stems under moist conditions. Long, black sclerotia form in and on stems.	Fungus survives in soil as sclerotia, which germinate after a cold-dormancy period to produce airborne spores. Direct infection from sclerotia may occur. Fungus has a wide host range. Favored by overhead irrigation and high humidity.	Avoid planting in infested fields or fumigate soil. Treat soil with PCNB before planting. Carrots, celery, and lettuce are common hosts. Irrigate early in the day so plants dry quickly. Spray base of plants and lower foliage with thiophanate-methyl.
Crown gall* (*Agrobacterium tumefaciens*)	Spherical galls on stems most often at base of plant. Heavily infected plants are stunted.	Soilborne bacterium with a wide host range. Survives in soil for several years.	Plant disease-free plants. Propagate from clean plants. Dip or spray cuttings with *Agrobacterium radiobacter* 'K84' immediately if wounded. Avoid wounds, especially when plants are wet.
Downy mildew* (*Peronospora radii*)	Young tip leaves are dull green, severely stunted, and roll downward. Gray-purple fungus grows on undersides of leaves. Disease is common on seedling phase; large plants are less frequently attacked. Infected plants fail to produce flowers.	Thick-walled resting spores (oospores) in dead plant parts. Airborne spores. Favored by cool (40° to 60°F), wet weather.	In greenhouse, reduce humidity. Drench seedlings with an oomycete (water mold) specific fungicide. Do not replant in fields where disease has been severe. Steam treat to kill resting spores. Protect foliage with mancozeb.
Pythium root rot* (*Pythium* spp.)	Plants stunted as a result of reduced root system. Small roots rotted.	Soilborne pathogen. Spores spread with soil and water. Favored by excess soil moisture and poor drainage.	Avoid poorly drained soils. Plant on raised beds. Reduce amount of irrigation water. An oomycete (water mold) specific fungicide applied at transplanting will help get plants started.
Root knot nematode** (*Meloidogyne hapla*)	Plants are stunted; swellings or galls on roots. Galls have lateral roots.	Nematodes survive in soil as eggs. Disease is usually most severe in sandy soils. Also prevalent in cooler climates: optimum temperature to invade roots is 59° to 68°F (15° to 20°C) and for growth and reproductions is 68° to 77°F (20° to 25°C).	Preplant fumigate with chloropicrin or a chloropicrin combination or solarize soil.
Root lesion nematode (*Pratylenchus* spp.)	Plants are stunted. Necrotic lesions on roots that involve the cortex and deeper tissues.	Nematodes survive in soil as adults, larvae, and eggs.	Preplant fumigate with chloropicrin or a chloropicrin combination or solarize soil.
Southern blight* (*Sclerotium rolfsii*)	Plants wilt and collapse. Basal stem and roots are rotted. White cottony fungus growth may be present on infected parts and soil. Small (0.625 inch), tan or brown sclerotia form on rotted tissues and in soil.	Sclerotia survive in soil. No airborne spores are formed. Sclerotia germinate and infect susceptible plants. Fungus has a wide host range.	Avoid fields where the disease has occurred or fumigate with chloropicrin or a chloropicrin combination. PCNB applied to the base of plants or as a preplant treatment will help.

Marguerite Daisy is also susceptible to powdery mildew* (*Golovinomyces cichoracearum*), Verticillium wilt* (*Verticillium dahliae*), leaf spot (*Ramularia* sp.), curly top (*Beet curly top virus*), and aster yellows (*Aster yellows phytoplasma*).

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

NARCISSUS

Narcissus spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Basal rot (*Fusarium oxysporum* f. sp. *narcissii*)	Infected plants are stunted with distorted and yellow leaves, and usually die. The basal plate is decayed and reddish brown in color. The white to pinkish fungus is sometimes seen at the base between the scales. Eventually the bulb rots.	Fungus survives as chlamydospores in soil for long periods. Short rotations are not effective. Disease is favored by warm soils and is limited below 55°F; disease is favored by high levels of nitrogen fertilization. Potassium fertilizer may decrease disease sensitivity.	Avoid excessive fertilization. Dig up bulbs in diseased areas as soon as possible. Store bulbs below 64°F. Dip bulbs in thiabendazole as soon as possible after digging. Hot water treatment (see stem and bulb nematode) is also effective in reducing the disease. Rotate out of narcissus for at least 3 years. Plant when soil is cool.
Susceptibility of narcissus cultivars to basal rot: Susceptible: Carlton, Golden Harvest Moderately susceptible: Toorak Gold, Dutch Master, Hollywood Moderately resistant: Malvern City, Rijinveld's Early Sensation, White Lion, Soleil d'Or, Dulcimer Resistant: St. Keverne			
Crown rot or Southern blight (*Sclerotium rolfsii*)	A bulb rot that is at first wet and later becomes dry and woody. A white fungus mat and small (0.03–0.125 inch), round, tan to brown sclerotia occur on decaying bulbs and in surrounding soil.	Disease is favored by warm weather. Fungus survives in soil for long periods (10 years). Fungus has a wide host range. Can be spread by infected bulbs.	Avoid infested fields for 4 years or longer. Deep plowing is sometimes practiced to bury sclerotia. Treat bulbs in hot water. (See stem and bulb nematode.) PCNB applied in the furrow at planting can be effective.
Fire (*Botryotinia polyblastis*)	Water-soaked areas on petals that become brown and wither. Flowers are attacked first, and later the foliage. Foliage spots are small, elliptical, tan and usually near the tips. Yellow streaking follows the leaf spots.	Fungus survives as sclerotia in leaf debris. Sclerotia germinate in spring to produce fruiting bodies (apothecia), which produce airborne spores (ascospores). Conidia, which are also airborne, cause secondary spread. The disease is favored by mild, humid conditions.	Remove flowers before fungus produces apothecia in March/April. Protect flowers and foliage with a fungicide.
Scorch (*Stagonospora curtsii*)	Yellow to brown lesions at leaf tips. Elongate reddish brown leaf spots. Small black pycnidia form in necrotic areas.	The fungus survives in the neck and between scales. Disease is favored by mild, moist conditions. Spores are spread in splashing water. The fungus infects members of the Amaryllidaceae.	Treat bulbs with hot water. Protect plants in the field with fungicides. Make first application as leaves emerge.
Smoulder (*Botrytis narcissicola*)	A dark brown lesion first appears on leaf tips. Infected leaves may curl when infection occurs on inner edge. Masses of fuzzy gray spores (conidia) and small black sclerotia form on diseased tissues, especially near soil.	Fungus survives in infected bulbs and as sclerotia in soil. Conidia are airborne. Favored by cool, wet weather.	Rotate with other crops. Dig bulbs early. Dip bulbs in suitable fungicide such as thiabendazole. If disease is severe in field, spray with iprodione, fenhexamid, or thiophanate-methyl.

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Narcissus, continued

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Stem and bulb nematode** (*Ditylenchus dipsaci*)	Leaves are stunted and distorted, and often swollen and thickened near the base. Yellow or brown swellings occur in leaf centers and margins. Severely infected bulbs are unproductive and may rot.	Nematodes survive in infected bulbs and in bulb debris in fields for about 3 years. Optimum temperature for infection and reproduction is 50° to 60°F. (Little activity occurs when soil temperatures are lower than 50°F and greater than 68°F.) Nematodes are spread by irrigation water and equipment. They also survive in weed hosts and can survive desiccation.	Remove infected plants and surrounding plants from the field. Clean equipment after use in diseased fields. Treat bulbs in hot water. Store bulbs at 60° to 64°F before treatment to reduce heat injury. Presoak bulbs 2 to 3 hours or overnight in water plus a wetting agent at 75°F. Increase temperature in morning to 109°F. Once the temperature of the treatment solution reaches 109°F, maintain a constant temperature of 109° to 111°F for 3 to 4 hours. Cool and dry bulbs immediately. CAUTION: Hot water treatment may injure bulbs causing stunting and flower blast or deformation. Obtain expert advice before large-scale treatment.
White mold (*Ramularia vallisumbrosae*)	Small, sunken, grey or yellow spots on leaves and green parts. Spots enlarge and darken to a yellow- brown with yellow margins. Masses of white, powdery spores (conidia) occur on leaves under moist conditions. Small, dark sclerotia are produced in older infected tissues.	Fungus survives as sclerotia in dead leaves and on bulbs. Sclerotia germinate to produce conidia as leaves emerge. Disease is favored by warm, moist conditions.	Do not replant for 1 year in fields where the disease has occurred. Protect foliage with mancozeb. Copper fungicides are also helpful.

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
White streak (*Narcissus white streak virus*)	Narrow, dark green to purple streaks, which later become white to yellow-white, appear in leaves and flower stalk after flowering. Bulb size and yields are reduced by premature senescence.	Narcissus is the only host of the virus, which is transmitted by aphids. Symptoms do not occur until air temperatures exceed 64°F.	Eliminate infected plants. Control aphids.
Yellow stripe (*Narcissus yellow stripe virus*)	Conspicuous light green to yellow streaks and mottling of leaves and flower stalk, which occurs shortly after emergence. Sometimes leaves are distorted and a color-break of flowers occurs. Bulb yields are reduced.	The virus infects only narcissus and is spread by aphids. Symptoms appear early in growing season.	Eliminate infected plants. Control aphids.

Equipment that has come into contact with diseased bulbs should be thoroughly cleaned by heat treatment.

Narcissus may become infected by a number of other viruses; some produce inconspicuous symptoms. Narcissus is also susceptible to Stromatinia dry rot (*Stromatinia narcissi*), black slime (*Sclerotinia bulborum*), soft rot (*Rhizopus stolonifer*), bacterial streak (*Pseudomonas* sp.) and root lesion nematode** (*Pratylenchus penetrans*).

** For additional information, see section on Nematodes.

PEONY

Paeonia spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Gray mold* (*Botrytis cinerea* or *B. paeoniae*)	Leafy shoots wilt and fall over as a result of rotting at the base. Fuzzy gray fungus sporulation is usually visible on infected tissues. Flower buds darken and wither; leaves also may be attacked.	Disease is favored by wet weather and injured tissue. Fungus survives on plant debris and as sclerotia in or on soil.	Remove or burn old growth in fall. Cut stalks below the ground level. Planting on raised beds also is helpful. Treat with fenhexamid.
Leaf blotch (*Cladosporium paeoniae*)	Small (0.02 to 0.04 inch), oval leaf spots that reach a diameter of 0.08 to 0.12 inch before they penetrate through the thickness of leaf. As spots enlarge, they merge giving the leaf an irregular, blotchy appearance. The upper surface of spots become purple while the lower surface is a dull brown.	Fungus survives on infected peony debris and probably on infected scales of crown buds. Disease is favored by rainy weather in spring.	Burn or remove plant residues in fall. Protect foliage in spring with a fungicide starting as soon as green shoots appear.
Phytophthora blight (*Phytophthora cactorum*)	Young shoots turn black and die or cankers appear along stems and cause them to collapse. Crown infections produce a wet rot that often destroys the entire plant.	Favored by cool, wet conditions such as very heavy rains, excessive irrigation, and poor drainage.	Grow plants in raised beds. Do not overwater. Some of the fungicides effective against *Phytophthora* spp., such as mefenoxam, would probably be helpful.
Verticillium wilt* (*Verticillium dahliae*)	Plants wilt at flowering, but no basal rots are present. The water-conducting tissue (xylem) in stems is discolored. Infected plants may appear to recover, but symptoms will reoccur the following year. Fungus is systemic in plant.	Disease is favored by cool, rainy weather and hot weather at flowering. Water stress exacerbates the disease. Fungus has a wide host range and survives for many years as microsclerotia in soil.	Avoid fields where susceptible plants such as tomatoes, cotton, strawberries, chrysanthemum, and others have been grown. Fumigate soil with chloropicrin or a chloropicrin combination. Do not propagate from plants that exhibit any symptoms of the disease.

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Le Moine Disease (cause unknown)	Plants are dwarfed with many spindly shoots that fail to form flowers. Roots of affected plants are often irregularly swollen. The disease slowly spreads in plantings in a manner suggesting a soilborne vector.	Plants are systemically affected and do not recover.	Destroy infected plants.
Ringspot (*Peony ringspot virus*)	A marked yellow mottle that is in the form of chlorotic rings occasionally accompanied by small necrotic spots. Growth is probably reduced but not obviously.	Virus is systemic in infected plants. The virus is mechanically transmitted but little else is known about natural transmission.	Destroy infected plants.

Peonies are also susceptible to Armillaria root rot* (*Armillaria mellea*), crown gall* (*Agrobacterium tumefaciens*), and black root rot* (*Thielaviopsis basicola*).

* For additional information, see section on Key Diseases.

POINSETTIA

Poinsettia spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Bacterial canker* (*Curtobacterium flaccumfaciens* pv. *poinsettiae*)	Longitudinal water-soaked lesions on stems and petioles. Spotting of leaves and defoliation. In advanced stages, stem lesions split open.	Infected poinsettia plants and debris. Favored by warm, moist conditions. Bacteria spread in water. Bacteria may be present in symptomless plants and cuttings.	Plant pathogen-free cuttings. Avoid overhead irrigation and syringing. Steam soil and disinfect benches with copper naphthenate; disinfect tools.
Bacterial leaf spot* (*Xanthomonas campestris* subsp. *poinsettiaecola*)	Spots start out on the undersides of leaves, expand, and become visible on the upper surfaces. Spots are grey to brown, becoming darker as they expand. Generally, they are surrounded by a water soaked area of lighter green or yellow.	Infected poinsettia plants and cuttings can survive in dried leaf debris for one year. Favored by high humidity, warm temperatures, and close plant spacing.	Prevention is the best management strategy, primarily by avoiding overhead watering that allows splashing of bacteria to adjacent plants. Once present, discard affected plants and disinfect benches. Control can be difficult, but sprays of copper compounds have shown some level of success.
Bacterial stem rot (*Dickeya* (=*Erwinia*) *chrysanthemi*)	Watery, soft rot of cuttings or stems, resulting in disintegration of infected tissues. Rot develops rapidly and plant collapses.	In diseased plant tissues. Favored by high temperatures (73° to 86°F) and succulent plants.	Avoid high temperatures and practices that produce succulent growth. Careful sanitation practices will minimize spread of bacteria. Disinfect tools with quaternary ammonium.
Gray mold* (*Botrytis cinerea*)	Blasting of flowers and browning or spotting of bracts. Fuzzy gray fungal growth forms on dead parts. Lesions on stems and leaves.	In plant debris. Favored by cold, moist conditions and condensed moisture on bracts and flowers.	Provide better growing conditions and air circulation. Clean up plant debris. Avoid wetting leaves and try to lower relative humidity. Protect plants with fenhexamid.
Greasy canker (*Pseudomonas viridiflava*)	Greasy-appearing cankers on stems. Necrotic lesions with chlorotic margins on leaves. Sometimes confused with bacterial canker.	Infected plant debris. Bacterium has a wide host range. Disease favored by high humidity, high temperature, and condensed moisture on plants.	Reduce humidity. Sanitize pruning tools. Avoid wetting foliage.
Powdery mildew* (*Oidium* spp.)	Yellow spots or whitish growth on upper leaf surfaces and bracts.	On living plants. Favored by moderate temperatures and crowded, shaded foliage.	Regularly inspect plants. Remove, bag, and dispose of infected plants at first sign of infection. Apply protectant fungicide when plants are young and more easily sprayed.
Root and stem rot* (*Thielaviopsis basicola*, *Rhizoctonia solani*, *Pythium* spp.)	Plants are stunted and wilt easily. Lower leaves become chlorotic and may fall. Roots are rotted and dark brown, water-soaked stem lesions develop. Large roots and lower stem may be enlarged and ridged. Young plants frequently are killed. Each fungus can cause disease independently, or fungi may interact to produce rapid decline. Symptoms vary with the pathogen.	In soil. Favored by excess moisture and overcrowding of plants. *Thielaviopsis* and *Pythium* severe at high (86°F) or low (63°F) soil temperatures, whereas *Rhizoctonia* develops most rapidly between 63° to 79°F. Disease development most severe at rooting and just before maturing.	Plant disease-free cuttings in heat-treated or chemically treated soil. Before planting, mix into soil mefenoxam plus thiophanate-methyl. If root rots occur after potting, drench with mefenoxam plus thiophanate-methyl.
Rust* (*Uromyces euphorbiae*)	Pustules of cinnamon-brown spores on both leaf surfaces.	On living plants. Favored by moist conditions.	Pick off and burn diseased leaves. Protective fungicide sprays help in control.
Spot anthracnose or scab (*Sphaceloma poinsettiae*)	Circular, buff-colored spots that develop into scablike lesions on leaves and stems.	Infected plants and debris. Favored by wet conditions. Spores spread in water.	Do not wet foliage. Protective fungicidal sprays should help in control. Avoid splashing water.

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Mosaic	Distortion of leaves and bracts. Some bracts may fail to	May be symptomless in poinsettias. Mechanically	Obtain virus-free plants. Grow at higher temperatures. Discard

(*Poinsettia mosaic virus*)	color normally. Mild mottling of leaves. Angular leaf spotting, apparent only under cool temperatures. Symptoms most severe on plants grown at 61° to 68°F. Plants grown at 75° to 82°F appear normal.	transmitted.	plants with symptoms.

Poinsettias are also susceptible to Rhizopus soft rot (*Rhizopus stolonifer*).

* For additional information, see section on Key Diseases.

POT MARIGOLD

Calendula officinalis (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Powdery mildew* (*Podosphaera xanthii*)	White, powdery mildew fungus on surface of leaves and stems. More common on older leaves and older plants.	Disease is favored by moderate temperatures and somewhat shaded conditions; however, powdery mildew may occur on lower leaves of plants in full sun. Spores (conidia) are windborne.	Protect plants with a powdery mildew fungicide.
Root rot* (*Phytophthora* spp.)	Plants are stunted and somewhat chlorotic. Roots are rotted.	*Phytophthora* spp. are present in many field soils. Favored by poor drainage, heavy soils, or overwatering.	Plant on raised beds. Drench soil with an oomycete (water mold) specific fungicide.
Smut (*Entyloma calendulae*)	Circular to irregular (0.25 to 0.5 inch in diameter), greenish yellow to brownish spots, sometimes with a darker brown border. Spots are somewhat thickened and evident on both sides of the leaf.	Spores are windborne or rainborne. Fungus survives on *Calendula* and *Calendula* refuse, and probably on other related hosts. Favored by rain and overhead irrigation.	Avoid overhead irrigation. Protect foliage with mancozeb.

Pot marigolds are also susceptible to Pythium root rot* (*Pythium* spp.), gray mold* (*Botrytis cinerea*), rust* (*Puccinia melampodii*), spotted wilt (*Tomato spotted wilt virus*), root knot nematode** (*Meloidogyne* spp.), aster yellows* (*Aster yellows phytoplasma*), mosaic (*Cucumber mosaic virus*), southern blight* (*Sclerotium rolfsii*), cottony rot* (*Sclerotinia sclerotiorum*), Alternaria leaf spot (*Alternaria* sp.), Charcoal root rot (*Macrophomina phaseolina*), stem rot* (*Sclerotinia sclerotiorum*), and Verticillium wilt* (*Verticillium dahliae*).

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

ROSE

Rosa spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Armillaria root rot* (*Armillaria mellea*)	A general decline and eventual death. White plaques of fungal growth develop between bark and wood.	In infected wood buried in soil. Could be introduced with leaf mold if there are woody branches or roots present or in incipient infection on plant.	Fumigate infested soil with chloropicrin or a chloropicrin combination.
Black spot* (*Diplocarpon rosae*)	Black spots with fringed margins mainly on both sides of leaves and on succulent stems. Yellowed areas develop around spots. Causes defoliation.	On living and dead leaves, and on infected stems. Waterborne spores are spread by splashing water.	Avoid wetting foliage. Remove, incorporate, or burn infected fallen leaves when pruning. Protect foliage with chlorothalonil. Do not compost unless using rapid methods.
Botrytis blight* (*Botrytis cinerea*)	Spotting of flower petals and bud rot. Twig dieback and cane canker. Fuzzy gray fungal spores form on decayed tissues.	Plant debris. Favored by high humidity, condensed moisture, and low temperatures. Spores are airborne.	Clean up debris. Protect susceptible tissues with chlorothalonil, iprodione, mancozeb.
Canker diseases (*Coniothyrium fuckellii*, *Botryosphaeria dothidea*, *Cryptosporella umbrina*)	Brown cankers, sometimes with gray centers. Small, black, spore-producing fungal structures (pycnidia) develop in dead tissues.	On dead plants and debris. Favored by wet weather. Spores are waterborne. Infection occurs mainly through wounds.	Keep plants in vigorous condition. Prune diseased portions. When pruning, cut back to node.
Crown gall* (*Agrobacterium tumefaciens*)	Overgrowths or galls form on stem and roots. Infection occurs mainly through wounds.	In soil. Bacteria spread in water. Gall development is favored by rapidly growing host.	Avoid injuring base of plant and roots. Paint galls with Gallex to eradicate them. Use good sanitation in propagating areas.
Downy mildew* (*Peronospora sparsa*)	Purplish red to dark brown, irregular angular spots on leaves. Lower surface covered with sparse, downy fungal growth that may be hard to see. Leaves turn yellow and fall.	Spores produced only on living plants. Resistant spores (oospores) carry fungus over unfavorable periods. Moist, humid conditions.	Protect foliage with mancozeb, fosetyl-al, or mefenoxam.
Powdery mildew* (*Podosphaera pannosa* var. *rosae*)	White-to-gray powdery growth on leaves and other green parts, mainly on new growth. Leaves are distorted and discolored.	On living plants and in infected buds. Favored by moderate temperatures (60° to 80°F) and high relative humidity at night (90 to 99%).	Protect foliage with myclobutanil, neem oil, propiconazole, stylet oil, potassium bicarbonate, or sulfur. Eradicate infections with horticultural oils, neem oil, or jojoba oil.
Rust* (*Phragmidium disciflorum* or *P. speciosum*, *P. tuberculatum*)	Small orange pustules on undersides of leaves and other green parts. Leaves frequently are yellow. May cause defoliation. Cultivars differ widely in susceptibility. In fall, black teliospores form on leaves.	On living leaves; rarely on stems. Favored by cool, moist weather, and condensed water on leaves. Spores are airborne.	Avoid overhead irrigation. Protect foliage with myclobutanil, triadimefon, or mancozeb. Remove and destroy all leaves during winter months.
Verticillium wilt* (*Verticillium dahliae*)	Leaf fall is followed by dieback of one or more shoots. One-sided purpling of stems sometimes present.	In soil for many years. May go undetected in budwood. Symptoms are most severe during warm weather following a cool period.	Fumigate infested soil. Obtain disease-free plants. Manetti rootstock is resistant to most strains of the fungus.

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Rose, continued

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Mosaic (*Prunus necrotic ringspot virus*, *Rose mosaic virus (=Apple mosaic virus), Arabis mosaic virus* among others. Mixed infections common.)	Symptoms vary with rose cultivar and virus. Symptoms range from general yellowing to conspicuous yellow blotches and intricate rings with line patterns. Plants may be somewhat stunted.	Carried in living plants and spread by budding and grafting and by rooting cuttings from infected plants. No insect vectors known. *Arabis mosaic virus* can be transmitted by nematodes. Symptoms appear at moderate-to-low temperatures and are masked at high temperatures.	Obtain virus-free plants. Heat treatment helps control the virus in rose stocks; 100°F temperatures for 4 weeks inactivates virus in 99% of cuttings taken from treated plants.
Rose leaf curl (probably a virus)	Downward curling of leaves and cane dieback. Leaves readily fall from new shoots, which are characteristically pointed with a broad base.	Infected rose plants. Slow natural spread.	Obtain healthy, symptomless plants. Destroy infected plants.
Rose ring pattern (probably a virus)	Symptomless or inconspicuous in some cultivars, especially floribunda types. *Rosa multiflora* 'Burr' is severely stunted with small, deformed leaflets that have a distinct mottling and wrinkling. Most hybrid teas show green mosaic and fine-line patterns in few or many leaves.	Infected rose plants. No natural spread. Readily transmitted by grafting.	Obtain virus-free plants. Virus is sensitive to thermal inactivation. (See Mosaic)
Rose spring dwarf (probably a virus, RSDaV)	Leaves that emerge in spring are balled or recurved on very short shoots and exhibit conspicuous vein clearing. Symptoms tend to disappear later in growing season.	Infected rose plants. No natural spread.	Obtain virus-free plants.

Roses are also susceptible to crown canker (*Cylindrocladium scoparium*), gray mold* (*Botrytis cinerea*), hairy root (*Agrobacterium rhizogenes*), root lesion nematode** (*Pratylenchus* spp.), root knot nematode** (*Meloidogyne* spp.), and virus diseases: leaf curl (virus suspected), Rosette (virus suspected), and streak (virus suspected).

* For additional information, see section on Key Diseases.
** For additional information, see section on Nematodes.

SHASTA DAISY

Chrysanthemum maximum (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Acremonium wilt (*Acremonium strictum*)	Wilting, stunting, chlorosis and necrosis, often unilateral, of lower leaves. Vascular browning. Symptoms often develop with the onset of flowering.	Soilborne fungus. Disease is intensified if plants are stressed by excessive soil moisture. Fungus has a wide host range, including many weeds.	Plant disease-free plants. Fumigate soil with chloropicrin or a chloropicrin combination.
Cottony rot* (*Sclerotinia sclerotiorum*)	Plants wilt and die. Basal stem rot. Cottony, white mycelium present in and on stems under moist conditions. Large black sclerotia form in and on stems.	Fungus survives in soil as sclerotia that germinate after a cold-dormancy period and produce airborne spores, which infect only dead or dying tissue. Direct infection from sclerotia may occur. Fungus has a wide host range. Optimum temperature for germination of fungus is 56° to 59°F and needs high soil moisture for at least 10 days.	Avoid planting in infested fields or fumigate soil. Carrots, celery, and lettuce are common hosts. Treat soil with PCNB before planting. Protect plants with thiophanate-methyl.
Fasciation (*Rhodococcus fascians*)	Short, swollen clumps of distorted shoots that do not elongate at the base of plants. Vigor of plant is reduced. Secondary rotting of clumps may kill plant.	Bacteria survive on infected plants and debris. Bacterium has a wide host range. Spreads in water.	Plant disease-free plants. Avoid injuries to base of plant, especially when plant is wet. Control is difficult; plants may have to be discarded.
Leaf spot* (*Septoria leucanthemi*)	Brown, circular and irregular spots on leaves. Heavily infected leaves yellow and die. Minute black dots (pycnidia) are visible in the center of spots.	Fungus survives on infected plants and debris. Spores are spread by splashing water. Pathogen needs condensed moisture to germinate and infect.	Use disease-free plants. Rotate land for 2 years. Avoid overhead irrigation and cultural operations when foliage is wet. Protect plants in rainy weather with chlorothalonil or thiophanate-methyl.
Pythium root rot* (*Pythium* spp.)	Plants stunted as a result of reduced root system. Small roots rotted.	Soilborne pathogen. Spores spread with soil and water. Favored by excess soil moisture and poor drainage.	Avoid poorly drained soils. Plant on raised beds. Reduce amount of irrigation water. An oomycete (water mold) specific fungicide applied at transplanting will help get plants started.
Root knot nematode** (*Meloidogyne hapla*)	Plants are stunted. Swellings or galls on roots.	Nematodes survive in soil as eggs. Disease is usually most severe in sandy soils and in warmer climates.	Preplant fumigate soil with chloropicrin/chloropicrin combination or a nematicide or solarize soil.

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

SNAPDRAGON

Antirrhinum majus (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Black root rot* (*Thielaviopsis basicola*)	Roots are girdled by decay; tops slowly die. In less severe cases, elongated, black lesions occur on roots. Disease is particularly damaging to seedlings.	Soilborne fungus; produces dark, resting spores. Spores are spread in water. Favored by cool, wet soils.	In greenhouse, steam or chemically treat soil. Before planting, incorporate thiophanate-methyl into top 3 inches of soil.
Cottony rot* (*Sclerotinia sclerotiorum*)*	Infections girdle plant stems. Cottony fungal growth or large, black sclerotia develop inside stems. Dead stems take on a bleached, white color.	As sclerotia in soil. Airborne spores produced by sclerotia, which infect dead or weak tissues. Sclerotia produce hyphae, which infect plant tissues. Favored by wet weather.	In greenhouse, steam treat or fumigate soil. Treat soil with PCNB before planting. Protect plants with iprodione, or thiophanate-methyl. Mancozeb also helps control this fungus.
Damping-off and stem rot* (*Rhizoctonia* spp., *Pythium* spp., *Phytophthora* spp.)	Seedlings killed. Stems rot at soil line. If problem is caused by *Pythium*, it usually begins at root tips.	Soilborne organisms. Favored by conditions unfavorable for plant growth.	Steam treat or fumigate soil. Incorporate PCNB into top inch of soil before transplanting, or spray bases of plants with thiophanate-methyl or iprodione to control *Rhizoctonia*. Include an in preplant treatment or use later as a drench to protect against *Pythium* and *Phytophthora* spp.
Downy mildew* (*Peronospora antirrhini*)	Young tip leaves are dull green, severely stunted, and roll downward. Gray-purple fungus grows on undersides of leaves. Disease is common on seedling phase; large plants are less frequently attacked. Infected plants fail to produce flowers.	Thick-walled resting spores (oospores) in dead plant parts. Airborne spores. Favored by cool (40° to 60°F), wet weather.	In greenhouse, reduce humidity. Drench seedlings with mefenoxam or oomycete- or water mold- specific fungicide. Do not replant in fields where disease has been severe. Steam treat to kill resting spores. Protect foliage with mancozeb.
Gray mold* (*Botrytis cinerea*)	Brown, water-soaked decay of flowers, leaves, and stems. Fuzzy gray fungal spores form on rotted tissues. Frequently found on stems of cut flowers.	In plant debris. Airborne spores. Favored by continued cool, moist conditions.	Reduce humidity in greenhouse. Clean up all plant debris. Protect foliage with iprodione or fenhexamid. Mancozeb also helps control gray mold.
Powdery mildew* (*Golovinomyces orontii*)	White, powdery fungus grows on both leaf surfaces. Severely infected leaves may be killed.	On living leaves. Airborne spores; not in soil or on seeds. Favored by moist, shaded conditions, and dry foliage.	Protect foliage with triadimefon or sulfur.
Rust* (*Puccinia antirrhini*)	Pustules of dark brown to purple powdery spores develop on leaves and stems. Rapid water loss from severely rusted leaves causes them to dry up.	On living snapdragon plants and spores on seed. Does not survive in soil, but does in plant refuse. Airborne spores. Favored by abundant dew, cool nights (50° to 55°F), and warm days (70° to 75°F).	In greenhouse, avoid wetting foliage and prevent moisture condensation at night by balancing heat and ventilation. Protect foliage with myclobutanil or triadimefon. Mancozeb also helps protect foliage from infection. Remove and destroy infected plants.
Verticillium wilt* (*Verticillium dahliae*)	Plants wilt, frequently on one side. Wilting is more pronounced near time of bloom. Problem is most important in seed fields.	In soil for many years. Favored by cool weather. Plants wilt during hot weather.	Steam treat or fumigate soil with a chloropicrin or a chloropicrin combination or solarize soil.
Water mold root rots (*Pythium* spp. and *Phytophthora* spp.*)	Plants are stunted, wilt, or suddenly collapse. Roots decay. Plants fail to "push" after flowers are cut. Remaining stubs are more susceptible to gray mold.	Soilborne pathogen. Favored by heavy, waterlogged soils.	Avoid planting on poorly drained soils. Do not overirrigate. Steam treat or fumigate greenhouse soil. Drench plants with oomycete (water mold) specific fungicide.

Snapdragons are also susceptible to collar rot (*Rhizoctonia solani*), crown gall* (*Agrobacterium tumefaciens*), leaf and stem spot (*Phyllosticta antirrhini*), mosaic* (*Cucumber mosaic virus*), root knot nematode** (*Meloidogyne* spp.), and stem rot (*Phyllosticta antirrhini*). Anthracnose (*Colletotrichum antirrhini*) is important elsewhere but is not found in California.

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

STATICE

Limonium spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Anthracnose (*Colletotrichum gloeosporioides*)	Plants wilt and become mildly chlorotic. Crown tissues decay and plant may die. In initial stages, roots are not affected. The fungus also causes leaf, stem, and flower spots, but this phase of the disease is not common in California. Gold Coast cultivar is highly susceptible; blue and white cultivars are more tolerant.	The fungus survives on infected plants and debris. The disease is favored by wet weather and overhead irrigation. Spores are spread by splashing water.	Avoid overhead irrigation. Protect plants with chlorothalonil or copper. Chlorothalonil may cause blackening of flowers.
Cercospora leaf spot (*Cercospora insulana*)	Small, dull red lesions that enlarge up to 0.67 inch (15 mm) and become tan and membranous in the center with reddish borders.	Spores are airborne. Disease is favored by warm, moist conditions and condensed water on foliage.	Avoid overhead irrigation. Protect foliage with chlorothalonil.
Downy mildew* (*Peronospora statices*)	Bluish gray sporulation occurs on undersides of leaves. On upper surface of leaves, infections appear as light green areas that turn yellow, then coalesce, and eventually the leaf dies. In California it is currently found on cultivars in the "Misty" series; in Europe it occurs on many *Limonium* species.	Unlike powdery mildew fungi, this fungus requires very wet conditions to flourish. Favored by cool temperature. High relative humidity (90% or greater) and free moisture required for spores to germinate and infect plants. Spores require a minimum of 8 hours of wetness before infection occurs.	In greenhouse, provide good air circulation and keep relative humidity below 85%. Avoid wetting foliage, using drip instead of overhead irrigation if possible. Remove infected plants immediately. Protect foliage with fungicides if necessary.
Gray mold* (*Botrytis cinerea*)	Rot of leaves, stems, and flowers. Rot may enter crowns and kill plants. Fuzzy gray fungus sporulation develops on decayed tissues. Flower stubs remaining after flower harvest are particularly susceptible. The fungus also may kill seedlings.	Fungus has a wide host range and develops on dead plant parts. Spores are airborne. The disease is prevalent in California in cool (below 77°F) rainy weather.	Clean up plant debris. Incorporate crop residue into soil as soon after harvest as feasible. Avoid overhead irrigation especially when flowers are present. Protect plants with iprodione or fenhexamid.
Verticillium wilt* (*Verticillium dahliae*)	Plants are stunted. Lower leaves yellow, wilt, and dry.	The fungus, which has a wide host range, survives in soil as microsclerotia.	Fumigate soil with chloropicrin or a chloropicrin combination. Heat, fumigate, or solarize soil used in production of transplants.

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Aster yellows* (Phytoplasma)	Stunted growth, multiple production of short stalks, malformation and bunching of young leaves. Leaves on more mature plants are reddened in the basal rosette. Flowers are abnormal: reduced size, abnormal shape and color (frequently green), and may fail to open.	Phytoplasma is transmitted by leafhoppers.	Control insects. Destroy infected plants.
Turnip mosaic* (*Turnip mosaic virus*)	Plants are stunted and have a mosaic pattern of light and dark green in leaves. Plants infected when young often die. Leaves may be distorted.	Virus is transmitted by several different aphids and is common in many weedy plants in the mustard family (Cruciferae).	Control nearby cruciferous weeds. Control aphids.

Statice is also susceptible to powdery mildew* (*Erysiphe polygoni*), rust* (*Uromyces* spp.), bacterial crown rot (*Pseudomonas* spp.), southern blight* (*Sclerotium rolfsii*), *Broad bean wilt virus*, *Cucumber mosaic virus*, *Statice virus Y*, *Tobacco rattle virus*, *Tomato bushy stunt virus*, and root knot nematode** (*Meloidogyne* spp.).

* For additional information, see section on Key Diseases.

** For additional information, see section on Nematodes.

STOCK

Matthiola spp. (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Bacterial blight* (*Xanthomonas campestris* pv. *incanae*)	Basal leaves turn yellow and drop. Leaf scar is blackened. Soft, water-soaked stem cankers later become dark and sunken. Plant stems may break and fall over because they are weakened by the cankers. Black discoloration of the vascular system occurs.	Seedborne and in plant debris; also in soil for 2 years. Favored by cool, wet weather. Bacteria are spread by water.	When buying seed, specify that it be grown from seed treated in hot water (122° to 131°F for 10 minutes). Follow a 3-year crop rotation. Avoid splashing water.
Cottony rot* (*Sclerotinia sclerotiorum*)	Girdling infections that cause stems to turn chalky white. Cottony, white masses of fungus or large, black sclerotia develop on and in stems. Black sclerotia may develop in seed pods in the shape of stock seed.	As sclerotia in soil. Airborne spores produced by sclerotia only infect weak or dying tissue. Sclerotia also produce hyphae that infect plant. Favored by cool, moist conditions.	Avoid fields where disease has occurred (common disease of many vegetable crops). Apply PCNB to soil before planting. Spray foliage with thiophanate-methyl combined with mancozeb.
Foot rot or wire stem* (*Rhizoctonia solani*)	Brown rot of stem occurs at the soil line; area later becomes a dry, sunken canker. Stems are girdled. Brown fungus strands are visible with a hand lens. Also causes damping-off of seedlings.	Soilborne fungus. Favored by warm, moderately moist soil.	Use PCNB on soil before planting. Spray iprodione or thiophanate-methyl over the row and bases of plants.
Fusarium wilt* (*Fusarium oxysporum* f. sp. *mathioli*) (important in seed fields)	Lower leaf veins turn yellow, then entire leaf becomes yellow, withers, and drops. Basal leaves are affected first. Plants are stunted. Seed pods turn a light-tan color. Brown vascular discoloration occurs.	Soilborne for many years; also seedborne. A warm-weather disease; rarely a problem in the winter grown cut-flower crop.	No control necessary for the cut-flower crop grown in cool, coastal areas. Fumigate soil with a chloropicrin or a chloropicrin combination (tarped).
Gray mold* (*Botrytis cinerea*)	A soft, brown decay that occurs on flowers or entire flower heads. Fuzzy gray fungus spores form on decayed tissues. Decay may also start on dead leaves and rot the growing points and flower buds.	In plant debris. Favored by cool, moist conditions and condensed moisture on plants. Spores (conidia) are airborne.	Protect flowers with thiophanate-methyl in combination with mancozeb or treat with iprodione. Avoid overhead irrigation.
Leaf spot* (*Alternaria raphani*)	Round to elongate, concentric, brown spots covered with black, powdery spores. Spots are small at first, then turn gray-green with water-soaked margins.	On growing stock, cruciferous plants, and crop refuse. Favored by wet weather. Spores are airborne. Also found on other cruciferous crops.	Destroy all plant refuse by plowing under plants as soon as flowers are harvested. Spray with a copper fungicide or mancozeb during wet weather. Avoid overhead irrigation.
Verticillium wilt* (*Verticillium dahliae*)	Foliage yellows and wilts. Leaves die and dry progressively upward from the base of the plant. Dark discoloration may occur in the vascular system.	Soilborne as microsclerotia for many years. Symptoms most severe when weather turns warm after a cool period. Host range of this form of *Verticillium* is different from that of the common *Verticillium*.	Avoid fields where disease has occurred or fumigate soil with a chloropicrin or chloropicrin combination (tarped). This combination also controls most weeds, nematodes, soil insects, and other fungi and bacteria.
Water mold root rots *Phytophthora* spp.* and *Pythium* spp.*)	Plants wilt easily or suddenly collapse. Roots and crown become decayed. Also causes damping-off of seedlings.	Soilborne pathogens. Associated with poorly drained, waterlogged soils. Spores are spread in water.	Provide drainage and avoid excessive irrigation. Plant on raised beds. Seed treatments help to control the damping-off phase. An oomycete (water mold) specific fungicide may also be effective.

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Stock, continued

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Mosaic (several viruses, including *Impatiens necrotic spot virus* and *Turnip mosaic virus*)	Leaf mottling and flower breaking occur. Leaf symptoms vary with different viruses. White and yellow varieties do not show flower breaking.	In cruciferous weeds (mustard, wild radish, shepherd's-purse, etc.). Spread by aphids. Not seedborne. Symptoms favored by cool weather.	Destroy nearby weeds. Avoid fields near uncontrolled weedy areas. Plow under stock as soon as the crop is cut. Control aphids.

Stock is also susceptible to downy mildew* (*Peronospora parasitica*).

* For additional information, see section on Key Diseases.

STRAWFLOWER

Helichrysum bracteatum (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Downy mildew* (*Plasmopara halstedii* and *Bremia lactucae)*	Two distinct downy mildews infect strawflower, though symptoms are similar for both diseases: yellow foliage with downy white sporulation on the undersurface. Leaves roll downward. Tissues sometimes are killed	Disease is favored by cool (59°F), wet weather. Spores (sporangia) are airborne. Chilean tarweed (*Madia sativa*) and other members of the family Compositae are hosts of *P. halstedii*.	Control tarweed for some distance away if possible. Protective fungicides should be effective but few if any are labeled for strawflower.
Verticillium wilt* (*Verticillium dahliae*)	Wilting and yellowing of lower leaves on one side of plant. Vascular discoloration.	Favored by cool spring. Symptoms develop rapidly in hot weather at flowering. Fungus survives in soil for long periods as microsclerotia. Many plants are infected including weeds, crop plants, and ornamentals.	Avoid fields that are known to be infested. Soil fumigation with chloropicrin or a chloropicrin combination is effective.

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Aster yellows* (*Aster yellows phytoplasma*)	Plants stunted and yellow. Frequently one-sided. Flowers may be green.	*Aster yellows phytoplasma* is spread by leafhoppers. A wide variety of plants including weeds are susceptible.	Control weeds in and around planting. Leafhopper control may help.

* For additional information, see section on Key Diseases.

SWEET PEA

Lathyrus odoratus (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Black root rot* (*Thielaviopsis basicola*)	Poor top growth. Black lesions on roots and root rot. Seedlings may be killed.	Fungus is soilborne. Favored by cool, wet soils and any condition that weakens the plant.	Avoid fields previously planted in legumes. Avoid overirrigation and overfertilization. Plant on raised beds.
Powdery mildew* (*Erysiphe trifolii*)	White powdery growth on surface of leaves and stems. Older infected leaves yellow and wither. Growth of heavily infected plants is diminished.	Favored by moderate temperatures. Spores (conidia) are produced in great abundance and they are airborne. Moisture is not necessary for germination and infection and is detrimental to the fungus.	Several powdery mildew fungicides are effective if applied in a regular preventative program commencing with the first signs of the fungus. Check product label for registration.
Ramularia leaf spot (*Ramularia deusta*)	Large, irregular or circular tan spots without definite margins. Lower leaves are first affected. Infected leaves often drop.	Fungus is specific to sweet pea and survives in sweet pea refuse. Favored by wet conditions.	Rotate with other crops for 2 years. A fungicide may be necessary in some severe cases. Avoid overhead irrigation.
Seed decay (*Pythium* spp. and other fungi)	Seeds rot in soil. Seedlings do not emerge.	Favored by wet soil and poor aeration.	Provide better drainage. Grow on raised beds.

Virus or viruslike disease	Symptoms	Host range and natural spread	Comments on control
Enation mosaic (*Pea enation mosaic virus*)	Leaves contain scattered translucent areas ("windows"). Foliage may be crumbled and stunted. There may be "windows" in the flowers.	Virus is spread by aphids. Host plants include many legumes.	Control nearby weeds, especially legumes. Control aphids.
Mosaic (*Pea mosaic virus*)	Mottling and chlorosis of the foliage. Dark green areas interspersed with yellow-green portions of leaves. Flowers have "broken" colors.	Virus is spread by aphids. Host plants include many legumes.	Control nearby weeds, especially legumes. Control aphids.
Spotted wilt (*Tomato spotted wilt virus*)	Reddish brown streaks on stems. Leaves with circular spots that are yellow at first and later turn brown. Plant may die.	Spread by thrips. Virus has a wide host range, including many weeds. Juvenile thrips (nymphs) acquire the virus and transmit it as adults.	Control nearby weeds including grasses. Control thrips.

Sweet peas are also susceptible to Ascochyta blight (*Ascochyta lathyri*), bacterial streak (*Pantoea agglomerans,* formerly *Erwinia herbicola*), fasciation (*Rhodococcus fascians*), Pythium root rot* (*Pythium* spp.), cottony rot* (*Sclerotinia sclerotiorum*), downy mildew* (*Peronospora trifoliorum*), and damping-off* (*Rhizoctonia solani*, *Fusarium* spp., and *Pythium* spp.)

* For additional information, see section on Key Diseases.

SWEET WILLIAM

Dianthus barbatus (11/20)

Disease (causal agent)	Symptoms	Survival of pathogen and effect of environment	Comments on control
Fusarium wilt* (*Fusarium oxysporum* f. sp. *dianthi*)	Yellowing of new growth. Plants stunted and leaves point downward instead of upward as in a healthy plant. Leaves gradually turn yellow and die. The vascular system of the lower stem and roots is brown.	Fungus survives in soil for many years as chlamydospores. Disease is favored by warm soils and high temperatures.	Fumigate soil with chloropicrin or a chloropicrin combination. Grow seedlings in heat-treated, solarized, or fumigated soil or growing medium.
Leaf spot (*Cladosporium echinulatum*)	Yellowish brown, withered spots surrounded by a purplish margin on leaves. As the disease progresses, entire leaves and stems become necrotic.	Spores (conidia) are airborne. Fungus survives on sweet william debris. Favored by wet weather and overhead irrigation.	Avoid overhead irrigation. Protect foliage with a fungicide.

Sweet williams are also susceptible to rust* (*Uromyces caryophyllinus* and *Puccinia arenariae*), root rot* (*Pythium ultimum*), gray mold* (*Botrytis cinerea*), stem rot (*Rhizoctonia solani*), southern blight* (*Sclerotium rolfsii*), Septoria leafspot (*Septoria dianthi*), anther smut (*Microbotryum violaceum*, formerly *Ustilago violacea*), curly top (*Beet curly top virus*), and aster yellows* (aster yellows phytoplasma).

* For additional information, see section on Key Diseases.

Host-Pathogen Index (11/20)

The host-pathogen index is a list of ornamental hosts not covered in the Disease Control Outlines and some of the pathogens that attack these hosts. Diseases covered in Key Diseases are noted with an asterisk.

African Violet (*Saintpaulia ionantha*)

Bacterial blight	*Dickeya* (=*Erwinia*) *chrysanthemi*
Foliar nematode**	*Aphelenchoides ritzemabosi*
Gray mold*	*Botrytis cinerea*
Phytophthora crown rot*	*Phytophthora parasitica*
Powdery mildew*	*Odium* spp.
Pythium root rot*	*Pythium* spp.
Rhizoctonia stem rot	*Rhizoctonia solani*
Ring spot	physiological (cold water and light)

Christmas cactus (*Schlumbergera bridgesii*)

Crown rot*	*Phytophthora parasitica*
	Pythium aphanidermatum
Fusarium rot*	*Fusarium oxysporum*
Gray mold*	*Botrytis cinerea*
Root and stem rot	*Rhizoctonia solani*
Root rot*	*Pythium irregulare*
Stem rot	*Phytophthora* spp.
Stem rot and leaf spot	*Bipolaris cactivora*
Virus	*Cactus virus X*

Candytuft (*Iberis amara*)

Alternaria leaf spot*	*Alternaria brassicae*
Basal stem rot	*Phoma lingam*
Club root	*Plasmodiophora brassicae*
Downy mildew*	*Peronospora parasitica*
Gray mold*	*Botrytis cinerea*
Phytophthora root rot*	*Phytophthora* spp.
Powdery mildew*	*Erysiphe cruciferarum*
Pythium root rot*	*Pythium* spp.
Root knot nematode**	*Meloidogyne* sp.
White rust	*Albugo candida*

Cineraria (*Senecio cruentus*)

Collar rot	*Rhizoctonia solani*
Downy mildew*	*Plasmopara halstedii*
Gray mold*	*Botrytis cinerea*
Impatiens necrotic spot	*Impatiens necrotic spot virus*
Leaf spot*	*Alternaria cinerariae*
Powdery mildew*	*Erysiphe cichoracearum*
	Sphaerotheca fuliginea
Root and collar rot*	*Phytophthora* spp.
Root rot*	*Pythium ultimum*
Spotted wilt	*Tomato spotted wilt virus*
Stem rot*	*Sclerotinia sclerotiorum*

* For additional information, see section on Key Diseases.

* For additional information, see section on Nematodes.

*

Gardenia (*Gardenia jasminioides*)

Bacterial leaf spot	*Xanthomonas campestris* pv. *maculifoliigardeniae*
Chlorosis	iron deficiency
Petal blight (gray mold)*	*Botrytis cinerea*
Phomopsis canker	*Phomopsis gardeniae*
Root knot nematode**	*Meloidogyne* spp.

Gerbera (*Gerbera jamesonii*)

Bacterial leaf spot*	*Pseudomonas cichorii*
Black root rot*	*Thielaviopsis basicola*
Crown and root rot	*Rhizoctonia solani*
Gray mold*	*Botrytis cinerea*
Leaf spots	*Alternaria porri*
	Cercospora gerberae
	Septoria spp.
	Ascochyta gerberae
Phytophthora crown rot*	*Phytophthora cryptogea* and others
Powdery mildew*	*Golovinomyces cichoracearum*
Pythium root rot*	*Pythium* spp.
Sclerotinia crown rot	*Sclerotinia sclerotiorum*
Spotted wilt	*Tomato spotted wilt virus*
Verticillium wilt*	*Verticillium dahliae*
White rust***	*Albugo tragoponis*

German violet (*Exacum affine*)

Basal stem rot	*Nectria hematocca*
Gray mold*	*Botrytis cinerea*
Root rot*	*Pythium ultimum*
Spotted wilt	*Tomato spotted wilt virus*

Gloxinia (*Sinningia speciosa*)

Cottony rot and flower blight*	*Sclerotinia sclerotiorum*
Crown rot	*Myrothecium roridum*
Crown rot and tuber rot	*Rhizoctonia solani*
Gray mold*	*Botrytis cinerea*
Ring spot	physiological (cold water and light)
Root and crown rot*	*Phytophthora cryptogea*
	P. nicotiana
Root rot*	*Pythium* spp.
Southern blight*	*Sclerotium rolfsii*
Spotted wilt	*Tomato spotted wilt virus*

Hydrangea *(Hydrangea macrophylla)*

Gray mold*	*Botrytis cinerea*
Powdery mildew*	*Golovinomyces orontii*
Rhizoctonia stem rot	*Rhizoctonia solani*
Ringspot	*Hydrangea ringspot virus*
Root knot nematode**	*Meloidogyne* spp.
Root rot*	*Pythium* spp.
Virescens	Phytoplasma

* For additional information, see section on Key Diseases.
** For additional information, see section on Nematodes.
** Not reported in U.S.A.
*

Impatiens (*Impatiens walleriana*)

Bacterial fasciation	*Rhodococcus fascians*
Bacterial leaf spot*	*Pseudomonas syringae*
Black root rot*	*Thielaviopsis basicola*
Brown crown canker	*Rhizoctonia solani*
Crown rot*	*Pythium ultimum*
	Rhizoctonia solani
Downy Mildew*	*Plasmopara obducens*
Gray mold*	*Botrytis cinerea*
Impatiens necrotic spot	*Impatiens necrotic spot virus*
Leaf spot	*Phyllosticta* sp.
Root rot*	*Pythium* sp.
Southern blight*	*Sclerotium rolfsii*
Spotted wilt	*Tomato spotted wilt virus*
Verticillium wilt*	*Verticillium dahliae*

Kalanchoe (*Kalanchoe blossfeldiana*)

Aster yellows*	*Aster yellows phytoplasma*
Edema	Physiological; cause unknown
Fasciation	*Cercospora* sp.
Impatiens necrotic spot	*Impatiens necrotic spot virus*
Kalanchoe mosaic	*Kalanchoe mosaic virus*
Leaf and stem blight	*Botrytis cinerea**
Leaf spots	*Stemphylium* spp.
Powdery mildew*	*Sphaerotheca fuliginea*
Root and crown rot*	*Phytophthora* spp.
Spotted wilt	*Tomato spotted wilt virus*
Stem rot	*Myrothecium roridum*

Lilac (*Syringa vulgaris* and *S. persica*)

Armillaria root rot*	*Armillaria mellea*
Bacterial blight**	*Pseudomonas syringae* pv. *syringae*
Crown gall*	*Agrobacterium tumefaciens*
Gray mold*	*Botrytis cinerea*
Leaf blotch	*Heterosporium syringae*
Phytophthora blight	*Phytophthora* spp.
Phytophthora root rot**	*Phytophthora* spp.
Powdery mildew*	*Microsphaera penicillata*
Shoot blight*	*Sclerotinia sclerotiorum*

Lilies (*Lilium* spp.)

Cottony rot and petal blight*	*Sclerotinia sclerotiorum*
Foliar nematode*	*Aphelenchoides* spp.
Gray mold*	*Botrytis* spp.
Leaf spots*	*Cercospora, Heterosporium,* and *Ramularia* spp.
Root knot nematode	*Meloidogyne* spp.
Rust*	*Uromyces* spp.
Scale rots	*Colletotrichum* spp.

Lisianthus (*Eustoma grandiflora*)

Foliar nematode**	*Aphelenchoides* spp.
Gray mold*	*Botrytis cinerea*
Leaf spot*	*Cercospora eustomae*
Powdery mildew*	*Leveillula taurica*
Root knot nematode**	*Meloidogyne* spp.
Root and stem rot	*Fusarium avenaceum, Phytophthora, Pythium,* and *Rhizoctonia* spp.

Viruses	Tomato spotted wilt virus, Impatiens necrotic spot virus

Pouch Flower (*Calceolaria* x *herbeohybrida*)

Cottony rot*	*Sclerotinia sclerotiorum*
Gray mold*	*Botrytis cinerea*
Root and crown rot*	*Phytophthora* spp.
Root rot*	*Pythium* spp.
Spotted wilt	*Tomato spotted wilt virus*
Stem rot	*Myrothecium* sp.
Verticillium wilt*	*Verticillium dahliae*

Primula (*Primula* x *polyantha*)

Crown rot	*Rhizoctonia solani*
Fasciation	Physiological; cause unknown
Gray mold*	*Botrytis cinerea*
Leaf spot	*Ramularia primulae*
Root rot*	*Pythium* spp.
Spotted wilt	*Tomato spotted wilt virus*

Protea (*Protea, Banksia, Leucospermum*, and other spp.)

Canker	*Botryosphaeria* spp.
Gray mold*	*Botrytis cinerea*
Leaf spots	*Colletotrichum* spp., *Mycosphaerella* spp.
Root and crown rot*	*Phytophthora* spp., *Rhizoctonia solani*
Root knot nematode*	*Meloidogyne* spp.
Verticillium wilt*	*Verticillium dahliae*

Queen Anne's Lace (*Daucus carota*)

Aster yellows	*Aster yellows phytoplasma*
Bacterial blight*	*Xanthomonas campestris* pv. *carotae*
Black root rot	*Alternaria radicina*
Early blight*	*Cercospora carotae*
Leaf blight*	*Alternaria dauci*
Powdery mildew*	*Erysiphe heraclei*
Root and stem rot	*Fusarium* spp.
Root, crown, and stem rots*	*Phytophthora, Pythium,* and *Rhizoctonia* spp.
Southern blight*	*Sclerotium rolfsii*
Tuber rot	*Rhizopus* spp.
Viruses	*Celery mosaic virus, Carrot motley dwarf virus*

Ranunculus (*Ranunculus* spp.)

Aster yellows*	*Aster yellows phytoplasma*
Bacterial blight*	*Xanthomonas campestris* pv. *carotae*
Cottony rot*	*Sclerotinia sclerotiorum*
Downy mildew*	*Peronospora* spp.
Gray mold*	*Botrytis cinerea*
Leaf spots*	*Ramularia* spp.
Powdery mildew*	*Erysiphe polygoni*
Root rots*	*Pythium spp., Rhizoctonia solani*
Rust	*Puccinia* spp.
Smut	*Entyloma* spp.
Southern blight*	*Sclerotium rolfsii*
Viruses	*Tomato spotted wilt virus, Ranunculus mosaic virus*

Stephanotis (*Stephanotis floribunda*)

Crown rot	*Rhizoctonia solani*
Gray mold*	*Botrytis cinerea*
Powdery mildew*	Oidium sp.
Stem dieback	*Glomerella cingulata*
Virus	*Impatiens necrotic spot virus, Tomato spotted wilt virus*

Sunflower (*Helianthus* sp.)

Aster yellows*	*Aster yellows phytoplasma*
Charcoal rot	*Macrophomina phaseolina*
Cottony rot*	*Sclerotinia sclerotiorum*
Downy mildew*	*Plasmopara halstedii*
Gray mold*	*Botrytis cinerea*
Head rot	*Rhizopus oryzae*
Leaf spots*	*Alternaria, Cercospora,* and *Septoria* spp.
Powdery mildew*	*Golovinomyces cichoracearum*
Root and stem rot*	*Phytophthora* sp.
Rust*	*Coleosporium, Puccinia,* and *Uromyces* spp.
Smut	*Entyloma calendulae*
Southern wilt*	*Sclerotium rolfsii*

* For additional information see section on Key Diseases.

Insects, Mites, and Other Invertebrates

(Section reviewed 1/22)

General Information

COMMON SIGNS AND SYMPTOMS ON PLANTS DAMAGED BY PEST INSECTS, MITES, SLUGS, AND SNAILS (ARTHROPODS) AND THE PROBABLE CAUSES

(3/21)

Symptoms	Causes
arthropod by-products	• cast skins (translucent or whitish): aphids, leafhoppers, lace bugs, spider mites • dark fecal specks: lace bugs, leafminer adults, plant bugs, shore fly adults, thrips • flocculence (cottony, waxy material): adelgids, certain aphids, lerp psyllids, mealybugs, certain scale insects, whiteflies • large excrement (frass) particles: caterpillars, leaf beetles • pale foam or spittle: spittlebugs • pitch masses: larvae of certain moths e.g., Sequoia pitch moth • pitch tubes: certain bark beetles (Scolytinae) • shiny trails or slime: fungus gnat larvae, slugs, snails • silken mats, tents, or webs or rolled leaves: leafrollers, tent caterpillars, webworms • sticky honeydew and blackish sooty mold: aphids, mealybugs, psyllids, soft scales, whiteflies
bleached, bronzed, stippled, or yellowed foliage	• eriophyid mites e.g., blister, bud, erineum, gall, or rust mites • lace bugs • leafhoppers • plant bugs • spider mites • thrips
chewed or tattered blossoms or foliage	• adults and larvae of leaf-feeding beetles • crickets, grasshoppers, or katydids • larvae (caterpillars) of butterflies and moths (Lepidoptera) e.g., armyworms, cabbage looper, cutworms, diamondback moth, European pepper moth (Dufo moth) • larvae of sawflies (broad-waisted wasps) e.g., rose slugs

Symptoms	Causes
	• leafcutting bees, which are important pollinators and should not be killed. Where these bees have been collecting material for their nests covering those plants with cheesecloth or other screening prevents further damage. Place out these barriers when leaf cutting is first observed or the time of year (late winter or spring) when damage first occurred during previous seasons. Barriers can be removed about midsummer when the mother bees are no longer active. • snails or slugs e.g., brown garden snail
dieback of plant parts	• armored scales • gall wasps • katydids • larvae of boring beetles or moths • sharpshooters (large leafhoppers) • weevils
distortion of plant parts	• aphids • eriophyid or tarsonemid mites e.g., broad, cyclamen, blister, bud, erineum, gall, or rust mites • gall wasps • larvae of certain moths • lygus bugs or stink bugs • other true bugs (Heteroptera) • psyllids • thrips
foliage mines	• larvae of certain flies, moths, or sawflies (broad-waisted wasps)
holes in stems, bark or twigs	• adult beetles e.g., bark beetles, flatheaded borers, longhorned beetles • larvae of boring beetles or caterpillars (e.g., clearwing moths) feeding hidden in plants

Adapted from *Container Nursery Production and Business Management Manual*, UC ANR Publ. 3540

MONITORING WITH STICKY TRAPS (3/21)

Trapping can be an efficient and informative monitoring tool. Traps can alert growers to pests early before crop damage occurs and before pests become abundant and more difficult to control.

Yellow sticky traps

Yellow cards (commonly 3 × 5 inches or larger) covered on both sides with sticky material attract and capture the adults of various flying insects. Yellow sticky traps can indicate localized spots of high pest abundance or periods of migration of adult pests into crops and the predominant direction from which they are arriving (e.g., from an adjacent field of drying weeds). Traps can also provide a relative measure of insect abundance; comparisons of the number of adults caught among sample dates can indicate whether pest density is decreasing, increasing, or remaining about the same over time. Pests captured by yellow sticky traps include adults of fungus gnats, thrips, and whiteflies, aphids, psyllids, and sharpshooters. Others presented side-by-side for comparison in *Sticky Trap Monitoring of Insect Pests* include leafminers, shore flies, and adults of certain parasites and predators.

Blue sticky traps are sometimes used for thrips because this color is more attractive to thrips. However insects are more difficult to discern and count in blue traps. Yellow sticky traps attract a wider variety of pest insects and are recommended for most situations.

Sticky traps may not be a good tool for deciding treatment need, whether any action thresholds are exceeded (see ESTABLISHING ACTION THRESHOLDS), and they are generally not effective for direct control. Immature stages feeding on crops commonly cause the most damage; sticky traps typically capture only airborne adults, which in many species do not feed on plants. Adult trapping sometimes is not a reliable indicator of pest presence or abundance on the crop. Many of the trapped adults may be migrating species that don't feed on the crops being grown. Adults often cannot readily be discriminated to species; for example, the adults can obviously be aphids but whether they are aphid species that infest the crops present may not be discernable from specimens stuck in sticky material. Always use traps in combination with visual inspection of plants for the presence of damage and pest feeding stages.

Unless other guidelines are recommended use at least one sticky trap per 10,000 sq. ft. of growing area. When monitoring whiteflies, use about one trap per 1,000 sq. ft. of growing area with crops susceptible to infestation. Actual trap density will be dictated by the growing area and the time and effort devoted to trapping. But each pest management unit should have at least one, well-maintained, yellow sticky trap. In addition, put one trap inside growing areas by doors and vents to detect pests migrating in. Also put at least one trap in each crop that is very susceptible to damage by pests and do not locate the most pest-susceptible crops near doors. Use bright yellow traps, each 3 × 5 inches or larger and covered with sticky material.

Orienting traps horizontally (facing the soil or upwards) is sometimes recommended when monitoring pests such as fungus gnats and shore flies that emerge from or rest upon growing media. However, to catch a wider range of targeted insects, orient the longest part of the trap vertically (up and down). Place each trap so that its bottom is even with the top of the plant canopy. For rapidly growing crops, locate trap bottoms a few inches above the canopy so that the plants do not soon overgrow the traps. As plants grow, move each trap up so that its bottom remains about even with the top of the canopy or somewhat higher. For example use one or two clothespins to attach each trap to a bamboo post or wooden dowel embedded in the growing media or a stand. Alternatively hang traps from rafters or wires strung between posts.

Number each trap and map its location in your growing area. Inspect each trap at least once or twice weekly. It is easiest to replace traps each time you inspect them. Wrap traps in clear plastic film and take them to a more comfortable location for counting. Alternatively replace traps when they become too fouled to effectively capture insects or count them quickly. If traps are reused, note this because catches become cumulative; you must subtract the number of insects present the last time that particular trap was checked, or sum and average the counts from all traps in a specific growing area then subtract the previous average from that currently.

Count and record the number of each type of pest caught. When abundant it is not necessary to count all insects on the entire trap; counting the insects in a vertical column 1 inch wide on both sides of the trap,

then multiplying the results by the trap width in inches, gives results that are representative of the entire trap. Do not reduce traps to 1 inch vertical strips because smaller traps will be less attractive to insects. Waterless hand cleaner can be useful for removing the sticky material from hands.

Because many insects in traps may be beneficial or harmless, carefully identify insects before taking management actions. High-quality color photographs and line drawings of commonly trapped insects are available in *Sticky Trap Monitoring of Insect Pests*. You can also wrap used traps in clear plastic and take those containing unknown insects to offices of the UC ANR Cooperative Extension or county agricultural commissioner for help in identification.

Interpreting Information from Yellow Sticky Traps

Regularly summarize trap data to facilitate comparison. For example, graph the average numbers of each pest in all traps from a particular growing area on each sample date. This allows visual recognition of trends in pest abundance and facilitates comparison to stages of crop growth and when particular management actions were taken.

Interpreting trap information requires knowledge, skill, and practice. Traps catch both migrating insects as well as adults that emerged from the crop. Canopy density, plant foliage quality, and temperature influence adults' tendency to fly. Wind and ventilation fans can discourage flight, reducing trap catches. The number of adults trapped may temporarily drop after a pesticide application even if there has been relatively little change in immature abundance on plants. Conversely, adult numbers of some species may temporarily increase in traps after applying an adulticide, so the numbers caught for several days after an application might not be best when comparing adult densities among sample dates.

Foliage disturbances, such as sprinkling with water (overhead irrigation) or shaking plants to promote pollination or monitor adults (e.g., of whiteflies), increase trap catches. Even large numbers of pest species in traps do not necessarily indicate that control action is needed. Always use traps in combination with plant inspection to determine whether economically damaging numbers of pests and stages susceptible to control actions are present. For more information, see ESTABLISHING ACTION THRESHOLDS.

Sticky Tape Traps

Crawlers, the mobile first instars of certain Sternorrhyncha (formerly Homoptera), are the life stage most susceptible to many pesticides. Traps made of double-sided clear sticky tape (available at stationery stores) are an efficient method of monitoring crawlers of armored scales, foliar-feeding mealybugs, soft scale insects, and certain other arthropods. On each of several plants infested with adult females, snugly wrap a stem with tape. Double over the loose end of the tape several times so you can pull the end to easily unwind it. Place a tag or flag near each tape so you can readily find each tape trap. Change the tapes at regular intervals, about weekly. After removing the old tape, wrap the stem at the same location with fresh tape. Preserve the old sticky tapes by sandwiching each tape unrolled between a sheet of pale-colored or white paper and a sheet of clear plastic. Label the tapes with the collection date, location, and host plant.

Crawlers get stuck on the tapes and appear as yellow or orange specks. Examine the tapes with a hand lens to distinguish the crawlers (which are round or oblong, have very short appendages, and may have two dark eye spots) from contaminants such as dust, pollen, and spider mites. A contact insecticide and certain other pesticide types can be applied when crawlers are abundant. If a single application is planned, visually compare the tapes collected on each sample date. The best time for a single spray is after a sharp increase in crawlers in traps or soon after crawler numbers have peaked and begun to decline.

ESTABLISHING ACTION THRESHOLDS (3/21)

The presence of a few pest insects or mites and some amount of arthropod damage commonly is unavoidable and can be tolerated. The number of pests or level of damage beyond which management action should be taken is known as the action threshold, a fundamental concept in integrated pest management. When management action should be taken (when a threshold is exceeded) is determined by the total cost of the action (including monitoring), the value of the crop, and the impact on the environment. Few thresholds have been established for flower and nursery crops, in part because of the lack of research in comparison with the large number of crop plants, pests, and growing situations. Specific thresholds or management action guidelines may be developed over the long term by growers who regularly monitor crops, keep good records, and evaluate and summarize outcomes for comparison over time. Consult the chapters "Integrated Pest Management" and "Insects, Mites, and Other Pests" in the *Container Nursery Production and Business Management Manual* and also *Integrated Pest Management for Floriculture and Nurseries* for more discussion and illustration of these techniques.

Why Use Thresholds

Pesticides sometimes are applied on a calendar schedule, when pest presence is only suspected, or when pest numbers are already high and difficult to control. Using thresholds can maintain or improve crop quality while reducing the cost and frequency of control measures. Less frequent applications help maintain pesticide efficacy by reducing the development of pesticide resistance. Fewer applications reduce the disruptions to cultural practices that occur during applications and the subsequent restricted entry interval (REI). In addition, fewer applications may improve plant growth and quality by minimizing phytotoxicity and increase profit by reducing costs of pesticide purchases, application labor, and regulatory compliance.

When to Take Management Action

Because crops are grown for profit, action thresholds are based largely on economics. Management action is warranted when the increased revenue expected from improved crop quality or yield will exceed the cost and adverse impacts (such as phytotoxicity, harvest disruption) of the action. The amount of pest damage or presence that can be economically tolerated is determined by many factors, including the type of pest and damage, crop species and cultivar, stage of plant development, time until harvest or sale, and market conditions. Tolerance to pests can be higher if infested plant parts are not marketed, such as older leaves on seed crops or cut flowers. Thresholds can often be higher if highly effective or quick-acting methods are available for controlling the problem. Conversely, if available controls are slow-acting or only partially effective, or crops are of an exceptionally high value, thresholds may be relatively low. In certain situations, regulations such as quarantines may impose zero tolerance for exotic organisms even when numbers are low or an organism does not directly damage the marketed crop.

Mother stock and new plants should have virtually no pests. If pests are present at the beginning of the production cycle, many arthropods can develop through multiple generations resulting in large populations before plants are shipped. Abundant pests on young plants may require repeated management actions and greatly increase the likelihood of damaged, poor-quality plants.

Action thresholds may be higher for mature plants of certain crops. More mature plants are often better able to tolerate some level of certain types of pests or their damage. It is unlikely that susceptible crops can always be maintained pest-free throughout their production cycle. As crops mature, they may be increasingly likely to become infested and are often more difficult to treat effectively because of the risk of phytotoxicity to colored bracts or flowers, increased difficulty in achieving good spray coverage on larger plants, and pesticide reentry intervals relative to crop harvest or shipping.

If monitoring reveals very low pest abundance or damage near the end of production, it may not be necessary to take management actions because there may be insufficient time for populations to develop to problem levels before the crop is sold.

How to Establish Thresholds

Establish thresholds by regularly monitoring plants in a consistent and systematic manner. Keep good records and judge the acceptability of the finished crop in comparison with records of pest monitoring and management actions and the price received for the crop. Experiment over time to develop thresholds

appropriate for your situation and market conditions. Be flexible in adjusting thresholds and adapt monitoring and management methods as appropriate.

Thresholds should be quantitative or numerical to be useful. For example, thresholds could be based on the

- average number of pests per trap each week
- percent of leaves or plants found to be damaged or infested during visual inspection
- number of pests dislodged per beat or shake sample

Quantitative thresholds can be developed for most pest monitoring methods, such as treating when certain conditions are conducive to disease development or when invertebrate pests or damaged plant parts exceed specified numbers or percentages. For example, management action may be warranted for whiteflies early in production when more than about 5 adults per trap per week are captured on one well-maintained 3-by-5-inch yellow sticky trap deployed per 1,000 sq. ft. of production. Thresholds for your situations may be very different.

BIOLOGICAL CONTROL (3/21)

Biological control is the beneficial action of parasites (technically parasitoids), pathogens, and predators in managing pests and preventing or reducing their damage. Biocontrol provided by these living organisms called "natural enemies" is especially important for reducing the abundance of pest insects and mites and their damage to crops.

Conservation

Preserve resident natural enemies by choosing cultural, mechanical, and selective chemical controls that do not kill these species or disrupt their beneficial activities. Many insect and mite pests in flower and nursery crops have natural enemies that can keep their populations below economically damaging levels. Conservation is the primary way to successfully use biological control. For example, using selective pesticides that do not kill natural enemies or disrupt their beneficial activities is a key component of integrated pest management.

To enhance the effectiveness of biological control

- Consult the *Natural Enemies Gallery* to become familiar with common and important parasites and predators of pests.
- Control ants, which protect some pests from parasites and predators.
- Exclude pests (e.g., bring only pest-free plants into growing areas, screen greenhouses) and use excellent sanitation (e.g., promptly remove infested crop debris and eliminate weeds and other nearby noncrop hosts of pests). These methods provide direct control and reduce or prevent the in-migration of abundant pests that can overwhelm the potential effectiveness of natural enemies that are resident or released.
- Grow flowering insectary plants in or near outdoor nurseries to provide nectar and pollen to feed adult parasites and predators. Grow a series of plants that flower sequentially so blossoms are available throughout the growing season. Ideal insectary plants are those that can also be marketed, such as for culinary herbs and cut flowers. Avoid insectary-plant species that host arthropod pests or plant pathogens that can move to damage nearby crops. Consult *Flowers*; *Fruit Trees, Nuts, Berries, and Grapevines*; *Trees and Shrubs*; and *Vegetables and Melons* for lists of the pests reported on these plants.
- Keep growing areas and plants clean and free of dust, which can impede parasites' and predators' ability to locate and attack prey.
- Minimize or avoid the application of broad-spectrum, persistent (long-residual) acaricides and insecticides.
- Rely on pesticides that do not kill natural enemies or disrupt their beneficial activities where this is feasible. Consult the table Relative Toxicities of Pesticides Used in Floriculture and Nurseries to Natural Enemies and Honey Bees to learn which insecticides and miticides can be applied with minimal impact on natural enemies.
- When pesticides are used, apply them in a selective manner. For example, spray only the more heavily infested portions of the crop (hot spots) and where needed to prevent crop damage. Conserving resident natural enemies elsewhere in the unsprayed growing area allows parasites and predators to reproduce and the adults to disperse and attack pests elsewhere in growing areas where the plant-feeding species are not currently abundant or causing noticeable damage.

Augmentation

When the desired natural enemies are not present, or they are not abundant enough to sufficiently reduce pest numbers, biological control can sometimes be augmented with the purchase and release of commercially reared natural enemies. Augmentative releases can be inoculative or inundative. As discussed below and in more detail in Natural Enemy Releases for Biological Control of Crop Pests, there are various release strategies (e.g., banker plants discussed below). Be aware that in most situations, employing practices that conserve resident natural enemies is more effective and less expensive and time consuming than purchasing and releasing them.

Inoculative release

When pest populations are low, relatively few natural enemies may be needed for effective release. The introduced parasites or predators are expected to reproduce, and it is their progeny that are expected to provide biological control. Releasing the mealybug destroyer lady beetle (*Cryptolaemus montrouzieri*) in

late winter or spring to control foliar-feeding mealybugs is an example of inoculative release. The lady beetle is a highly effective predator of mealybug species that lay eggs in a cottony mass (ovisac). But this predator is native to the semi-tropics and does not survive cold weather, so to be effective it must be purchased and released early each growing season where mealybugs have been a problem. A parasitic wasp, *Leptomastix dactylopii*, can be released to kill nymphs of citrus mealybug. The mealybug destroyer and *Leptomastix dactylopii* parasite can be released in combination where citrus mealybug is a pest.

Inundative release
When releasing large numbers of natural enemies, often several times over a growing season, the individuals released are expected to provide biological control. Periodically releasing *Trichogramma* spp. egg parasitic wasps to destroy moth eggs is an example of inundative biological control. *Trichogramma* releases to kill moth eggs are compatible with applying *Bacillus thuringiensis* (Bt) to control the caterpillar stages and drenching soil with entomopathogenic nematodes (*Heterorhabditis* and *Steinernema* spp.) to kill the soil-dwelling, mature larvae and pupae of armyworms, cutworms, and European pepper moth (Dufo moth).

Periodically releasing large numbers of convergent lady beetles (*Hippodamia convergens*) to temporarily control aphids is also inundative release. Each convergent lady beetle can consume several dozen aphids per day. Because the beetles will virtually all disperse within 1 or 2 days of being released, and generally will lay few eggs and not reproduce in the crop, releases must be repeated about weekly to provide control where aphids are an ongoing problem. Because the purchased beetles are field collected from mountainous foothills during their overwintering (diapause) phase, when collected, transported, and released, the convergent lady beetles are physiologically obliged to fly and disperse before settling to lay eggs among aphids. For more information, see *Lady Beetle Releases for Aphid Control: How to Help Them Work* (PDF) from the newsletter *UC IPM Retail Nursery and Garden Center IPM News*.

Banker plants
One strategy for releases is to maintain natural enemies by rearing them on alternative insects that are not pests of the desirable crops. For example, barley, oats, or wheat infested with bird cherry-oat aphid might be used to maintain *Aphidius colemani* parasitic wasps in the greenhouse. This aphid is not a pest of many greenhouse bedding plants, but the wasps will feed on many other kinds of aphids (like green peach aphid) that are pests. These banker plants (e.g., planted in containers) with nonpest aphids and parasites or predators can be scattered throughout a greenhouse or nursery to provide a continual source of natural enemies that disperse to consume pest species on crops, such as for aphid control in greenhouses (PDF).

Effectiveness of releases
Augmentation is likely to be effective only in situations where researchers or other pest managers have previously demonstrated success. Guidelines for releasing natural enemies are provided in this publication in the sections on aphids, foliar-feeding mealybugs, fungus gnats, twospotted spider mite, and whiteflies.

Because natural enemies are living organisms, they require food (adults of many species require nectar and pollen), shelter from harsh conditions, suitable environmental conditions, and water. Natural enemies may be adversely affected by low humidity or extreme conditions such as hot temperatures. Residues of certain pesticides can persist for weeks or months, harming natural enemies long after losing their effectiveness against pest species. Many beneficial species stop reproducing under short day length or prolonged cool conditions; supplemental light may be necessary for them to reproduce and be effective year-round. Environmental conditions required by natural enemies (such as long days) may not be compatible with production needs of certain crops.

Desperate situations where pests are already abundant or damaging are not good opportunities for augmentation. Because pest presence is necessary to sustain natural enemies, choose crops where some levels of the target pests and their feeding can be tolerated (crops with moderate to high pest thresholds). Begin making releases early in the production cycle even before infestations are observed. Consider what other pests may occur in the crop and how they can be managed in ways that are compatible with conserving natural enemies. For more information, see *Natural Enemies Handbook: The Illustrated Guide to Biological Pest Control*, UC ANR 3386 (print edition), 9038 (ePub); Natural Enemy Releases for Biological Control of Crop Pests, andRelative Toxicities of Pesticides Used in Floriculture and Nurseries to Natural Enemies and Honey Bees.

RELATIVE TOXICITIES OF PESTICIDES USED IN FLORICULTURE AND NURSERIES TO NATURAL ENEMIES AND HONEY BEES (01/22)

This table summarizes the relative effects of insecticides and miticides (acaricides) on parasites and predators (natural enemies) and honey bees. See *Best Management Practices to Protect Bees from Pesticides* and *Protecting Natural Enemies and Pollinators* for more information.

Common name (Example trade name)	Mode of Action[1]	Selectivity (affected groups)[2]	Predatory Mites[3, 4]	Predators, other[4]	Parasites[4]	Duration of impact on natural enemies[5]	Honey Bees[6]
abamectin (Avid)	6	intermediate (leafminers, mites, thrips, whiteflies)	M	H	H	long	I
abamectin/S-methoprene bait (TruFin Ant Bait)	6/7A	narrow (certain ants)	none	L[11]	none	none	III
acephate (Acephate)	1B	broad (insects, mites)	H	H	H	intermediate	I
acetamiprid (TriStar)	4A	broad (insects)	L–M[7]	H	H	long	II
azadirachtin (Azatin) (Ornazin)	—	broad (insects, mites)	L–M	M	M–H	short	II
Bacillus thuringiensis spp. *aizawai* (Xentari)	11A	narrow (caterpillars, larvae of butterflies and moths)	none	none	L	none	II
Bacillus thuringiensis spp. *israelensis* (Gnatrol)	11A	narrow (larvae of certain flies e.g., fungus gnats, mosquitoes)	none	none	none	none	III
Bacillus thuringiensis spp. *kurstaki* (Deliver)	11A	narrow (caterpillars, larvae of butterflies and moths)	none	none	none	none	III
Beauveria bassiana (BotaniGard, Mycotrol)	—	narrow (aphids, lygus bugs, whiteflies)	L	L[8]	L	short	II
bifenazate (Floramite)	20D	narrow (mites)	M	L	none	intermediate	II
bifenthrin (Attain, Talstar)	3A	broad (insects, mites)	H	H	H	long	I
borate (Revenge Granular Ant Bait)	8D	narrow (ground-dwelling invertebrates including ants, crickets)	none	L[11]	none	short	III
buprofezin (Talus)	16	narrow (leafhoppers, mealybugs, sharpshooters, soft scales, whiteflies)	L[9]	L[10]	none	intermediate	II

carbaryl foliar* (Carbaryl 4L)	1A	broad (insects, mites)	H[7]	H	H	long	I
chlorantraniliprole (Acelepryn)	28	intermediate (aphids, clear-wing moths, lace bugs, leaf-feeding caterpillars, root-feeding grubs)	L	L	L–M	short	III
chlorfenapyr (Pylon)	13	narrow (leafminers, mites)	L	L	M	intermediate	II
cinnamaldehyde (Cinnacure)	—	intermediate (aphids, mites, thrips)	L	L	L	short	III
Cryptolaemus montrouzieri (mealybug destroyer)	—	narrow (ovisac-forming mealybugs and scales)	none	none	none	none	III
cyantraniliprole (Mainspring GNL)	28	intermediate (caterpillars, leafminers, sucking insects)	L	L	L	short	I
cyfluthrin (Decathlon)	3A	broad (insects, mites)	H	H	H	intermediate	I
cyfluthrin/imidacloprid (Discus)	3A/4A	broad (insects, mites)	H	H	H	long	I
cyromazine (Citation)	17	narrow (fungus gnats, leafminers, shore flies)	L	M	none	short	II
diazinon (Diazinon AG500)	1B	broad (insects, mites)	H	H	H	intermediate to long	I
diflubenzuron (Adept)	15	narrow (fungus gnats)	L	M	L	intermediate	II
dinotefuran (Safari)	4A	broad (insects)	L	M	M	long	I
etoxazole (Eschaton)	10B	narrow (mites)	—	—	—	—	—
fenazaquin (Magus)	21A	narrow (mites)	M	—	—	—	I
fenpropathrin (Tame)	3A	broad (insects, mites)	H	H	H	intermediate	I
fenpyroximate (Akari)	21A	narrow (mites)	M	L	M	short to intermediate	III
flonicamid (Aria)	29	intermediate (sucking insects)	L	L	L	short	III
flupyradifurone (Altus)	4D	broad (insects)	L	M	H	intermediate	II
Heterorhabditis spp. (entomopathogenic nematodes)	—	narrow (soil-dwelling insects)	none	L	none	short	III
hexythiazox (Hexygon)	10A	narrow (mite immatures)	M	L	L	long	II
imidacloprid, soil (Marathon)	4A	broad (insects, mites)	L[7]	L	M	long	I
Isaria fumosorosea (Ancora)	—	narrow (certain insects)	L	L	L	short	II

lambda-cyhalothrin (Scimitar)	3A	broad (insects)	H	H	H	intermediate	I
malathion (Malathion 8)	1B	broad (insects, mites)	M	H	H	intermediate	I
metaflumizone bait (Siesta)	22B	narrow (certain ants)	none	L	none	intermediate	III
metam sodium* (Vapam)	8F	broad (soilborne fungi, soil-dwelling insects, nematodes, mites, weeds)	L	M	L	short	III
Metarhizium anisopliae (MET 52)	—	broad (insects, mites)	L	L	L	short	III
Methiocarb (Mesurol 75-W)	1A		—	—	—		—
methoxyfenozide (Intrepid 2F)	18	narrow (caterpillars)	L	L	L	short	II
narrow-range oil (JMS Stylet Oil, Organic JMS Stylet Oil)	—	broad (insects, mites)	M	M	L	short	II
neem oil (Triact 70, Trilogy)	—	intermediate (exposed insects)	M	M	M	short	II
novaluron (Pedestal)	15	broad (caterpillars, leafminers, lygus bugs, thrips, whiteflies)	L	M–H	M	intermediate	I
permethrin (Perm-UP 25 DF)	3A	broad (insects, mites)	H	H	H	long	I
polybutene (Tanglefoot)	—	narrow (ants, certain other flightless insects)	L	L	L	long	III
potassium salts of fatty acids (M-Pede)	—	broad (insects, mites)	L	L	L	short	III
pymetrozine (Endeavor)	9B	narrow aphids, whiteflies)	L	L	M	short	II
pyrethrins (PyGanic)	3A	broad (insects, mites)	M	M	H	short	I
pyrethrins/PBO[12] (Pyrethrum TR)	3A/—	broad (insects)	M	H	H	short	I
pyridaben (Sanmite)	21A	narrow (mites)	H	M	H	intermediate	I
pyridalyl (Overture)	—	narrow (caterpillars, thrips)	L	—	—	—	—
pyrifluquinazon (Rycar)	9B	intermediate (sucking insects)	L	—	—	—	—
pyriproxyfen (Distance)	7C	intermediate (aphids, armored scales, fungus gnats, leafminers, shore fly, soft	L	H	M	long	II

		scales, white-flies)					
pyriproxyfen bait (Distance)	7C	narrow (certain ants)	none	L	none	intermediate	III
S-Kinoprene (Enstar)	7A	intermediate (immature in-sects)	none	M	none	short	III
spinosad (Con-serve SC, Entrust Naturalyte, Entrust SC)	5	intermediate (caterpillars, leafminers, thrips)	M	M[13]	H	intermediate	II
spiromesifen (Savate)	23	narrow (mites, whiteflies)	—	—	—	—	II
spirotetramat (Kontos)	23	intermediate (sucking in-sects, mites)	L	L	L	short	II
Steinernema spp. (entomopatho-genic nematodes)	—	narrow (fungus gnats, soil-dwelling in-sects and larvae and pupae of certain other in-sects)	none	L	none	short	III
sulfur dust (vari-ous products)	—	intermediate (mites)	M	L–M	M	intermediate	III
sulfur wettable (various products)	—	intermediate (mites)	L–M	L	L	short	III
tau-fluvalinate (Mavrik)	3A	broad (insects, mites)	H	H	H	long	I
Tebufenozide (Confirm 2F)	18	narrow (caterpillars)	L	L	L	short	II
thiamethoxam, fo-liar (Flagship)	4A	broad (insects)	M	M–H	H	long	I
thiamethoxam, systemic (Flag-ship)	4A	broad (insects)	L	L	M	long	I
tolefenpyrad (Ha-chi-Hachi)	21A	broad (insects)	—	—	—	—	I

Relative adverse effect: H = high, or medium to high M = medium, or low to medium L = low or none

— = Information not available or not presented

1 To prevent the development of resistance, rotate pesticides with a different mode-of-action group number, and do not use prod-ucts with the same mode of action more than twice per season, especially if they target the same, or successive, generations of a pest. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nemat-icides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Selectivity: *Broad* means the pesticide affects most groups of insects and mites. *Narrow* means the pesticide affects only one or a few specific groups.

3 Toxicities generally are to western predatory mite, *Galendromus occidentalis*.

4 Toxicities are averages of reported effects and should be used only as a general guide. Actual toxicity of a specific pesticide can vary depending on factors including application rate, environmental conditions, and the life stage and species of parasite or predator.

5 Duration: *Long* means many weeks or months. *Intermediate* (medium) means days to 2 weeks. *Short* means hours to days.

6 Honey bees, guidance on how to avoid bee poisoning: I–Do not apply or allow to drift to plants that are flowering including weeds. Do not allow pesticide to contaminate water accessible to bees including puddles. II–Do not apply or allow to drift to plants that are flowering including weeds, except when the application is made between sunset and midnight if allowed by the pesticide label and regulations. Do not allow pesticide to contaminate water accessible to bees including puddles. III–No bee pre-caution, except when required by the pesticide label or regulations.

7 May cause an increase in spider mites.

8 Toxic to (infects and kills) soil-dwelling predators e.g., predaceous ground beetles and certain spiders.

9 Use lowest rates for best management of predatory mite/spider mite ratio.

10 Kills lady beetles and other predatory beetles.

11 Toxic to ground-dwelling predators including predaceous ground beetles and rove beetles e.g., *Dalotia =Atheta* spp.

12	PBO = piperonyl butoxide
13	Toxic to certain natural enemies (lacewing and syrphid fly larvae, predatory beetles and thrips) when sprayed and up to 5 to 7 days after, especially for syrphid fly larvae.
*	Permit required from county agricultural commissioner for purchase or use.
#	Acceptable for use on organically grown ornamentals.

Sources: *Bee Precaution Pesticide Ratings*; Croft BA. 1990. *Arthropod Biological Control Agents and Pesticides*. Wiley, New York; Data mining of the 2018 University of California, Integrated Pest Management Pest Management Guidelines (UC IPM PMGs); Hassan SA. et al. 1994. *Results of the Sixth Joint Pesticide Testing Programme of the IOBC/WPRS Working Group–Pesticides and Beneficial Organisms*. Entomophaga 39:107–119; Jepson PC. 1989. *Pesticides and Non-target Invertebrates*. Wimborne. Dorset, UK; *Orchard Pesticide Effects on Natural Enemies Database* (OPENED); International Organisation for Biological and Integrated Control - West Palearctic Region Section *IOBC-WPRS Pesticide Side Effect Database*; Sterk G. et al. 1999. *Results of the Seventh Joint Pesticide Testing Programme Carried Out by the IOBC/WPRS-Working Group Pesticides and Beneficial Organisms*. Bio-Control 44 (1): 99–117.

ANTS (01/22)

Scientific Names: Argentine ant: *Linepithema humile*
Native gray ants: *Formica* spp.
Red imported fire ant: *Solenopsis invicta*
Southern fire ant: *Solenopsis xyloni*

DESCRIPTION OF THE PESTS

Ants (Formicidae) develop through four life stages: egg, larva, pupa, and adult. Most ants outside the nest are wingless, sterile females (workers). More than one dozen species of ants can potentially infest greenhouses or nurseries in California. These including those named above are distinguished in the well-illustrated *Identification Key to Ant Species* (PDF). It can be very helpful to identify the particular ant species present because their biology differs, as can their management.

Argentine ant workers are about ⅛ inch long and uniformly dark brown. They forage and travel in trails characteristic of many ants that move between their underground nests and irrigation lines, plants, and the surface of structures and soil. Argentine ants lack prominent hairs and have one node (hump) on the petiole, the waist-like (narrow) area between the thorax and the gaster (swollen part of abdomen behind the petiole).

The abundance of Argentine ants increases greatly during late winter and spring, peaking during mid-summer and early fall. The nests where immatures and queens occur are relatively shallow and usually the entire colony is within 2 inches of the soil surface. Argentine ants feed on sweet liquids any time of year they are active. They are also attracted to and feed on protein (e.g., granules of solid ant baits) during the spring when colonies are reproducing rapidly.

Native gray ant workers are a mix of gray and reddish brown and commonly appear grayish overall. They are up to about ⅕ inch long and the largest ants commonly found around plants. Workers are relatively solitary and move in an irregular pattern. Their scattered trails contain many fewer individuals than do the trails of Argentine ants. Native gray ants nest in topsoil or under rocks and soil debris.

Southern fire ant adults have a light reddish-brown head and thorax and a blackish, hairy abdomen. Fire ants can be distinguished from most other ants by the presence of varying size workers; both relatively large (up to ⅕ inch) and small (about 1/16 inch) individuals occur together in foraging trails, unlike with Argentine ant and native gray ants where all workers are approximately the same size. Fire ants build nests with openings that are loose craters or mounds of soil, such as near the base of trees and other objects. Fire ants will bite and sting aggressively when disturbed.

Red imported fire ant adults of this species cannot readily be distinguished in the field from southern fire ant. This ant feeds on almost any plant or animal material, including chewing bark off of young trunks, which can kill the plants. When disturbed red imported fire ants will bite and sting aggressively, possibly causing allergic reactions.

DAMAGE

Many pest ants feed on honeydew excreted by phloem-feeding insects including aphids, mealybugs, psyllids, soft scales, and whiteflies. Ants protect these other insects from their natural enemies, allowing populations to increase and become more damaging to crops. Argentine and native gray ants are the most common ant species that aggressively protect pest insects. In addition, Argentine ants and red imported fire ants can plug up irrigation sprinklers. Fire ants directly damage plants and can attack workers.

MANAGEMENT

Cultural and chemical controls are used to manage pest ants.

Biological Control

The primary natural enemies of the ants are other species of ants. There are no known methods for effectively controlling pest ants with parasites, pathogens, or predators.

Cultural Control
Exclude ants from benches by encircling bench legs with sticky material in a manner that keeps the material out of the way of workers. Or place each leg bottom in a shallow container filled with water, becoming an ant-exclusion moat. Cultivation reduces ant abundance, but avoid creating dust that can disrupt the effectiveness of natural enemies of other pests.

Organically Acceptable Methods
Cultural controls, including the use of sticky materials, are organically acceptable management methods.

Monitoring and Treatment Decisions
Monitor growing areas regularly for ants, ant nests, and honeydew-producing insects at least from late winter through fall. Periodically inspect for ants and bark damage under any trunk wraps of trees.

Insecticides
Baits are the preferred chemical method for ant control. Effective bait insecticides have slow-acting toxicants that worker ants collect and pass to other ants during their sharing of food and colony communication chemicals. Most products attract ants using protein-based solids or sugar-based liquids, and most ant species are highly attracted to only one of these bait types. If the bait does not attract the ant species present, it provides no control.

For the most effective and economical control apply ant baits beginning in late winter to early spring when the abundance of most ant species and their above-ground activities increases. Identify the most common species of ants present to guide bait selection. Fire ants are controlled only with solid baits using grain protein and plant oil as the attractants. Argentine ant and native gray ants are primarily controlled by insecticides in sweet liquid baits. Where Argentine ants are the predominant species, both types of bait may be effective during late winter through spring.

When in doubt about the ant species and best bait choice(s), deploy two or more types of baits, observe which type(s) the ants are feed on, then more widely place out the attractive product(s) where ants are a problem. Note that ants' attraction to baits and preference for particular types can change during the growing season in part due the availability of alternative foods, such as plant seeds (protein) and insect honeydew (sugary liquid).

Corncob grit and oil baits
Solid baits generally contain corncob grits or other grains mixed with soybean oil to attractant protein-feeding fire ants. The insecticides tend to degrade in light, so apply baits early in the morning or late in the day and in shady spots beneath plant canopies when ants are active and can take the bait into the nest. These granular or pellet grain and oil baits can be broadcast over the site, but spot application at the location of the ant nests is preferred because it concentrates the food where the ants most occur.

Sugar-water baits
Sweet liquid baits attract Argentine ant and native gray ants. For liquid baits using borate (e.g., boric acid, disodium tetraborate, orthoboric acid) as the insecticide, the effective concentration is 1/2 to 1% active ingredient. Evaporation of the bait liquid can cause the concentration of the toxicant over time to increase to a concentration that repels ants. But certain types of liquid bait stations greatly reduce or largely prevent evaporation. Note that borate insecticide may only be available for use in and around structures.

Broad-spectrum, persistent insecticide sprays
Avoid spray applications for ant control; surface sprays may not reach the immature ants and queens underground, so more ants will be produced and emerge to re-infest sites. Organophosphates (e.g., malathion), phenylpyrazoles (fipronil), and pyrethroids (permethrin) historically sprayed for ants are increasingly restricted because their movement after application is contaminating surface waters. Contact the county agricultural commissioner to learn the current regulations before spraying surfaces for ant control.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.			
A. STICKY POLYBUTENE MATERIAL (Tanglefoot)#	Label rates	NA	NA
MODE-OF-ACTION GROUP NUMBER[1]: — COMMENTS: A sticky petroleum product as a barrier to exclude ants and other flightless insects.			
B. METAFLUMIZONE BAIT[2] (Siesta Insecticide Fire Ant Bait)	Label rates	12	NA
MODE-OF-ACTION GROUP NUMBER[1]: 22B COMMENTS: A sodium channel blocker insecticide mixed with solid bait (granules) of corncob grit and soy oil. Effective only against fire ants because they are attracted to the protein and oil bait.			
C. ABAMECTIN/S-METHOPRENE (bait)[2] (TruFin Ant Bait)	1 lb/acre	12	NA
MODE-OF-ACTION GROUP NUMBER[1]: 6 COMMENTS: An avermectin insecticide mixed with an insect growth regulator. Effective against fire ants.			
C. PYRIPROXYFEN BAIT[2] (Distance Fire Ant Bait)	1–1.5 lbs/acre	12	NA
MODE-OF-ACTION GROUP NUMBER[1]: 7C COMMENTS: An insect growth regulator (IGR) mixed with solid bait (granules) of corncob grit and soy oil. Effective only against fire ants because they are attracted to the protein and oil bait.			
D. BORATE BAIT (Terro Multi-Purpose Insect Bait)	Label rates	NA	NA
MODE-OF-ACTION GROUP NUMBER[1]: 8D COMMENTS: A mineral insecticide mixed with bait for use against Argentine ant, native gray ants, and other sweet-feeding ants. Not for fire ants. Only for use in and around structures.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Pre-harvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Effective only against fire ants because they are attracted to this kind of bait, commonly of soy oil mixed with corncob grits. Apply when fire ants are most active during the season (especially early summer and fall) and when they are most active during the day (early evening and early morning when soil temperature is above 60°F). Treatments are most effective if applied 2 days after an irrigation, when ant activity is high. Do not irrigate again until at least 24 hours after application. Do not apply if rainfall is anticipated with 4 to 6 hours after application. Bait can be broadcast using properly calibrated ground equipment to assure proper dosage and uniform distribution; however, spot applications are preferred where ant nests located. Retreatment may be warranted (e.g., after 3 to 4 months).

APHIDS (01/22)

Scientific Names: Melon aphid: *Aphis gossypii*
Green peach aphid: *Myzus persicae*

DESCRIPTION OF THE PESTS

Aphids develop through three life stages: adult, egg, and nymph. Adults and nymphs are oblong to pear-shaped, soft-bodied insects that suck phloem sap. At maturity, most species have a body length of 1/25 to 1/12 inch (1–2 mm). Species that feed openly on foliage are distinguished by the presence of cornicles, a pair of tubelike, rear-pointing appendages on top the abdomen. Root-feeding aphids and those that feed within wax they secrete on foliage and shoots commonly lack obvious cornicles. Eggs hatch within adult females most of the growing season, and generally can be observed only during fall on deciduous perennials where aphids overwinter in the egg stage.

Numerous species of aphids feed on flower and nursery crops. Some are host-specific; these generally feed on only one or a few kinds of plants. Some host-specific aphids migrate seasonally between different hosts or plant parts or both, such as feeding on foliage of their deciduous host during spring through fall and overwintering on the roots of a conifer host. Consult *Aphids on the World's Plants: An Online Identification and Information Guide* for more information, including complete lists of each species' known host plants. The most common pest species are the cotton, or melon, aphid and green peach aphid, each having over 200 plant hosts.

Identifying the particular aphid species present can be important for reasons including

- Differences in susceptibility to certain pesticides.
- Different host plants, including weeds, that can help maintain a population.
- Differences in biology, which may offer clues on management.
- Their role as virus vectors between susceptible crops and weeds that hosts those viruses. Note that some viruses can be moved in other ways, such as on contaminated propagation and pruning tools.

Green peach and cotton (melon) aphids are generally the most common pest species in floriculture and nurseries. They can be distinguished using a hand lens or other magnification. Green peach aphid antennae attach to bumps or rounded projections (tubercles) on the front of the head, with a distinct indentation between; the tubercles slightly converge (point towards each other) so the head depression is wider at the base than the opening. Green peach aphids are commonly pale green overall, but can be yellowish, red, rose-pink, or whitish. The antennae and cornicles are relatively long, extending beyond the rear of the body. Winged adults have a black to dark green head and blotch on top of the abdomen and thorax.

Melon (cotton) aphids have no antennal tubercles; the front of their head is relatively flat, including where antennae attach. Melon aphids are commonly dark to light green, but can also be gray, orangish, yellow, or whitish. Melon aphids populations commonly consist of a mix of colors. Their cornicles are stout and relatively short and entirely black. Antennae when folded over the back reach only to the middle of the abdomen. Winged adults have a black head and thorax.

Adult (reproducing) aphids may or may not have wings. Winged aphids are produced when plants become heavily infested and the aphids crowded or plant quality declines and when day length shortens during the fall. Green peach aphids produce winged adults at lower population densities than the melon aphid. The optimal temperature for green peach aphid development is 75°F, whereas melon aphid develops fastest above 75°F.

During most of the year adult aphids give birth to nymphs; eggs hatch within females except when laid for overwintering in the fall. Depending upon temperature, aphids commonly mature and begin giving birth when they are 7 to 10 days old. Under optimal conditions, aphids of many species can complete 1 generation in about 1 week.

DAMAGE

Aphids have tubular, sucking mouthparts and excrete copious amounts of sticky, sweet honeydew as they feed. The honeydew can foul plant parts and induce growth of blackish sooty mold fungi. The translucent to white cast skins of aphids stick to surfaces and detract from plants' appearance. Feeding by abundant aphids can cause foliage to yellow. Leaves and shoots infested while immature can become

twisted as they grow. Melon aphids transmit (vector) at least 44 plant viruses. Green peach aphids transmit more than 100 plant viruses.

MANAGEMENT

Biological control, cultural controls (e.g., excellent sanitation, exclusion, and reflective mulches), and insecticide application are key methods for managing aphids.

Biological Control

Important predators of aphids include brown lacewings, green lacewings, lady beetles and the larvae of various flies, including aphid flies, aphid midges, and flower flies or syrphids. Some of these are commercially available for purchase and release, such as the aphid midge *Aphidoletes aphidimyza* that is commonly released for aphid control in greenhouses and nurseries and has been well-demonstrated to be effective when properly used. The larval stage of parasitic wasps such as *Aphelinus abdominalis*, *Aphidius* spp., and *Diaeretiella rapae* are important natural enemies of many aphid species. Some of these parasites are also commercially available; banker plants may be the most common method of economically sustaining parasitic wasps for aphid control (PDF).

The most economical and effective method for using biological control in field crops is to conserve naturally occurring parasites and predators. Control ants and dust and rely mostly on types of acaricides (miticides) and insecticides that are not persistent and toxic to natural enemies. These methods are necessary for both naturally occurring and released parasites and predators to be effective. Unless additional, compatible methods are employed for aphids that infest marketed parts of plants, biological control alone generally does not provide satisfactory control. For more information, see Natural Enemy Releases for Biological Control of Crop Pests, Protecting Natural Enemies and Pollinators, and Relative Toxicities of Pesticides Used in Floriculture and Nurseries to Natural Enemies and Honey Bees.

Cultural Control

Since common pest aphids feed on a wide variety of plant species. Keep production areas free of weeds that can host aphids. Exclude winged adults by covering greenhouse openings with screens that have a pore width of 0.355 mm (355 microns, about 1/100 inch) or smaller and sufficient surface area to allow adequate ventilation.

Before starting a new crop, carefully inspect the plants to ensure that they are free of aphids and other pests. Treat effectively or rogue any infested plants. Avoid the use of excess nitrogen fertilizer, which can increase aphid abundance.

Reflective mulch

For field-grown crops, applying reflective mulch in the middle of planted rows or entirely covering the soil surface and planting through holes in the mulch can greatly reduce the extent of aphid infestation. Reflective mulch also reduces infection from insect-transmitted viruses when crops are young and most susceptible to damage by these plant pathogens. Reflective mulch can increase crop growth and the yield of cut flowers and reduce the frequency of irrigation by conserving soil moisture. See Reflective Mulches for more information.

Organically Acceptable Methods

Biological and cultural controls are organically acceptable aphid management methods. Certain insecticides are acceptable for organic use, including the botanicals azadirachtin, neem oil, and pyrethrins without piperonyl butoxide (PyGanic), the microbial *Beauveria bassiana*, and certain oils (Organic JMS Stylet Oil).

Monitoring and Treatment Decisions

Melon aphids tend to occur throughout infested plants, and their presence on the underside of lower leaves can easily go undetected if these areas are not inspected. Green peach aphids tend to occur mostly around growing points, so their presence is more readily observed. Green peach aphids produce winged individuals at lower densities than melon aphids on crops such as chrysanthemums.

Yellow sticky cards can be used to detect winged aphids. Consider treating if there is an average of 5 to 10 aphids per card per week. However, since aphids produce winged individuals in response to crowding, they may be abundant on plants before they are found on sticky traps. Visually inspect plants for

aphids, cast skins, honeydew, and sooty mold. For more information, see Monitoring with Sticky Traps and *Sticky Trap Monitoring of Insect Pests*.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.			
A. POTASSIUM SALTS OF FATTY ACIDS[3]			
(M-Pede)#	Label rates	12	0
MODE-OF-ACTION GROUP NUMBER[1]: —			
COMMENTS: Insecticidal soap. Must contact insect, so thorough coverage is important. This insecticide may not effectively control melon aphid because it is often on the underside of lower leaves. Do not make more than three sequential applications. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.			
A. NARROW-RANGE OIL[3]			
(JMS Stylet Oil, Organic JMS Stylet Oil)#	1 oz/gal water	4	0
MODE-OF-ACTION GROUP NUMBER[1]: —			
COMMENTS: Works mainly on contact but may also be repellent. Do not spray stressed plants. Target pest must be completely covered with spray. This insecticide may not effectively control melon aphid because it is often on the underside of lower leaves. Check label for plants that can be treated. Do not use with sulfur products; check label for tank mix restrictions.			
A. CINNAMALDEHYDE			
(Cinnacure A3005)	Label rates	4	0
MODE-OF-ACTION GROUP NUMBER[1]: —			
COMMENTS: A botanical-based synthetic. Use product within 10 days of breaking seal. Do not apply to plants that are stressed or recent transplants until roots are well established.			
A. NEEM OIL[3]			
(Triact 70, Trilogy)#	1–2 gal/100 gal water	4	NA
MODE-OF-ACTION GROUP NUMBER[1]: UNE			
COMMENTS: A botanical oil with unknown mode of action. Do not spray stressed plants. Target pest must be completely covered with spray. This insecticide may not effectively control melon aphid because it is often on the underside of lower leaves. Check label for plants that can be treated. May injure flowers.			
B. *BEAUVERIA* BASSIANA			
(BotaniGard 22 WP)	0.5–1 lb/100 gal spray volume	4	0
(BotaniGard ES)	0.5–1 qt/100 gal spray volume	4	0
(Mycotrol ESO)#	0.5–1 qt/100 gal spray volume	4	0
MODE-OF-ACTION GROUP NUMBER[1]: UNF			
COMMENTS: An insect pathogenic fungus. Apply every 7 days if warranted. Do not tank mix with most fungicides; wait 48 hours after application to apply any fungicide.			
C. AZADIRACHTIN			
(Azatin O)#	10–16 fl oz/100 gal water	4	0

	(Ornazin 3% EC)	Indoor: 8 oz/100 gal Outdoor: 10 oz/acre	12	0

MODE-OF-ACTION GROUP NUMBER[1]: UNE

COMMENTS: A botanical insect growth regulator (IGR). Must contact insect. Repeat applications as necessary. Aphid suppression only. Label permits low-volume application. Do not exceed 22.5 oz/acre per application.

D.	S-KINOPRENE (Enstar AQ)	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 7A

COMMENTS: An insect growth regulator (IGR). Apply pre-bloom. Also labeled for low volume use.

D.	PYRIPROXYFEN (Distance)	6–8 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 7C

COMMENTS: An insect growth regulator (IGR). Do not apply more than twice per crop or per 6 months. Do not apply through any type of irrigation system.

D.	CHLORANTRANILIPROLE (Acelepryn)	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 28

COMMENTS: A diamide. Do not apply more than 38.3 fl oz per acre per year.

E.	PYMETROZINE (Endeavor)	2.5–5.0 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 9B

COMMENTS: A pyridine. Apply as foliar spray at 7 to 14 day intervals. For outdoor use do not apply more than 48 oz/acre per year. For indoor use do not use more than 100 oz.

F.	PYRETHRINS (PyGanic EC 5.0 II, PyGanic EC 1.4 II)#	Label rates	12	0

MODE-OF-ACTION GROUP NUMBER[1]: 3A

COMMENTS: A botanical.

F.	PYRETHRINS/PBO[2] (Pyrethrum TR)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A/—

COMMENTS: An aerosol botanical and synthetic synergist pre-mix.

G.	IMIDACLOPRID[4] (Marathon 1% Granular)	Label rates	12[4]	NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A

COMMENTS: A neonicotinoid. Do not apply to soils that are waterlogged or saturated. Do not apply to bedding plants intended to be used as food crops.

H.	ACEPHATE (Acephate 97UP, Orthene Turf, Tree & Ornamental WSP, 1300 Orthene TR)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B

COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol organophosphate only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

Pyrethroids (below) are generally ineffective for green peach aphid because of resistance. Apply them only if melon aphid or other aphid species are the problem.

I.	BIFENTHRIN[5] (Talstar S Select)	5–10 fl oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid.			
I.	CYFLUTHRIN[5] (Decathlon 20 WP)	1.9 oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid.			
I.	FENPROPATHRIN[5] (Tame 2.4 EC)	Label rates	24	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid.			
I.	LAMBDA-CYHALOTHRIN[5] (Scimitar GC)	1.5–5 fl oz/100 gal water	24	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid. Apply at 7-day intervals if warranted. Do not apply more than 52.4 fl oz of concentrate/acre per year. Do not mix with EC formulations or oils.			
I.	PERMETHRIN[5] (Perm-UP 25 DF)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, and salvia. Label permits low-volume application.			
I.	*TAU*-FLUVALINATE[5] (Mavrik Aquaflow)	4–10 fl oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal. Greenhouse, interiorscape, outdoor ornamental plantings, plantscapes, and containerized nursery stock only.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 PBO = piperonyl butoxide.

3 Single doses of oils and potassium salts of fatty acids (soaps) can be used anytime as pesticide rotation without negatively impacting resistance management.

4 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

5 Pyrethroids generally are not effective against green peach aphid because excess exposure to them has induced development of resistance. Apply them only when melon aphid or other aphid species are the problem.

ARMORED SCALES (01/22)

Scientific Names: Oystershell scale: *Lepidosaphes ulmi*
Greedy scale: *Hemiberlesia rapax*
California red scale: *Aonidiella aurantii*
Oleander scale: *Aspidiotus nerii*
San Jose scale: *Diaspidiotus* (=*Quadraspidiotus*) *perniciosus*

DESCRIPTION OF THE PESTS

Armored scales develop through three life stages: egg, nymph, and adult, and the appearance of a stage can change as it ages. Adults are ⅛ inch or smaller, flattened, and rounded to irregular shaped. The body of armored scales rests beneath a plate-like cover that during most of the settled, development stages can be lifted off to reveal the insect body underneath. The coloration, shape, and microscopic features of the body and sometimes the cover and host distinguish the species of armored scale. However, some armored scale species cannot be determined by cover appearance due to similarity with other species. Armored scales lack wings and obvious body parts except for adult males that are not commonly observed and appear not to exist in certain species.

Most armored scales lay eggs that hatch beneath the cover of mature females; in some species eggs hatch within the female. The newly hatched immature scales, known as crawlers, are oval to rounded, orangish to yellow, and less than 1/25 inch (1 mm) long. They are mobile and may take up to 1 or 2 days to locate a suitable feeding site. Crawlers are also spread by wind or as contaminants on equipment, propagation tools, or people. After settling to feed they remain in the same spot and do not move. Unlike most other types of scales that feed on phloem sap, armored scales feed mostly on parenchyma tissue and do not produce honeydew. Most armored scales have several generations a year.

DAMAGE

High populations of certain armored scales are associated with plant dieback and decline and may kill young plants. One exception is oleander scale, which appear to only minimally affect plant health even when very numerous. When abundant, the numerous, tiny scale covers can give infested plant parts a crusty brownish, grayish, or yellowish appearance. The salivary secretions of certain armored scales, such as San Jose scale, can cause discolored spots or streaks and severe growth distortion of some hosts.

MANAGEMENT

Biological and cultural controls and the application of insecticides are the major management methods for armored scales.

Biological Control

Scale predators include brown lacewings, green lacewings, multicolored Asian lady beetle, *Rhyzobius* spp. lady beetles, and twicestabbed lady beetle. Parasitic wasps generally are the most important natural enemies of armored scales, including *Aphytis*, *Comperiella*, and *Encarsia* spp. *Aphytis melinus* is a naturally occurring and commercially available parasites that can be released to effectively control California red scale infesting citrus. For natural enemies to be effective, avoid application of persistent, broad-spectrum insecticides. Control ants, keep growing areas clean, and prevent dusty conditions, which impair the activity of natural enemies. Rely on cultural, mechanical, and selective chemical controls that do not kill parasites and predators or interfere with their beneficial activities. For more information, see Biological Control, Protecting Natural Enemies and Pollinators, and Natural Enemy Releases for Biological Control of Crop Pests.

Cultural Control

Start crop production with uninfested stock and introduce only pest-free plants into growing areas. Dispose of heavily infested plants and crop debris in covered containers. Begin the work day in uninfested growing areas and keep containers, equipment, hands, and tools clean to minimize moving scale crawlers to other plants. Exclude windblown crawlers by covering greenhouse openings with fine mesh screens of sufficient surface area to allow adequate ventilation. On woody plants some use a strong spray of water to remove scales. This can help expose any remaining scales to subsequent treatment.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. The botanical insecticide neem and certain oils (Organic JMS Stylet Oil) are also organically compatible.

Monitoring and Treatment Decisions
Carefully inspect new plants before introducing them into production areas to ensure that they are free of scales and other pests. Quarantine new plants in separate growing areas until they have grown some and been periodically inspected for pests. Rogue or effectively treat infested plants.

Visually inspect plants at regular intervals to locate infestations, identify any scale species present, and help you decide when control is likely to be most effective. Insecticide application is generally warranted when scales are present and most crawlers (the stage most susceptible to insecticide) have emerged.

Armored scales may have multiple generations that overlap, with crawlers that emerge over a lengthy period. In this case multiple insecticide applications are commonly warranted to provide satisfactory control. First-generation crawler emergence earlier in the growing season generally occurs over a shorter time period, so treating early can reduce the total number of needed applications. To monitor crawler activity for timing applications, use traps of double-sided sticky tape wrapped around green stems or twigs in late winter near where female scales are observed. See Monitoring with Sticky Tape Traps for how to use this technique.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A.	NARROW-RANGE OIL[2] (JMS Stylet Oil, Organic JMS Stylet Oil)#	1 oz/gal water	4	0
	MODE-OF-ACTION GROUP NUMBER[1]: —			
	COMMENTS: An oil and contact insecticide. Do not spray stressed plants. Target pest must be completely contacted with spray. Check label for plants that can be treated. May injure flowers. Do not use with sulfur products; check label for tank mix restrictions.			
B.	S-KINOPRENE (Enstar AQ)	Label rates	4	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 7A			
	COMMENTS: An insect growth regulator (IGR). Apply prebloom. Target crawler stage. Also labeled for low volume use. Greenhouse, shadehouse, lathhouse, and interiorscape use only.			
B.	PYRIPROXYFEN (Distance)	8–12 fl oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 7C			
	COMMENTS: An insect growth regulator (IGR). Do not apply more than twice per crop or per 6 months. Target the crawler stage. Do not use through any type of irrigation system in California.			
C.	ACEPHATE			

	(Acephate 97UP, 1300 Orthene TR, Orthene Turf, Tree & Ornamental WSP)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B

COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol for greenhouse use only. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult the label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

C.	CARBARYL* (Carbaryl 4L)	1 qt/ acre or 1qt/100 gal water	See label	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1A

COMMENTS: A carbamate. Not for use in greenhouses. The REI is 18 days for ornamentals grown for cuttings (cut flowers or cut foliage) where production is in outdoor areas and where average annual rainfall is less than 25 inches a year.

C.	MALATHION (Malathion 8)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B

COMMENTS: An organophosphate. Not for greenhouse use.

D.	CYFLUTHRIN (Decathlon 20WP)	1.9 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A

COMMENTS: A pyrethroid. Label permits low-volume application.

D.	*TAU*-FLUVALINATE (Mavrik Aquaflow)	4–10 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A

COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal. Greenhouse, interiorscape, outdoor ornamental plantings, plantscapes, and containerized nursery stock only.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

* Permit required from county agricultural commissioner for purchase or use.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Single doses of oils and potassium salts of fatty acids (soaps) can be used anytime as pesticide rotation without negatively impacting resistance management.

ARMYWORMS AND CUTWORMS (01/22)

Scientific Names: Beet armyworm: *Spodoptera exigua*
Yellowstriped armyworm: *Spodoptera ornithogalli*
Variegated cutworm: *Peridroma saucia*
Western yellowstriped armyworm: *Spodoptera praefica*

DESCRIPTIONS OF THE PESTS

Adults (Noctuidae) are night-active moths and attracted to lights. At rest the top of the body and forewings are a mottled mix of blackish, brown, gray, tan, and whitish. The underside and hind wings are pale and the wingspread is 1 to 2 inches. Young larvae are mostly greenish. Older larvae have more coloration and markings useful for distinguishing the species. Last instars grow up to 1 to 1-½ inches long.

Beet armyworm is the most common of these pests. The female lays eggs in a mass on leaves, covered with fluffy, pale, hairlike scales. The first through third instars commonly feed in a group, chewing the surface of leaves and causing patches of skeletonized (windowpane-like) foliage. Larvae also feed on or inside buds, killing the bud. Late instars feed individually, chewing holes in leaves and flowers and clipping off plant parts. Late instars can vary in color and overall may appear brown, blackish, grayish, or green. Commonly they are dull green with wavy, lengthwise stripes of paler green, yellow, and whitish lines. A black spot on each side of the abdomen above the second pair of legs distinguishes beet armyworms from larvae of other pest noctuids.

Beet armyworm feeds and reproduces throughout the year in locations with mild winters and migrate into floriculture and nursery crops from numerous alternate hosts including cole crops, cotton, lettuce, strawberry, tomato, and numerous weeds. One generation occurs in about 31 days or 24 days at an average temperature of 75° or 80°F, respectively.

Yellowstriped armyworm larvae have a pair of black triangles on the back of most segments. Some larvae appear nearly completely black when viewed from above. A lengthwise stripe on each side is bright orange or yellow. The adult has a complex and highly contrasting pattern of brown, yellow, and white on the front wings, and wingspread is about 1-½ inches.

Variegated cutworm adults have a distinct kidney-shaped marking (an oval with an inward curve on one side) near the center of each front wing and their wingspread is 1-1/2 inches to a little over 2 inches. Larvae have yellow or orange spots or a broken, longitudinal stripe at the top of the body, which is otherwise gray. Often there is a dark triangle or W-shaped mark on the top of the eighth body segment. The variegated cutworm overwinters as a naked pupa in topsoil.

Western yellowstriped armyworm females lay eggs in clusters covered with a gray, cottony material. Adults are a mix of black, brown, tan, and whitish. Larvae grow up to 1-½ inches long and commonly are blackish to brown with yellowish and whitish, longitudinal stripes on each side of the body. The larval head is brown with pale lines.

DAMAGE

Armyworms and cutworms chew or clip off flowers and leaves that would normally be marketed. Late instars in seedling flats can consume a large portion of small plants. However, moderate early-season armyworm feeding on gypsophila was found to increase tillering and yields.

MANAGEMENT

Biological and cultural controls and insecticide application are used to manage armyworms and cutworms.

Biological Control

Numerous species of parasitic tachinid flies and wasps and various predators prey on armyworms and cutworms and significantly reduce their abundance in fields where broad-spectrum, persistent insecticides are not applied. Parasitized armyworms and cutworms commonly continue to feed through to the last instar and still damage crops, but will not mature to adults that produce subsequent generations. Naturally occurring viruses also kill the later instars.

To conserve natural enemies rely on insecticide baits, use *Bacillus thuringiensis* (Bt), and entomopathogenic nematodes to control armyworms and cutworms and avoid broad-spectrum, persistent insecticides for all pests in the crop where feasible. Control ants and dust that can interfere with biological control. For more information, see Biological Control, Protecting Natural Enemies and Pollinators, and Relative Toxicities of Pesticides Used in Floriculture and Nurseries to Natural Enemies and Honey Bees.

Cultural Control
Keep production areas free of weeds, many of which can host armyworms and cutworms. Exclude winged adults by covering openings to greenhouses with screens of sufficient surface area to allow adequate ventilation. Screens are especially important when lights are used at night to control flowering because lights attract moths. Switch from always-on night lighting to motion-activated, security lights. Cover seedling flats with screens to exclude adults and larvae. Apply row covers to exclude moths in the field, but use hoops or otherwise hold the mesh above plant surfaces to eliminate egg laying through the fabric. Hand-removal may be practical for small-scale situations, such as when a few caterpillars are found when scouting plants for pest problems.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. The botanical azadirachtin, entomopathogenic nematodes (*Heterorhabditis* and *Steinernema* spp.), the microbial insecticides *Bacillus thuringiensis* ssp. *aizawai* and Bt ssp. *kurstaki*, and certain spinosad formulations (Entrust Naturalyte, Entrust SC) are acceptable for organic production.

Monitoring and Treatment Decisions
Visually inspect hosts regularly to detect larvae and their chewing damage and droppings (frass). Randomly inspect leaves, terminals, and entire plants throughout the growing area at least once per week. If growing areas are lighted at night and not effectively screened, devote extra time to inspecting plants near unscreened vents and on the outside of field blocks near unmanaged vegetation or other alternate hosts.

Use species-specific, pheromone-baited sticky traps to determine when adult males are flying (most pheromone traps only attract and trap males) and most abundant, especially when timing applications of *Bacillus thuringiensis* and other pesticides with short-residual activity. When males are trapped, expect females are laying eggs or will soon and Bt applications to control young larvae are likely warranted. Make at least a second application after 7 to 10 days to control larvae hatching later because Bt is not persistent. For guidelines on when to treat, see Establishing Action Thresholds.

Degree-days
Insect and mite development is highly dependent upon temperature, so accumulated 'heat units' can be used calculate egg-to-adult generation times using degree-days (DD) based on a minimum developmental temperature of 54°F. For example, eggs hatch about 94 DD after they are laid, so expect young larvae to be present after this period has elapsed starting soon after the first adult males are trapped. The larval and pupal stages require accumulation of 470 DD and 318 DD, respectively, for females and 540 DD and 344 DD, respectively, for males. The total DD for eggs, larvae, and pupae is the period for one generation, which at cooler temperatures corresponds to more calendar days in comparison with fewer days per generation when temperatures are warm. Knowing the seasonal variations in generation time by monitoring DD helps to schedule monitoring and control actions, saving money and time and improving management efficacy. To calculate these development times based on prevailing temperatures, see Degree-days on the UC IPM website. See Using Degree-Days: Video Tours for more information on this technique.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. *HETERORHABDITIS* AND *STEINERNEMA* SPP. ENTOMOPATHOGENIC NEMATODES

(NemaSeek, NemAttack)#	Label rates	NA	NA

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: Entomopathogenic (insect-killing), tiny roundworms to control the soil-dwelling larvae and pupae. Commercially available for chemigation, drench, or spraying of planting media. Require high humidity or moist conditions and the absence of exposure to bright or direct light to be effective.

B. DIFLUBENZURON

(Adept)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15

COMMENTS: An insect growth regulator (IGR).

B. NOVALURON

(Pedestal)	6–8 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15

COMMENTS: An insect growth regulator (IGR). Use no more than twice per year. Do not exceed 36 oz/acre per year. Do not use on poinsettia.

B. TEBUFENOZIDE

(Confirm 2F)	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 18

COMMENTS: An insect growth regulator (IGR). Only for use on Christmas trees and certain food crops.

B. CHLORANTRANILIPROLE

(Acelepryn)	2–16 fl oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 28

COMMENTS: A diamide. Do not apply more than 38 fl oz per acre per year.

C. SPINOSAD

(Conserve SC)	6 fl oz/100 gal water	4	NA
(Entrust)#	1 oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 5

COMMENTS: A fermentation product. Adding narrow-range oil to the spray mix and using water with a pH of 6 to 8 can increase the translaminar (into leaf) movement and efficacy persistence; if so do not spray stressed plants and do not use with sulfur products.

D. AZADIRACHTIN

(Azatin O)#	4–16 fl oz/100 gal water	4	0

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: A botanical and insect growth regulator. Must contact insect. Repeat applications as necessary. Label permits low-volume application.

D. *BACILLUS THURINGIENSIS* SSP. *KURSTAKI*

(Deliver)#	0.25–1.5 lb/acre	4	0

MODE-OF-ACTION GROUP NUMBER[1]: 11A
COMMENTS: A microbial. Most effective against early instars; pheromone trapping recommended for timing applications.

D. *BACILLUS THURINGIENSIS* SSP. *AIZAWAI*

(Xentari)#	Label rates	4	0

MODE-OF-ACTION GROUP NUMBER[1]: 11A
COMMENTS: A microbial. Most effective against early instars; pheromone trapping recommended for timing applications.

E. CARBARYL*

(Carbaryl 4L)	1 qt/acre or 1qt/100 gal water	See label	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1A
COMMENTS: A carbamate. Not for use in greenhouses. The REI is 18 days for ornamentals grown for cuttings (cut flowers or cut foliage) where production is in outdoor areas and where average annual rainfall is less than 25 inches a year.

F. CYANTRANILIPROLE

(Mainspring GNL)	2–8 fl oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 28
COMMENTS: A diamide. For use only in greenhouses. Do not apply more than 32 fl oz per acre per crop.

F. ACEPHATE

(Orthene Turf, Tree & Ornamental WSP, 1300 Orthene TR)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

F. CHLORFENAPYR

(Pylon)	2.6–6.4 fl oz/100 gal water	12	0

MODE-OF-ACTION GROUP NUMBER[1]: 13
COMMENTS: A pyrrole. For use only in greenhouses.

G. BIFENTHRIN

(Attain TR, Talstar S Select)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Attain TR is a fogger for greenhouse use only. Check label for allowed uses.

G. CYFLUTHRIN

(Decathlon 20WP)	1.3 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

G. FENPROPATHRIN

(Tame 2.4EC Spray)	10.6 fl oz/100 gal water	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A

COMMENTS: A pyrethroid.

G. PERMETHRIN
(Perm-UP 25 DF) 6.4–12.8 fl oz/100 gal water 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, and salvia. Label permits low-volume application.

G. *TAU*-FLUVALINATE
(Mavrik Aquaflow) 4–10 fl oz/100 gal water 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal.

H. PYRETHRINS/PBO[2]
(Pyrethrum TR) Label rates 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A/—
COMMENTS: A botanical and synthetic synergist premix aerosol.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

* Permit required from county agricultural commissioner for purchase or use.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 PBO = piperonyl butoxide.

BARK AND WOOD BORERS (01/22)

Scientific Names: Erythrina stem and twig borer: *Terastia meticulosalis*
Nantucket pine tip moth: *Rhyacionia frustrana*
Olive bark beetle: *Phloeotribus scarabaeoides*
Pacific flatheaded borer: *Chrysobothris mali*
Peachtree borer: *Synanthedon exitiosa*
Pitch moth: *Synanthedon sequoiae*
Sycamore borer: *Synanthedon resplendens*
Western poplar clearwing: *Paranthrene robiniae*

DESCRIPTION OF THE PESTS

Various bark- and wood-boring insects can be pests of trees and shrubs in nurseries. Most of these are sporadic pests and not a problem except when woody species are grown to a relatively large size, such as in boxes. Because the damaging larval stage occurs hidden feeding under bark the symptoms of their feeding as described below under DAMAGE are commonly the first or only observed clue these pests are present.

Erythrina stem and twig borer adults (moths, family Crambidae) have mottled brown and gray forewings, white hind wings, and a wingspan of about 1 inch. At rest the adults hold the rear of their knobby abdomen curved upwards. The moth's coloration makes it difficult to observe on bark.

Adult females lay eggs singly in the axil of leaves near the tips of shoots of coral trees (*Erythrina* spp.). Eggs are translucent to white, half-dome shapes (convex), and about 1/32 inch (0.8 mm) in diameter. Larvae (caterpillars) are translucent to brown or cream-colored with a black head and dark prothoracic shield on the first segment behind the head. The prothoracic shield becomes lighter colored as a larva matures. Mature larvae are about 1-⅝ inch long and turn pinkish before pupating. The larvae bore into stems and hollow out the terminals of coral trees. Pupae occur in cocoons in protected places of the plant or in litter on the ground. For more information and numerous photographs of this relatively new pest see *Erythrina moths Terastia meticulosalis Guenée and Agathodes designalis Guenée* and *Terastia meticulosalis Guenee: Erythrina Twigborer*.

Nantucket pine tip moth adults (moths, family Tortricidae), mature larvae, and pupae are about ⅖ inch long. The adults are reddish brown moths with silver-gray markings. Eggs are spherical, orange or yellow, and occur on needles of pines. Young larvae are whitish with a dark head. Older larvae are yellow to pale brown with a dark head. Larvae chew in and on pine buds, needles, and terminals and cover infested shoot tips with fine silk. It is a pest primarily in Southern California, especially on Monterey pine. It has about four generations per year in Southern California. For more information see *Pine Tip Moths—Rhyacionia spp.*

Olive bark beetle adult females (subfamily Scolytinae) primarily bore into and lay eggs in olive trees. Other hosts include ash, common lilac, and oleander. Adult females each lay up to 60 eggs. Adults are about 1/12 inch (2 mm) long. They have an hard, oblong, dark brown to black body densely covered with yellowish hairs. The antennae have a clubbed (swollen) end with three distinctive movable, leaf-like segments. Mature larvae and pupae are about ⅛ inch (3 mm) long and occur under bark. Larvae are white and legless with a brown head. The oblong pupae are initially white but as they mature darken and develop distinct appendages folded against the body. Olive bark beetles may have several generations per year.

Be on the lookout for invasive shot hole borers, although these have not been reported infesting nurseries in California. Their appearance, damage, and life stages resemble those of olive bark beetle and other Scolytinae. For more information on olive bark beetle, see *Olive bark beetle (Phloeotribus scarabaeoides)* (PDF).

Pacific flatheaded borer (family Buprestidae) can infest at least 70 species of trees in 21 plant families. Adults are bullet shaped, hard bodied, and ½ to ¾ inch long. They have a coppery, dark bronze, or gray body and wing covers with pale mottling. This appearance blends with the color of bark making adults difficult to observe. The circular, disklike egg is laid on bark and is white and about 1/25 inch in diameter. The hatching larvae chew and bore into bark. Larva are pale yellow to whitish and legless. They have brown mouthparts and distinct segments and taper towards the rear. The segment immediately behind the head (prothorax) is greatly enlarged. At maturity larvae and pupae are ⅗ to ¾ inch long. The oval

pupa occurs under bark and is initially translucent white, then creamy white, then gradually takes on the color of adults.

Peachtree borer, sometimes called greater peachtree borer (family Sesiidae), this is a different species than the lesser peachtree borer (*Synanthedon pictipes*), which occurs only in the eastern United States. Peachtree borer primarily infests *Prunus* species including stone fruits such as apricot, cherry, peach, and plum. Adult peachtree borers are mostly bluish black and have a wasplike appearance. Males have narrow yellow bands on their abdomen. Females have a single orange band on the abdomen. Larvae are pinkish or whitish with a brown head. Pupae are oblong and brown to orange and occur at the base of plants in bark crevices or on the ground. For more information see *Pest Notes: Clearwing Moths*.

Pitch moth of pines larvae (family Sesiidae) infest Douglas-fir and most pine species, especially Monterey pine. Larvae are pale orange to pinkish with a brown head. Pupae and their empty pupal case commonly protrude from a hole in the pitch masses that form on bark where the larvae fed. Mature larvae and pupae are about 1-½ inches long. The adults are day-active moths and have a blackish and yellow head, legs, and thorax. The abdomen is covered with blackish and yellow hairs in alternating bands, resembling a paper wasp or yellowjacket wasp. Females are somewhat larger and plumper than males. The adult's body is about 3/4 inch long with a wingspan of ¾ to 1-¼ inches. For more information see *Pest Notes: Pitch Moths*.

Sycamore borer larvae (family Sesiidae) infest primarily ceanothus, oaks, and especially sycamores. Adults are mostly yellow with a brownish-black head and black bands on the body, mimicking yellow jacket wasps. The legs are yellowish and black. The mostly clear wings have dark veins and margins. Larvae are pinkish with a brown head. The brown to orangish, oblong pupae commonly occur lodged in bark crevices and at the base of infested hosts. For more information see *Pest Notes: Clearwing Moths*.

Western poplar clearwing moth (family Sesiidae) is also called the locust clearwing. Its larvae (caterpillars) infest birch, poplar, and willow, especially when trees are stressed. The adult resembles a yellowjacket wasp, but has a thick waist and feathery antennae of a moth, unlike the narrow threadlike waist and filamentous antennae of a wasp. Its forewings range from an opaque pale orange to a brownish color; the hind wings are clear. The thorax is black with a yellow hind border, and the abdomen is yellow with three broad black bands. The entire body of some individuals is pale yellow. Under bark the pale, dark-headed larvae have two hornlike spines on their back. For more information see *Pest Notes: Clearwing Moths*.

DAMAGE

Bleeding, cracked, gnarled, oozing, rough, or wet bark and dieback of limbs, shoots, or entire plants are commonly the first indications that larvae of these boring insects are present. Brown granular excrement from larval tunneling can occur around damaged bark. Because tunneling damages the plant's vascular system scattered limbs or shoot terminals may dieback. Some of these pests can eventually cause the entire plant to die.

Erythrina stem and twig borer hatching larvae bore inside and chew, feed, and tunnel causing die back of terminals. When abundant virtually every terminal on a coral tree can be killed. Infestation greatly reduces seed and flower production and the aesthetic quality of coral trees. Entire trees can be killed by the pest.

Nantucket pine tip moth larvae (caterpillars) boring in shoots cause pitch to exude. Infested terminals discolor and die. Larval damage to the central growing terminal (leader) can significantly alter tree shape, causing regrowth of stems to be bunchy, crooked, or forked.

Olive bark beetle larvae excavate galleries under bark, weakening and often completely girdling killing branches. Severe infestations may cause extensive dieback, stunt the growth of young trees, and reduce the number of flowers and olive fruits.

Bark becomes cracked and roughened where **Pacific flatheaded borer** larva feeds underneath. Peeling bark back can reveal the larva and its tunnel packed with reddish brown frass (excrement). After the

larva matures and pupates under bark the emerging adult leaves a D-shaped to rounded hole in bark about ¼ inch in diameter.

Peachtree borer brown granular excrement and ooze commonly occur on the lower trunk where larvae tunnel and damage cambial tissue. Shaving away bark at the base of infested trunks reveals gum deposits and tunnels packed with brown frass (excrement). Virtually all larval tunneling of peachtree borer occurs within a few inches of the ground near the base of the main trunk, including a short distance above and below the soil line. If infestations persist for several years, the tree may eventually become girdled and die prematurely.

Pitch moth of pines infestations are recognizable by the gray, pink, reddish, or yellowish gummy masses that protrude from infested trunks and limbs where a larva feeds underneath shallowly in bark. People unfamiliar with the damage sometimes confuse pitch moth pitch masses with bark beetle pitch tubes. Bark beetle pitch tubes are usually less than 1/2 inch in diameter, often have a distinct round hole near the center made by an adult beetle, and may resemble the end of a large gummy drinking straw protruding from bark. Pitch moth masses commonly grow to several inches in diameter. Prying a fresh pitch mass off bark commonly reveals a larva feeding underneath. This feeding increases the likelihood of limb breakage during windy conditions and reduces the aesthetic quality of infested trees, but generally does not kill pines.

Sycamore borer larvae tunneling shallowly under bark cause roughened bark. They produce abundant, granular, reddish brown frass (excrement) that can become abundant at the base of trees and in bark crevices. Tunneling generally does not cause limb dieback or kill hosts, but it reduces their aesthetic quality.

Western poplar clearwing larvae feeding under bark can cause gnarled growth and swellings on limbs and trunks. Dark oozing sap may run down bark from the location of an infested. Where a larva tunnels under bark commonly there is a glob of reddish brown frass protruding from the tunnel entrance. Infested poplars can experience dieback, but willows tolerate infestation without apparent serious harm. The aesthetic quality of hosts is reduced by infestations.

MANAGEMENT

Preventive cultural controls and insecticides are the major management methods.

Biological Control

Various parasitic wasps and predatory insects can prey on larvae under bark. But these do not appear to be of importance in providing biological control in nurseries.

Cultural Control

Excellent cultural care and providing woody plants optimal growing conditions are critical to avoiding most borer problems. Appropriate irrigation is particularly important as drought stress increases tree susceptibility to bark- and wood-boring insects. Erythrina stem and twig borer apparently is an exception to the situation where most borer problems are caused or aggravated by hosts being stressed.

Provide excellent cultural care to keep plants growing vigorously. Protect trunks and roots from injuries. Whitewash trunks, wrap them with heavy paper, or grow under shade covers or where plants receive afternoon shade to help prevent sunburned bark that attracts the egg laying adult females of many boring insects. If trunks are wrapped, periodically remove wrapping and inspect bark for injuries. If infestations are limited to a few limbs, prune these out and chip or otherwise dispose of cuttings because borers can often complete their development in cut wood then emerge as adults that cause infestation of nearby hosts. If trunks are infested, rough and chip or otherwise destroy the wood or dispose of it off-site.

For peachtree borer pheromone mating disruption has worked well for controlling this pest in crops where it is a regular problem. However, this technique apparently has not been studied for this pest in California nurseries.

Organically Acceptable Methods

Cultural controls, mating disruption for peachtree borer, and white painting or physically covering trunks are organically acceptable management methods.

Monitoring and Treatment Decisions
Regularly inspect plants and their environment and monitor cultural practices especially irrigation to ensure that plants are receiving excellent care and optimal growing conditions. If cultural and environmental conditions have been optimal and borers have still been a problem limbs and trunks can be sprayed with a persistent, broad-spectrum insecticide about twice per season in late winter and early summer to kill adults and hatching larvae before they bore under bark. Neither systemic insecticides or other methods are likely effective for controlling larvae under bark. Erythrina stem and twig borer may be an exception where a systemic neonicotinoid (e.g., imidacloprid, dinotefuran) may potentially be effective.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. WHITE LATEX INTERIOR PAINT# 50% paint and water mixture

COMMENTS: Paint trees at time of planting. Be sure paint extends to ground level and if possible 1 inch below the soil line. Alternatively wrap trunks with heavy paper. This treatment will prevent sunburn, which can reduce borer attack. Except not for Erythrina stem and twig borer.

B.	CARBARYL* (Carbaryl 4L)	Label rates	See label	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1A
COMMENTS: A carbamate. Not for use in greenhouses. The REI is 18 days for ornamentals grown for cuttings (cut flowers or cut foliage) where production is in outdoor areas and where average annual rainfall is less than 25 inches a year.

C.	BIFENTHRIN (Talstar S Select)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

C.	CYFLUTHRIN (Decathlon 20 WP)	1.9 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

C.	FENPROPATHRIN (Tame 2.4 EC Spray)	10.67 fl oz/100 gal water	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

C.	PERMETHRIN (Astro)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

C.	*TAU*-FLUVALINATE (Mavrik Aquaflow)	4–10 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

D.	ACEPHATE (Orthene Turf, Tree & Ornamental WSP)	1–1.3 lb/100 gal water	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

D.	MALATHION (Malathion 8)	1 pt/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate.

E.	CHLORANTRANILIPROLE (Acelepryn)	4–32 fl oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 28
COMMENTS: A diamide. Do not apply more than 38 fl oz per acre per year.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

* Permit required from county agricultural commissioner for purchase or use.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

BULB MITES (ACARID MITES) (01/22)

Scientific Name: *Rhizoglyphus* spp.

DESCRIPTION OF THE PESTS

These mites infest bulbs and host debris during storage and in the field. Note that bulb mites (family Acaridae) are a different pest than bulb scale mites, which are thread-footed mites (Tarsonemidae) Bulb scale mites are too small to be seen with the naked eye, unlike with the larger bulb mites discussed here.

Bulb mites are whitish with brownish spots and brown, stubby legs. At maturity they are about 1/50 to 1/32 inch (0.55–0.75 mm) long; immature stages are smaller. They are slow moving, oval shaped, and sometimes mistaken for insect eggs unless examined with a binocular microscope or high-powered hand lens and sufficient lighting. They feed between bud scales and in hollowed out and decomposing portions of bulbs and sometimes on basal stems, rhizomes, or roots. Egg to adult development time (1 generation) occurs in about 10 days at 80°F.

DAMAGE

Bulb mites feed on underground parts and contribute to increased infection and damage from soil-dwelling, plant-pathogenic bacteria and fungi. Mites and pathogens in combination cause infested parts to become soft and decayed during storage or in the field. Bulb mites are associated with spread and increased incidence of *Fusarium, Pseudomonas*, and *Stromatinia* diseases of bulbs. Bulbs attacked include those of freesia, hyacinth, lilies, narcissus, and onions. Freesia bulbs are particularly affected because they require high-temperature storage to break dormancy, and higher temperatures shorten mite generation time and increase their abundance. In lilies, mite-feeding underground stunts growth and feeding at the soil level (on basal stems) causes aboveground parts to topple. On peony, underground rhizomes are infested.

MANAGEMENT

Bulb mites are managed with cultural and chemical controls.

Biological Control

Biological control has not been investigated.

Cultural Control

Avoid injuring bulbs and other underground parts during digging, handling, or storage; injuries promote attack by mites and plant pathogens, and pathogen infection promotes bulb mite infestations. To minimize infestations, prevent disease development in hosts by providing adequate drainage and appropriate irrigation. Use pasteurized or sterile planting media and disease-resistant cultivars. Apply fungicides when warranted. Remove or in the field deeply bury crop debris and otherwise practice good sanitation because bulb mites can persist for long periods solely on decaying crop residue. Fallow fields, rotate to non-host crops, temporarily flood fallow fields, and use flood irrigation, which also reduce bulb mite abundance.

Heat treatment

Bulbs can be disinfested of mites by holding them for 24 hours at 100% relative humidity and 105.5°F. Aerated steam and hot water are highly effective for disinfesting mites and other pests from bulbs, corms, dormant stem cuttings, and tubers. First test small batches of each cultivar to determine control efficacy and plant tolerance to heat treatment before applying the method to large portions of the crop. A general recommendation is to presoak bulbs, corms, or rhizomes for 2 to 3 hours or overnight in 75°F water containing a wetting agent before immersing them in 111°F water for about 1-1/2 hours. Cool plants immediately afterward with clean, cold water; dry them thoroughly in warm air or sunshine, then store them under cool, low-humidity conditions until plants are used. See Control Pests by Heat Treatment of Plants in Nurseries for specific guidelines by crop.

Organically Acceptable Methods

Cultural controls including heat treatment are organically acceptable management methods. Dusts or sprays of the mineral sulfur are also acceptable for organic production.

Treatment

Thoroughly clean bulbs, dip them in a sulfur fungicide solution, and dry them following harvest. Sulfur

controls bulb mites as well as fungal diseases during storage. CO_2 fumigation can be useful if bulbs are held long enough in the absence of free oxygen.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

PREPLANT, FIELD-GROWN

A.	METAM SODIUM* (Vapam)	Label rates	See label	See label

MODE-OF-ACTION GROUP NUMBER[1]: 8F
COMMENTS: A methyl isothiocyanate generator. Fumigants such as metam sodium are a source of volatile organic compounds (VOCs), but are minimally reactive with other air contaminants that form ozone.

DURING STORAGE

A.	WETTABLE SULFUR (Microthiol)#	Label rates	See label	See label

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A mineral. May be phytotoxic, especially at higher temperatures.

B.	SULFUR DUST (Dusting sulfur)#	Label rates	See label	See label

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A mineral. May be phytotoxic, especially at higher temperatures.

POSTPLANT

The acaricides below are possibly effective, but have not been sufficiently researched to characterize their potential control of bulb mites in California floriculture and nursery crops.

A.	DIAZINON (Diazinon AG500)	1 pt/100 gal water	7 days for cut flowers 2 days for other ornamentals	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. Only for outdoor use in nurseries. No more than one application per crop cycle.

B.	BIFENTHRIN (Talstar Nursery Granular Insecticide)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Can be soil-injected or soil-incorporated. Do not apply through any type of irrigation system.

C.	ABAMECTIN (Abamectin 0.15 EC, Avid 0.15 EC)	4 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 6

COMMENTS: An avermectin. Add narrow-range oil to the mix to improve efficacy persistence if allowed by both labels. Apply as a spray. Do not apply through certain types of irrigation systems; consult label for restrictions.

D.	PYRIDABEN (Sanmite SC)	0.15–0.22 oz/1,000 sq ft	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 21A

COMMENTS: An inhibitor of arthropod energy metabolism. Do not apply more than 34.14 oz of product per acre per year.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

* Permit required from county agricultural commissioner for purchase or use.

— Unknown.

NA Not applicable.

1 Rotate insecticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

CABBAGE LOOPER (01/22)

Scientific Name: *Trichoplusia ni*

DESCRIPTION OF THE PEST

Cabbage looper larvae (caterpillars) grow up to 1-⅖ inch long and are green with lengthwise, narrow, yellowish or white stripes along the sides and top. They commonly move in a "looping" manner as they arch their abdomen upwards to pull their rear legs forward as they walk. True loopers (Geometridae) have one pair of mid-abdominal prolegs (leglike appendages), on segment 6. Cabbage loopers (Noctuidae subfamily Plusiinae) have two pairs of prolegs on the mid abdomen, on segments 5 and 6. Most other species of Noctuidae (e.g., armyworms and cutworms) and also Tortricidae (leafrollers) have four pairs of prolegs, on segments 3, 4, 5, and 6.

Adults (moths) are a mottled mix of black, brownish, gray, tan, and white. Near the center of each forewing is a silvery or whitish marking resembling a figure eight or looped string. At rest adults are about 1 inch long, and the wingspan is about 1-½ inch. The dome-shaped, spherical egg is pale green to whitish and laid singly or less commonly in a loose group of several under leaves. The brown to dark reddish pupa is about 1-½ inches long and occurs within loosely woven silk of the last instar. Pupae occur on plants near chewed foliage, on the ground in plant debris, or in topsoil, especially during the winter.

DAMAGE

Young cabbage looper larvae feed primarily on the underside of lower leaves, skeletonizing them similar to the damage of young beet armyworms, which can also be present. Older cabbage loopers chew entirely through leaves and sometimes flowers.

MANAGEMENT

Biological and cultural controls and insecticide application are used to manage cabbage looper.

Biological Control

Cabbage looper has many natural enemies that frequently keep its abundance below economic levels in the field unless they are killed by the use of broad-spectrum, persistent insecticides. Parasitic wasps include the tiny egg parasitic *Trichogramma* spp. and larger wasps that attack the caterpillars, including *Copidosoma truncatellum*, *Hyposoter exiguae*, and *Microplitis brassicae*. Tachinid flies such as *Voria ruralis* also commonly kill the loopers; these include species that lay eggs inside older loopers causing dark egg-laying wounds and species that lay their oval, whitish eggs on caterpillars. The dark, oblong pupae of tachinids commonly occur near cabbage looper chewing damage and a looper pupa with a parasite emergence hole. In some areas, the *Trichoplusia ni nuclear polyhedrosis virus* is an important biological control agent and occurs naturally.

Except for various predators and egg parasites, most of these natural enemies do not kill the loopers until they are older larvae or pupae, so larvae continue feeding and damaging crops sometimes through to the last instar even though parasitized or infected. Natural enemies do greatly reduce subsequent generations of the pest and its damage, including individuals migrating between crops and into growing areas.

Trichogramma spp. are commercially available for release to kill cabbage looper eggs, preventing larval emergence and feeding. To time the release the *Trichogramma* parasites, use blacklight traps that at night attract adults of various insects or species-specific, pheromone-baited, sticky traps to monitor adult activity to determine when adult moths are active and laying eggs.

For biological control to be effective rely on caterpillar-specific *Bacillus thuringiensis* (Bt), somewhat selective products such as certain insect growth regulators and spinosad, and contact insecticides such as oils. Employ nonchemical controls and other natural-enemy conservation methods as discussed in Biological Control, Protecting Natural Enemies and Pollinators, and Natural Enemy Releases for Biological Control of Crop Pests.

Cultural Control

Keep production areas free of weeds (e.g., mustards) and other noncrop hosts of armyworms, cutworms, cabbage loopers, and other moth pests. Exclude the night-flying adults by screening greenhouse vents with mesh of sufficient surface area to allow adequate ventilation. Completely screening shade houses

and other partially open growing areas is especially important when crops or nearby areas are lighted at night; artificial nighttime lighting attracts some moths. Individual seedling flats may also be covered by screens to exclude adults and larvae. Row covers and exclusion netting keep moths from field production as long as the mesh prevents entry of adults. Hold row covers above plant surfaces with hoops or other supports to eliminate oviposition through the mesh. Supervise work practices to ensure covers and screens are properly maintained.

Changing the color of security lamps from other than yellow or white, installing motion detectors to trigger security lights instead of continuous lighting at night, and hooding growing and security lamps to project light downward can also reduce the moth attraction.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. Entomopathogenic nematodes (e.g., *Heterorhabditis* and *Steinernema* spp.), and the microbial insecticides *Bacillus thuringiensis* ssp. *aizawai*, Bt ssp. *kurstaki*, and certain spinosad formulations (Entrust Naturalyte, Entrust SC) are acceptable for organic production.

Monitoring and Treatment Decisions
Visually inspect plants periodically to detect larvae and their chewing damage, excrement, and webbing. Especially if Bt sprays are planned, use pheromone traps to determine adult flight, which precedes periods of mating and egg laying. When adults are trapped, larvae likely are or will soon be present and Bt application is warranted because it is most effective against young larvae. Make at least a second application 7 to 10 days later because Bt is not persistent and not all eggs are laid or hatch at the same time. Additional applications may be needed as long as moths continue to be active. For guidelines on when to treat, see Establishing Action Thresholds.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. *BACILLUS THURINGIENSIS* SSP. *KURSTAKI*

(Deliver)#	0.25–1.5 lb/acre	4	0

MODE-OF-ACTION GROUP NUMBER[1]: 11A
COMMENTS: A microbial. Most effective against early instars; pheromone trapping recommended for timing applications.

A. *BACILLUS THURINGIENSIS* SSP. *AIZAWAI*

(Xentari)#	Label rates	4	0

MODE-OF-ACTION GROUP NUMBER[1]: 11A
COMMENTS: A microbial. Most effective against early instars; pheromone trapping recommended for timing applications.

B. SPINOSAD

(Conserve SC)	6 fl oz/100 gal water	4	NA
(Entrust)#	1 oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 5
COMMENTS: A spinosyn.

B. CYANTRANILIPROLE

	(Mainspring GNL)	2–8 fl oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 28
COMMENTS: A diamide. For use only in greenhouses. Do not apply more than 32 fl oz per acre per crop.

B.	CHLORANTRANILIPROLE (Acelepryn)	2–16 fl oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 28
COMMENTS: A diamide. Do not apply more than 38 fl oz per acre per year.

C.	PYRETHRINS/PBO[2] (Pyrethrum TR)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A/—
COMMENTS: A botanical and synthetic synergist premix aerosol.

D.	AZADIRACHTIN (Azatin O)#	4–16 fl oz/100 gal water	4	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A botanical and insect growth regulator (IGR). Must contact insect. Repeat applications as necessary. Label permits low-volume application.

D.	DIFLUBENZURON (Adept)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15
COMMENTS: An insect growth regulator (IGR). For indoor use only.

D.	NOVALURON (Pedestal)	6–8 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15
COMMENTS: An insect growth regulator (IGR). Use no more than twice per year. Do not exceed 36 oz/acre per year. Do not use on poinsettia.

D.	TEBUFENOZIDE (Confirm 2F)	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 18
COMMENTS: An insect growth regulator (IGR). Only for use on Christmas trees and certain food crops.

D.	CHLORFENAPYR (Pylon)	2.6–6.4 fl oz/100 gal water	12	0

MODE-OF-ACTION GROUP NUMBER[1]: 13
COMMENTS: A pyrrole. For use only in greenhouses.

E.	ACEPHATE (Orthene Turf, Tree & Ornamental WSP, 1300 Orthene TR)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

E.	CARBARYL* (Carbaryl 4L)	1qt/acre or 1qt/100 gal water	See label	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1A
COMMENTS: A carbamate. Not for use in greenhouses. The REI is 18 days for ornamentals grown for cuttings (cut flowers or cut foliage) where production is in outdoor areas and where average annual rainfall is less than 25 inches a year.

E. PYRIDALYL
(Overture 35 WP) 2 oz/100 gal water 12 NA
MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A pyridalyl of unknown mode of action. Only for use in greenhouses.

F. BIFENTHRIN
(Attain TR, Talstar S Select) Label rates 12 NA
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Attain TR is a fogger for greenhouse use only. Check label for allowed uses and restrictions.

F. CYFLUTHRIN
(Decathlon 20WP) 1.3 oz/100 gal water 12 NA
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

F. FENPROPATHRIN
(Tame 2.4EC Spray) 5.3–10.6 fl oz/100 gal water 24 NA
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

F. PERMETHRIN
(Perm-UP 25 DF) 6.4–12.8 fl oz/100 gal water 12 NA
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, and salvia. Label permits low-volume application. Do not apply more than 2 lb a.i./acre per year.

F. *TAU*-FLUVALINATE
(Mavrik Aquaflow) 4–10 fl oz/100 gal water 12 NA
MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

* Permit required from county agricultural commissioner for purchase or use.

— Unknown.

NA Not applicable.

1 Rotate insecticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 PBO = piperonyl butoxide.

CYPRESS TIPMINER (01/22)

Scientific Name: *Argyresthia cupressella*

DESCRIPTION OF THE PEST

Cypress tipminer larvae (caterpillars) are the most common of several *Argyresthia* spp. (family Argyresthiidae or Yponomeutidae) that tunnel in foliage of Cupressaceae, mostly in coastal growing areas. Hosts include arborvitae, coast redwood, cypress, and especially *Thuja occidentalis* and certain junipers. Tipminer larvae chew and feed inside branch tips and terminal foliage during summer through winter. First instars hatch from eggs in late winter through spring and feed briefly exposed on foliage as they chew a tunnel into foliage. Larvae grow up to ¼ inch long and are yellowish green to pinkish with a darker head and prothoracic shield (area on top the first thoracic segment). Mature larvae exit mines in late winter or early spring then pupate in white, silken cocoons between twiglets.

The adult appears silvery (shiny) to the naked eye. It is brown and whitish with a wingspan of about 1/3 inch. Adults occur mostly from March through May in Southern California and during April and May in Northern California. After mating, females lay flattened, ovoid eggs on green tips. The tiny eggs hatch soon after they are laid. There is one generation per year.

DAMAGE

Foliage of Cupressaceae infested with cypress tipminer turns yellow in early winter, then brown by late winter or early spring. Feeding damage is commonly limited to scattered, small areas of a plant. However, abundant tipminers can cause most of a plant's foliage to discolor. The green color is restored by new growth in the spring and summer, and even severe infestations do not kill plants. However, tipminer presence in a nursery causes plants to be obviously discolored, unsightly, and unmarketable.

MANAGEMENT

Cultural controls and insecticide application are key management practices for this pest. The importance of natural enemies (parasites, predators, and pathogens) is unknown for cypress tipminer.

Cultural Control

Where cypress tipminer has been a problem, consider avoiding production of highly susceptible hosts (e.g., *Thuja occidentalis*); instead, grow less susceptible cultivars and species. Hosts least susceptible to cypress tipminer include *Juniperus chinensis* 'Kaizuka,' *J. chinensis* var. *sargentii* 'Glauca,' *J. scopulorum* 'Erecta Glauca,' and *Thuja plicata.* Grow hosts within well-maintained screen structures or hoop houses to exclude the egg-laying moths, which are active mostly at night. To reduce moth attraction to growing areas consider using motion-activated security lights instead of always-on night lighting.

Organically Acceptable Methods

Cultural controls are organically acceptable management methods. The microbial insecticides *Bacillus thuringiensis* ssp. *aizawai* or ssp. *kurstaki*, and certain spinosad formulations (Entrust Naturalyte, Entrust SC) are acceptable for organic production.

Monitoring and Treatment Decisions

Where cypress tipminer has been a problem, examine host foliage tips for whitish cocoons about 1/5 inch long beginning in mid- to late winter. When cocoons appear, vigorously shake branches and watch for tiny, silvery moths that fly from the foliage. If it is uncertain whether the tiny moths dislodged are those of cypress tipminer several can be collected, such as with an aspirator, and taken to the local office of the county department of agriculture or University of California Cooperative Extension for identification.

One thorough foliar spray of a broad-spectrum, persistent insecticide can be made when a noticeable number of tip moths (adults) are present, between March and May. *Bacillus thuringiensis* is highly effective against first instars. Because eggs do not all hatch at the same time, make several Bt applications at about weekly intervals during late winter through spring to control larvae before they bore into plant tissue.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. SPINOSAD

(Conserve SC)	Label rates	4	NA
(Entrust)#	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 5
COMMENTS: A spinosyn.

B. ACEPHATE

(1300 Orthene TR, Orthene Turf, Tree & Ornamental WSP)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

B. CARBARYL*

(Carbaryl 4L)	Label rates	See label	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1A
COMMENTS: A carbamate. Not for use in greenhouses. The REI is 18 days for ornamentals grown for cuttings (cut flowers or cut foliage) where production is in outdoor areas and where average annual rainfall is less than 25 inches a year.

C. BIFENTHRIN

(Attain TR, Talstar S Select)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Check label for allowed uses and restrictions. Attain TR is a fogger for greenhouse use only.

C. CYFLUTHRIN

(Decathlon 20WP)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

C. FENPROPATHRIN

(Tame 2.4EC Spray)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

C. PERMETHRIN

(Perm-UP 25 DF)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, and salvia. Label permits low-volume application.

C. *TAU*-FLUVALINATE
(Mavrik Aquaflow) Label rates 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal.

D. ACETAMIPRID
(TriStar 8.5 SL) Label rates 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Apply as a foliar spray.

D. DINOTEFURAN
(Safari 20G) Label rates 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Apply as a foliar spray.

D. IMIDACLOPRID
(Marathon 1% Granular) Label rates 12[2] NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Do not apply to soils that are water logged or saturated. Do not apply to bedding plants intended to be used as food crops.

D. THIAMETHOXAM
(Flagship 25WG) Label rates See label NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Apply as a foliar spray.

E. *BACILLUS THURINGIENSIS* SSP. *KURSTAKI*
(Deliver)# Label rates 4 0

MODE-OF-ACTION GROUP NUMBER[1]: 11A
COMMENTS: A microbial. Only effective against first instars, before they bore into tissue. Monitor carefully and repeat application at about weekly intervals during egg hatch, late winter through spring.

E. *BACILLUS THURINGIENSIS* SSP. *AIZAWAI*
(Xentari)# Label rates 4 0

MODE-OF-ACTION GROUP NUMBER[1]: 11A
COMMENTS: A microbial. Only effective against first instars, before they bore into tissue. Monitor carefully and repeat application at about weekly intervals during egg hatch, late winter through spring.

F. PYRETHRINS/PBO[3]
(Pyrethrum TR) Label rates 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A/—
COMMENTS: A botanical and synthetic synergist premix aerosol.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.
# Acceptable for use on organically grown ornamentals.
* Permit required from county agricultural commissioner for purchase or use.
— Unknown.
NA Not applicable.

1 Rotate insecticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

3 PBO = piperonyl butoxide.

DIAMONDBACK MOTH (01/22)

Scientific Name: *Plutella xylostella*

DESCRIPTION OF THE PEST

The life stages of diamondback moth (family Plutellidae) are egg, larva, pupa, and adult. First instars are colorless or pale, tiny larvae (caterpillars) that mine leaves. Older larvae feed externally on buds, leaves, and terminals. Older larvae are grayish or pale green overall with numerous, pale tubercles (bumps), each with a tiny, black bristle. The larval body tapers at both ends and grows up to ⅖ inch long. Larvae have five pairs of prolegs (fleshy stubs on the abdomen) and a rear pair that protrude so when the caterpillar is viewed from above they form a distinct V-shape. Larvae when disturbed wriggle and commonly drop from plants on a silk thread.

Adults (moths) are ¼ inch long with a wingspread of ⅗ inch. Adults have long, forward-projecting antennae and are slender and mostly brownish with blackish and pale markings. At rest where wings meet over the back most adults have a broad, pale, lengthwise band. In some individuals portions of the cream-colored, pale brown, or whitish band constrict into one or more diamond shapes, hence the species common name.

Females lay minute eggs, each about 1/50 inch (0.5 mm) long. Eggs are laid singly or in groups of several on the underside of foliage and in existing depressions in leaves. Each female lays an average of about 75 eggs during her life. Pupae are green to yellowish, about ⅓ inch long, and occur in a loose, silken cocoon commonly on the underside of leaves.

Diamondback moth can feed and reproduce throughout the year in locations with mild winters. In California there can be up to 10 generations per year. Diamondback moths generally are most abundant in spring through early summer, then again during fall. Development from egg to adult (1 generation) occurs in about 29, 16, or 12 days when temperatures average 68°, 77°, or 87°F, respectively.

DAMAGE

Diamondback moth larvae feed only on Brassicaceae (crucifers) including cole crops, mustard weeds, and cruciferous ornamentals. Ornamental hosts include candytuft, stock, sweet alyssum, and wallflower. Larvae chew small circular holes in the underside of leaves, giving foliage a shothole appearance. When infested as seedlings, plant growth rate is slowed, plant parts may grow out distorted, and plants can be killed. Abundant larvae can extensively defoliate older plants, leaving mostly leaf veins. First instars chew inside or on buds, including flower buds.

Prior to the 1950s diamondback moth was generally a minor pest; this was mainly attributed to high rates of parasitism. After World War II the extensive use of newer insecticides that are toxic to natural enemies coincided with a widespread increase in diamondback moth abundance and damage. Diamondback moth was the first crop pest reported resistant to DDT. In the 1980s its resistance to pyrethroid insecticides was first documented. Diamondback moth is now notorious for developing insecticide-resistant populations and has become a common, serious pest of crucifers nationwide.

MANAGEMENT

Early in the growing season rely upon cultural and preventive controls including exclusion and sanitation, conservation of natural enemies, and the application of selective and semi-selective insecticides. For guidelines on when to treat, see Establishing Action Thresholds.

Biological Control

Natural enemies commonly control diamondback moth when broad-spectrum, persistent insecticides such as pyrethroids are not applied. The ichneumonid wasp, *Diadegma insulare* (=*D. insularis*), is the most common larval parasite in southern California. The wasps *Cotesia plutellae* and *Microplitis plutellae* also extensively parasitize diamondback moth larvae. *Trichogramma* spp. parasitize and kill the moth eggs. Predators including predaceous ground beetles and various true bugs also prey on immature diamondback moths. Viruses commonly kill the late instars.

Most natural enemies of larvae do not kill diamondback moth until the last instar, and parasitized or initially infected larvae will still damage crops. However, conserved natural enemies can greatly reduce the abundance of subsequent generations of the pest and its damage. Biological control reduces the migration between crops and into growing areas from alternative hosts because individuals of the previous

generation do not survive to adulthood. To encourage biological control rely on caterpillar-specific *Bacillus thuringiensis* (Bt), somewhat selective products such as certain insect growth regulators and spinosad. Excellent coverage under leaves can improve control with these insecticides. Especially early in the crop cycle employ nonchemical controls and practice other natural-enemy conservation methods as discussed in Biological Control and Protecting Natural Enemies and Pollinators.

Cultural Control
Keep production areas free of cruciferous weeds (e.g., mustards) that are alternate hosts of diamondback moth and certain other pests. When greenhouses or nearby areas are lighted at night, exclude migrating adults by covering openings with screens of sufficient surface area to allow adequate ventilation. To reduce moth attraction, switch from always-on night lighting to motion-activated security lights. Screen individual seedling flats to exclude migrating adults and larvae. Use row covers and exclusion netting to keep moths from field crops; hold row covers above plant surfaces with hoops or other supports to eliminate oviposition through the mesh. Ensure covers and screens are properly maintained.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. The botanicals azadirachtin, neem, and pyrethrins without piperonyl butoxide, or PBO (PyGanic), entomopathogenic nematodes (*Heterorhabditis* and *Steinernema* spp.), and the microbial insecticides *Bacillus thuringiensis* ssp. *aizawai*, Bt ssp. *kurstaki*, and certain spinosad formulations (Entrust Naturalyte, Entrust SC) are acceptable for organic production.

Monitoring and Treatment Decisions
Visually inspect hosts at least weekly to detect larvae and their chewing damage. Especially if Bt sprays are planned, use species-specific, pheromone-baited, sticky traps to determine when adults are flying. Adult captures indicate females are laying eggs and larvae are present or soon will be. At these times Bt applications are warranted as they are most effective against young larvae. Reapply Bt every 7 to 10 days while adults are trapped because Bt is not persistent and not all eggs are laid or hatch at the same time; rotate to another effective insecticide if populations increase.

Focus on excluding adults from growing areas and particular groups of plants and directly controlling the larvae. Especially early in the crop cycle, rely on exclusion, excellent sanitation, conservation of natural enemies, and the application of selective or semi-selective insecticides where feasible.

Diamondback moth has developed resistance to many insecticides, but the extent of resistance to particular modes of action varies among pest populations. For example, some populations may be resistant to spinosad, but others may still be susceptible. Applying ineffective, broad-spectrum insecticides and especially repeating applications of insecticides with the same mode of action can promote resistance in this and other pests while killing or disrupting the activities of natural enemies. If a thoroughly applied product does not control diamondback moth do not reapply that mode of action; switch to a different insecticide mode of action.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. *BACILLUS THURINGIENSIS* SSP. *KURSTAKI*[2]
(Deliver)# 0.25–1.5 lb/acre 4 0

MODE-OF-ACTION GROUP NUMBER[1]: 11A

COMMENTS: A microbial. Most effective against early instars; pheromone trapping recommended for timing applications.

A. *BACILLUS THURINGIENSIS* SSP. *AIZAWAI*[2]
(Xentari)# Label rates 4 0

MODE-OF-ACTION GROUP NUMBER[1]: 11A
COMMENTS: A microbial. Most effective against early instars; pheromone trapping recommended for timing applications.

B. SPINOSAD
(Conserve SC) 6 fl oz/100 gallons water 4 NA
(Entrust)# 1 oz/100 gal water 4 NA

MODE-OF-ACTION GROUP NUMBER[1]: 5
COMMENTS: A spinosyn.

C. DIFLUBENZURON
(Adept) Label rates 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 15
COMMENTS: An insect growth regulator (IGR). May damage poinsettias if used over labeled rate.

C. NOVALURON
(Pedestal) Label rates 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 15
COMMENTS: An insect growth regulator (IGR). Use no more than twice per year. Do not exceed 36 oz/acre per year. Do not use on poinsettia.

C. TEBUFENOZIDE
(Confirm 2F) Label rates 4 NA

MODE-OF-ACTION GROUP NUMBER[1]: 18
COMMENTS: An insect growth regulator (IGR). Only for use on Christmas trees and certain food crops.

D. CHLORANTRANILIPROLE
(Acelepryn) 2–16 fl oz/100 gal water 4 NA

MODE-OF-ACTION GROUP NUMBER[1]: 28
COMMENTS: A diamide. Do not apply more than 38 fl oz per acre per year.

D. CHLORFENAPYR
(Pylon) 2.6–6.4 fl oz/100 gal water 12 0

MODE-OF-ACTION GROUP NUMBER[1]: 13
COMMENTS: A pyrrole. For use only in greenhouses.

D. PYRIDALYL
(Overture 35 WP) 2 oz/100 gal water 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A pyridalyl of unknown mode of action. Only for use in greenhouses.

D. AZADIRACHTIN
(Azatin O)# 4–16 fl oz/100 gal water 4 0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A botanical and insect growth regulator (IGR). Must contact insect. Repeat applications as necessary. Label permits low-volume application.

E. PYRETHRINS/PBO[3]
(Pyrethrum TR) Label rates 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A/—
COMMENTS: A botanical and synthetic synergist premix aerosol.

E.	PYRETHRINS (PyGanic EC 5.0 II, PyGanic EC 1.4 II)#	Label rates	12	0
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A botanical.			
F.	ACEPHATE (1300 Orthene TR, Orthene Turf, Tree & Ornamental WSP)	Label rates	24	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 1B COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.			
F.	CARBARYL* (Carbaryl 4L)	Label rates	See label	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 1A COMMENTS: A carbamate. Not for use in greenhouses. The REI is 18 days for ornamentals grown for cuttings (cut flowers or cut foliage) where production is in outdoor areas and where average annual rainfall is less than 25 inches a year.			
G.	BIFENTHRIN (Attain TR, Talstar S Select)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid. Check label for allowed uses and restrictions. Attain TR is a fogger for greenhouse use only.			
G.	CYFLUTHRIN (Decathlon 20WP)	1.3 oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid. Label permits low-volume application.			
G.	FENPROPATHRIN (Tame 2.4EC Spray)	10.6 fl oz/100 gal water	24	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid.			
G.	PERMETHRIN (Perm-UP 25 DF)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, and salvia. Label permits low-volume application.			
G.	*TAU*-FLUVALINATE (Mavrik Aquaflow)	4–10 fl oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

* Permit required from county agricultural commissioner for purchase or use.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate insecticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Bt *aizawai* and Bt *kurstaki* applied separately can be useful in rotation with other modes of action because some populations of diamondback moth exhibiting resistance to one Bt subspecies may have little or no resistance to the other Bt.

3 PBO = piperonyl butoxide.

EUROPEAN PEPPER MOTH (DUFO MOTH) (01/22)

Scientific Names: *Duponchelia fovealis*

DESCRIPTION OF THE PEST

This insect was first found in California in 2004 and now occurs in much of the state. The life stages of European pepper moth (family Crambidae) are egg, larva, pupa, and adult.

Adults can fly and move with the wind long distances. They are ⅓ to ½ inch long with a wingspan of ⅘ inch. Adults are mostly brown to dark olive with bands on the abdomen and pale grayish or yellowish to white lines on the forewings; at rest the pale markings orient mostly perpendicular to body length. A distinguishing marking is the finger-shape (sharp curve) in the outer- or rear-most pale line of each forewing pointing to the rear. At rest the abdomen of males extends beyond the wings and the tip (rear end) curves distinctly upwards.

Eggs are flattened, oval, and about 1/35 inch (0.7 mm) long. They occur singly or in a group of several laid overlapping, mostly on the underside of leaves near veins. Eggs may also occur on the upper side of leaves or on stems or soil. They are pale green or yellowish to whitish when laid, then darken to pink, reddish orange, and then brown before hatching.

Larvae (caterpillars) grow ¾ to 1-¼ inches long. They are creamy whitish to pale or dark brown with a dark brown head and prothoracic shield (area on top immediately behind the head). The abdomen and thorax have rows of brown to grayish, slightly raised bumps (tubercles) each with one or two short bristles. Larvae produce thin, silken strands on chewed foliage, the base of stems, and other plant parts and on soil and plant debris in and near containers.

Pupae are yellowish brown and ¾ inch long or less. They occur enclosed in cocoons composed of chewed plant parts, frass (excrement), and soil particles webbed together. Cocoons are attached to the bottom and sides of plant containers, the underside of lower leaves, and on growing media, plant debris, and topsoil.

Egg to adult development (1 generation) occurs in 6 to 8 weeks when temperatures average 68°F; 3 to 4 weeks of this time are as feeding larvae. There can be 8 or 9 generations per year in California. In greenhouses and outdoor nurseries where winters are mild, larval feeding and all life stages can occur throughout the year.

DAMAGE

Larvae chew buds, flowers, fruit, leaves, roots, and stems; they especially cause pits and holes in lower leaves. When abundant the larvae tend to feed higher in the plant. Damaged leaves may drop prematurely or wilt. Larval chewing on the basal stem sometimes girdles (entirely surrounds) the stem, killing the plant.

Several dozen floriculture and nursery crops are hosts in Southern Europe and the Mediterranean region where European pepper moth is native. In cooler locations such as Canada and northern Europe it primarily is a pest in greenhouses. In southern California, damage has been observed in the field and in greenhouses on begonia, echinacea, gerbera, kalanchoe, and poinsettia. In roses it feeds primarily on fallen leaves and other crop debris.

MANAGEMENT

Cultural controls and insecticide application are important management practices. The potential effectiveness of biological control for European pepper moth in California is unknown.

Biological Control

Natural enemies of European pepper moth include predaceous ground beetles and soil-dwelling predatory mites, such as *Hypoaspis* and *Stratiolaelaps* spp. *Trichogramma* spp. wasps parasitize the eggs. The caterpillars are attacked by various parasitic wasps. For parasites and predators to potentially be effective, avoid applying broad-spectrum, persistent insecticides, especially early in the crop production cycle. Control ants, reduce dustiness, and use only selective and semi-selective insecticides where feasible. For more information see Biological Control, Protecting Natural Enemies and Pollinators, and Relative Toxicities of Pesticides Used in Floriculture and Nurseries to Natural Enemies.

Cultural Control
European pepper moth is a scavenger that feeds on almost any decaying or dropped plant debris, as well as directly on plants. Practice excellent sanitation to help limit its reproduction and spread. Control weeds, keep plant production areas clean, and promptly remove and dispose of crop debris in covered containers.

Remove the lowest leaves of hosts, especially those touching the surface of growing media, to reduce pest abundance and survival. For example, during regular monitoring, clip or pinch off and inspect the lowest leaves of each plant sampled. This also helps guide monitoring during subsequent dates by visually indicating which plants were previously inspected; during subsequent sampling, inspect different plants and clip off any leaves touching media. The underside of lowest leaves is especially difficult to cover when applying insecticide and this practice will improve coverage and the effectiveness of pesticide applications.

Avoid crowding plants; space containers so that foliage does not touch adjacent plants. Adequate spacing inhibits caterpillar movement between plants, facilitates more thorough foliage coverage when spraying pesticides, and reduces relative humidity within canopies. European pepper moth is native to marshlands (wetlands) and thrives under moist conditions.

Exclude migrating adults by covering greenhouse openings with screens of sufficient surface area to allow adequate ventilation. Screen and isolate individual flats to exclude adults and larvae from seedlings; larvae can also move from nearby hosts to infest new plants. Use row covers or exclusion netting to exclude moths from field crops, ensuring the cover is held above plant surfaces to eliminate oviposition on leaves contacting the material. Ensure covers and screens are properly maintained.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. The botanicals azadirachtin, neem, and pyrethrins without piperonyl butoxide (PyGanic), entomopathogenic nematodes (*Heterorhabditis* and *Steinernema* spp.), and the microbial insecticides *Bacillus thuringiensis* ssp. *aizawai*, Bt ssp. *kurstaki*, and certain spinosad formulations (Entrust Naturalyte, Entrust SC) are acceptable for organic production.

Monitoring and Treatment Decisions
Examine hosts at least once a week for caterpillars and their chewing damage, frass (excrement), and webbing. Randomly select plants throughout the growing area. Focus inspections for European pepper moth on the basal stems and the surrounding soil, bottoms and sides of containers, crop debris in and around containers, and especially the underside of lower leaves.

Pheromone-baited water traps are highly attractive to adult males, followed by sticky, delta traps, and funnel traps that attract and capture the adults. Bait traps with the species-specific pheromone as directed by product suppliers.

Larvae
Target early instars, regardless of the product applied, as they tend to be more susceptible and exposed to treatment. Adding narrow-range oil to the mix will kill eggs contacted directly and help to improve foliage coverage for larval control. Adding a narrow-range oil to spinosad where conditions and labels allow increases translaminar movement into plant tissue and efficacy. Applying selective (Bt) or semi-selective products (e.g., spinosad) early during the crops' production conserves natural enemies and can reduce the development of pesticide resistance. Reserve application of broad-spectrum, persistent insecticides such as organophosphates and pyrethroids for later in the production cycle.

Adults
Focus on excluding adults from growing areas and particular groups of plants. Adults can be controlled by fogging or spraying a labeled persistent, broad-spectrum contact insecticide. Sprays must be expertly applied directed to thoroughly wet the underside of foliage with high volume and large droplet size, especially the underside of lowest leaves. Adult moths do not feed and must be directly contacted. Aerosols or fogs applied in closed greenhouses during late afternoon before the night-flying adults become active

are also effective. After any adulticide application, turn off any night lighting in treated greenhouses for as long as compatible with the crops' production.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. *HETERORHABDITIS* AND *STEINERNEMA* SPP. ENTOMOPATHOGENIC NEMATODES

(NemaSeek, NemAttack)#	Label rates	NA	NA

MODE-OF-ACTION GROUP NUMBER[1]: –

COMMENTS: Entomopathogenic (insect-killing), tiny roundworms. Commercially available for chemigation, drench, or spraying of planting media. Require high humidity or moist conditions and the absence of exposure to bright or direct light to be effective. In comparison with the control of pest insects that feed or pupate mostly in soil, these soil-dwelling nematodes are not as effective for this pest because many of its individuals commonly pupate aboveground.

B. SPINOSAD

(Conserve SC)	6 fl oz/100 gallons water	4	NA
(Entrust)#	1 oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 5

COMMENTS: A spinosyn.

C. *BACILLUS THURINGIENSIS* SSP. *KURSTAKI*[2]

(Deliver)#	0.25–1.5 lb/100 gallons water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 11A

COMMENTS: A microbial. Most effective against early instars and when applied at high pressure to penetrate webbing; pheromone trapping is recommended for timing applications.

C. *BACILLUS THURINGIENSIS* SSP. *AIZAWAI*[2]

(Xentari)#	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 11A

COMMENTS: A microbial. Most effective against early instars and when applied at high pressure to penetrate webbing; pheromone trapping is recommended for timing applications.

D. DIFLUBENZURON

(Adept)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15

COMMENTS: An insect growth regulator (IGR).

D. TEBUFENOZIDE

(Confirm 2F)	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 18

COMMENTS: An insect growth regulator (IGR). Only for Christmas trees and certain food crops.

E. CHLORANTRANILIPROLE

(Acelepryn)	2–16 fl oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 28
COMMENTS: A diamide. Do not apply more than 32 fl oz per acre per crop.

E.	CHLORFENAPYR (Pylon)	2.6–6.4 fl oz/100 gal water	12	0

MODE-OF-ACTION GROUP NUMBER[1]: 13
COMMENTS: A pyrrole. For use only in greenhouses.

E.	PYRIDALYL (Overture 35 WP)	8 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A pyridalyl of unknown mode of action. Only for use in greenhouses.

E.	TOLFENPYRAD Hachi-Hachi SC	Label rates	12	0

MODE-OF-ACTION GROUP NUMBER[1]: 21A
COMMENTS: An inhibitor of arthropod energy metabolism. For early instars. Do not make more than two applications per crop.

E.	AZADIRACHTIN (Azatin O)#	4–16 fl. oz/100 gal water	4	0

MODE-OF-ACTION GROUP NUMBER[1]: –
COMMENTS: A botanical and insect growth regulator (IGR). Must contact the insect. Repeat applications as necessary. Label permits low-volume application.

F.	ACEPHATE (1300 Orthene TR, Orthene Turf, Tree & Ornamental WSP)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

G.	BIFENTHRIN (Attain TR, Talstar S Select)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Check label for allowed uses. Attain TR is a fogger for greenhouse use only.

G.	CYFLUTHRIN (Decathlon 20WP)	1.3 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

G.	FENPROPATHRIN (Tame 2.4EC Spray)	5.3 fl oz/100 gal water	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

H.	PYRETHRINS/PBO[3] (Pyrethrum TR)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A/—

COMMENTS: A botanical and synthetic synergist premix aerosol.

I.	PYRETHRINS (PyGanic EC 5.0 II, PyGanic EC 1.4 II)#	Label rates	12	0
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A botanical.			
J.	IMIDACLOPRID (Marathon 1% Granular)	Label rates	12[4]	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Do not apply to soils that are water logged or saturated. Do not apply to bedding plants intended to be used as food crops.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate insecticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, the organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Bt *aizawai* and Bt *kurstaki* applied separately can be useful in rotation with other modes of action because some populations of diamondback moth exhibiting resistance to one Bt subspecies may have little or no resistance to the other Bt.

3 PBO = piperonyl butoxide.

4 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

FOLIAR-FEEDING MEALYBUGS (01/22)

Scientific Names: Citrus mealybug: *Planococcus citri*
Madeira mealybug: *Phenacoccus madeirensis*
Longtailed mealybug: *Pseudococcus longispinus*
Obscure mealybug: *Pseudococcus viburni*

DESCRIPTION OF THE PESTS

Mealybugs (family Pseudococcidae) develop through three life stages: egg, nymph, and adult. Adult females appear grayish to whitish and are soft-bodied, wingless, and about 1/20 to ⅕ inch long. Females and settled nymphs are elongate to ovoid, segmented, and covered with pale, powdery wax of varying thickness that at least partly obscures the body of females and older nymphs. Many mealybugs have wax filaments around their margin that help distinguish among species; characteristics are based on the relative length of filaments, mostly those at the rear end as summarized in the table Distinguishing Common Mealybugs in Floriculture and Ornamental Nursery Crops. Mealybugs often occur where foliage is dense or touching and in other partly hidden areas of plants. Some species feed on roots.

Adult male mealybugs are rarely seen and do not feed. Males are tiny and delicate, gnat-like with one pair of opaque wings and long antennae. The body is commonly brownish to reddish.

Mealybugs can be confused with adelgids and woolly aphids that sometimes infest leaves and shoots of woody perennials. Aphids can be distinguished by their pear-shaped body and long legs, and those that produce pale wax generally occur only on deciduous broadleaved plants. Adelgids also produce cottony wax-like material but infest only conifers, which are not commonly infested by mealybugs.

Generally it is not necessary to determine the species of mealybug because cultural practices, exclusion and sanitation, and pesticides are similar for all. However, where biological control will be employed, correct identification of the species is necessary.

Distinguishing common mealybugs in floriculture and ornamental nursery crops.

Common name	Marginal filaments of adult females	Body color and wax of adult females	Produces ovisacs
Citrus mealybug	Relatively short marginal filaments of similar length, except for two somewhat longer filaments at the rear that are shorter than the rear-end filaments of the other species here.	Powdery wax commonly is thin in a lengthwise streak along the middle of the abdomen, revealing the dark to orangish body underneath.	Yes
Longtailed mealybug	Mostly short, marginal filaments, except at the rear are four, long filaments that include a central pair about 3/4 of body length or longer, except when broken off.	Powdery wax commonly is thin in a lengthwise streak along the middle of the abdomen, revealing the dark body underneath.	No
Madeira mealybug	Relatively short marginal filaments of similar length, except for two distinctly longer filaments at the rear.	Has a dark-colored or gray body, visible at thinly waxed depressions and small spots in rows down the back where segments occur.	Yes
Obscure mealybug	Relatively short marginal filaments of similar length, except for two distinctly longer filaments at the rear.	Uniformly covered with pale wax.	Yes

Because their waxy covering and filaments are easily disturbed, examine at least several adults to help discriminate the species. Compare your specimens to the California Department of Food and Agriculture's *Insect & Invertebrate Pest Sheets* and UC's *Mealybugs in California Vineyards.* Mealybugs of uncertain species can be taken for identification to the local offices of county agricultural commissioner or University of California Cooperative Extension.

DAMAGE

Mealybugs generally are a problem only on perennial or long-term crops. They suck phloem sap and excrete sticky honeydew, which supports the growth of blackish sooty mold and attracts ants. Mealybugs

tend to feed in groups, and their waxy bodies and white egg masses (of some species) on leaves and green shoots can be especially apparent. Feeding causes leaves to yellow and sometimes drop prematurely. Mealybug feeding on new growth can cause leaf and shoot distortion. Infested plants may decline in vigor and young plants may be killed.

MANAGEMENT

Inspect plants regularly for mealybugs and signs of their presence. Management is easier and more effective if infestations are detected and managed early before crop foliage becomes dense, mealybugs and their protective wax become abundant, and the crop is damaged. Practice excellent exclusion and sanitation to avoid introducing mealybugs into production areas, and when they are present to help avoid their spread.

Biological Control

If not disrupted, resident parasitic wasps and predators commonly control longtailed mealybug and sometimes certain others. Avoid application of broad-spectrum, persistent insecticides for any pests where feasible, especially early in crop production cycles. Control dust that disrupts the activity of many natural enemies, and control ants that carry mealybugs among plants and protect them from natural enemies. See Biological Control and Protecting Natural Enemies and Pollinators for more suggestions.

The mealybug destroyer (*Cryptolaemus montrouzieri*), a lady beetle, is commercially available for control of mealybugs that produce egg sacs. The beetle lays eggs in the egg masses of their host; the progeny (larvae) of these provide the control and feed on all mealybug life stages. For best results, release adults of the mealybug destroyer where mealybug egg masses are present. Mealybug destroyers will also control certain other ovisac-forming insects, such as green shield scale. Since longtailed mealybug females give live birth to young and produce no egg masses the mealybug destroyer will not reproduce or be effective against this species. Releases of mealybug destroyer must begin early during the crop's production cycle. Where mealybug eggs are available as food, female *Cryptolaemus* lay numerous eggs. The larvae resemble mealybugs, but mature to a larger size (1/4 to 1/2 inch), and when not feeding can move quickly (unlike mealybugs). If carefully observed, their chewing mouthparts can be seen.

Parasitic wasps specific to certain mealybug species can also be released. The *Leptomastix dactylopii* parasite has been effective for control of citrus mealybug in greenhouses and is sometimes released in combination with the mealybug destroyer. See Natural Enemy Releases for Biological Control of Crop Pests for more information.

Cultural Control

Practice excellent exclusion and sanitation. Mealybugs readily spread as crawlers (mobile, first instars) on contaminated containers, equipment, tools, workers, and the wind and move among nearby plants and surfaces before settling to feed. Mealybug adults and nymphs can also walk slowly throughout their life and spread within the crop.

Carefully inspect new plants and temporarily place new stock in quarantine or isolation until it is apparent that they are not infested; re-inspect new plants to ensure they are pest free before moving them into production areas. When disposing of infested plants, place them in covered containers to prevent them from becoming sources of infestation for other plants.

Brief exposure to dry heat or hot water can disinfest many crops of insects and certain plant pathogens. Carefully control the conditions as recommended. Before extensively employing heat, test the method on a small portion of each particular variety to ensure plants are not sensitive. See Some Pests Controlled by Heat Treatment of Plants for more information.

Organically Acceptable Methods

Biological control, including the mealybug destroyer lady beetle and parasitic wasps, and cultural controls are organically acceptable management methods. Certain formulations of the botanicals azadirachtin (e.g., Azatin) and neem oil, the microbial *Beauveria bassiana*, and narrow-range oil (Organic JMS Stylet Oil) are organically acceptable.

Monitoring and Treatment Decisions

Regularly inspect plants for honeydew, sooty mold, and whitish wax. Look for ants, which can indicate

mealybugs or other phloem-sucking insects are present. Concentrate monitoring for mealybugs on the basal stems, branch crotches, underside of foliage, and where plant parts touch. Sticky tape traps wrapped around infested stems can be useful to time insecticide applications for when crawlers are active and to compare mealybug activity before versus after pesticide application. Pheromone-baited sticky traps that attract male mealybugs are available for monitoring males of at least the grape mealybug (*Pseudococcus maritimus*) and vine mealybug (*Planococcus ficus*). Contact trap suppliers to learn what products are available and how to use them.

Early instars, especially crawlers, are most susceptible to insecticides. Crawler emergence generally occurs over a shorter time period earlier in the growing season; making treatments then can reduce the total number of warranted applications. To monitor crawler activity for timing applications or evaluating results, use traps of double-sided sticky tape wrapped around twigs in late winter placed near where egg masses or groups of mealybugs are observed. Since not all crawlers emerge at the same time, multiple insecticide applications may be needed depending on the crawler emergence period and the pesticide used. See Sticky Tape Traps for how to effectively use this technique.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.			
A. NARROW-RANGE OIL[2] (JMS Stylet Oil, Organic JMS Stylet Oil)#	1 oz/gal water	4	0
MODE-OF-ACTION GROUP NUMBER[1]: — COMMENTS: An oil and contact insecticide. Target pest must be completely covered with spray. Do not spray stressed plants. Check label for plants that can be treated. Do not use with sulfur products; check label for tank mix restrictions.			
B. *CRYPTOLAEMUS MONTROUZIERI*# (mealybug destroyer)	Label rates	0	NA
MODE-OF-ACTION GROUP NUMBER[1]: — COMMENTS: A predator. Release in early spring where foliar-feeding, ovisac-producing mealybugs have been a problem.			
C. NEEM OIL[2] (Triact 70, Trilogy)#	Label rates	4	0
MODE-OF-ACTION GROUP NUMBER[1]: UNE COMMENTS: A botanical oil. Target pest must be completely covered with spray. Do not spray stressed plants. Check label for plants that can be treated. May injure flowers.			
D. AZADIRACHTIN (Azatin O)#	10–16 fl oz/100 gal water	4	0
(Ornazin 3% EC)	Indoor: 8 oz/100 gal water Outdoor: 10 oz/acre	12	0
MODE-OF-ACTION GROUP NUMBER[1]: — COMMENTS: A botanical and insect growth regulator (IGR). Must contact insect. Repeat applications as necessary. Only effective on immatures. Label permits low-volume application. For Ornazin do not exceed 22.5 oz/acre per application.			

D. *ISARIA FUMOSOROSEA* APOPKA STRAIN 97
(Ancora)# 14–28 oz/100 gal water 4 NA

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: An insect pathogenic fungus.

E. BUPROFEZIN
(Talus 70DF) 12 oz/acre 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 16
COMMENTS: An insect growth regulator. Add narrow-range oil to the mix to improve efficacy if allowed by both labels; if so do not spray stressed plants and do not use with sulfur products. A maximum of two applications to each crop.

E. S-KINOPRENE
(Enstar AQ) Label rates 4 NA

MODE-OF-ACION GROUP NUMBER[1]: 7A
COMMENTS: An insect growth regulator (IGR). Apply prebloom. Only effective on immatures. Also labeled for low volume use.

F. ACETAMIPRID
(TriStar 8.5 SL) 8.5 oz/100 gal water 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Apply as a foliar spray.

F. DINOTEFURAN
(Safari 20G) Label rate 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Can be applied as a drench or foliar spray.

F. IMIDACLOPRID
(Marathon 1% Granular) Label rates 12[3] NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Do not apply to soils that are water logged or saturated. Do not apply to bedding plants intended to be used as food crops.

F. THIAMETHOXAM
(Flagship 25WG) Label rates See label NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Can be applied as a drench or foliar spray.

F. TOLFENPYRAD
(Hachi-Hachi SC) Label rates 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 21A
COMMENTS: An inhibitor of arthropod energy metabolism. Do not make more than two applications per crop.

G. FLONICAMID
(Aria) 2.1–4.3 fl oz/100 gal water 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 29
COMMENTS: Affects mechanosensory functions. Do not make more than two consecutive applications; rotate with other modes of action.

G. SPIROTETRAMAT
(Kontos) — Label rates — 24[3] — NA

MODE-OF-ACTION GROUP NUMBER[1]: 23
COMMENTS: An inhibitor of acetyl CoA carboxylase.

G. PYRIFLUQUINAZON
(Rycar) — 6.4 fl. oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 9B
COMMENTS: Affects mechanosensory functions. Only for greenhouse use.

H. ACEPHATE
(Acephate 97UP, Orthene Turf, Tree & Ornamental WSP, 1300 Orthene TR) — Label rates — 24 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

I. BIFENTHRIN
(Attain TR, Talstar S Select) — Label rates — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Check label for allowed uses. Attain TR is a fogger for greenhouse use only.

I. CYFLUTHRIN
(Decathlon 20WP) — 1.9 oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

I. FENPROPATHRIN
(Tame 2.4EC Spray) — 16 fl oz/100 gal water — 24 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

I. PERMETHRIN
(Perm-UP 25 DF) — Label rates — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, and salvia. Label permits low-volume application. Do not apply more than 2 lb a.i./acre per year.

I. *TAU*-FLUVALINATE
(Mavrik Aquaflow) — 4–10 fl oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal.

J. CYFLUTHRIN/IMIDACLOPRID
(Discus) — Label rates — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A/4A
COMMENTS: A pyrethroid and neonicotinoid premix.

K. PYRETHRINS/PBO[4]

	(Pyrethrum TR)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A/—			
	COMMENTS: A botanical and synthetic synergist premix aerosol.			
L.	*BEAUVERIA BASSIANA*			
	(BotaniGard 22 WP)	Up to 2 lb/100 gal spray volume	4	0
	(BotaniGard ES)	0.5–1 qt/100 gal spray volume	4	0
	(Mycotrol ESO)#	0.5–1 qt/100 gal spray volume	4	0
	MODE-OF-ACTION GROUP NUMBER[1]: UNF			
	COMMENTS: An insect-pathogenic fungus. Apply every 7 days if warranted. Do not tank mix with most fungicides; wait 48 hours after application to apply a fungicide.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Single doses of oils and potassium salts of fatty acids (soaps) can be used anytime as pesticide rotation without negatively impacting resistance management.

3 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

4 PBO = piperonyl butoxide.

FUNGUS GNATS (01/22)

Scientific Names: *Bradysia coprophila, Bradysia impatiens*

DESCRIPTION OF THE PESTS

Bradysia spp. adults are 1/16 to ⅜ inch long and delicate flies with long, thin antennae and legs. They resemble mosquitoes. Females lay eggs in soil, which hatch in about 4 days. Larvae grow through four increasingly larger instars up to about ⅓ inch long. Larvae have a shiny black head and clear body, with internal organs visible through their surface. Note that moth flies and shore flies can also be problems in overly wet conditions. Learn how to distinguish the adults and larvae of these from fungus.

Young larvae chew and feed on root hairs and algae; older larvae may additionally feed on the inside of roots, on stems near growing media, and on leaves touching the soil. When populations are high, larvae may bore into larger roots or stems. One generation may be completed 21 or 40 days at 72° or 61°F, respectively.

DAMAGE

Larvae usually feed on roots and algae within 1 inch of the soil surface. Root feeding can allow entry of plant pathogens. Direct damage can cause wilting even though the plants are being sufficiently watered and can be particularly severe in propagation areas and seedling flats. Adult fungus gnats also disseminate soil-inhabiting pathogens on their bodies and in their feces. Fungus gnat adults can be a nuisance to workers when present in large numbers.

MANAGEMENT

Monitoring, biological and cultural controls, and applying certain pesticides are the main management methods for fungus gnats.

Biological Control

Fungus gnat larvae can be controlled by drip-irrigating, drenching, or spraying growing media with entomopathogenic nematodes (*Steinernema feltiae*). Soil-inhabiting predaceous mites (*Hypoaspis* or *Stratiolaelaps* spp.) and a predatory rove beetle, *Dalotia* (=*Atheta*) *coriaria*, may occur naturally in crops and can be purchased and released according to the suppliers' directions to enhance biological control. For more information, see Biological Control, Protecting Natural Enemies and Pollinators, and Natural Enemy Releases for Biological Control of Crop Pests.

Cultural Control

Keep production areas free of algal scum and weeds, which provide breeding sites and food for fungus gnats and shore flies. Excess humidity, overwatering, poor drainage, prolonged wet surfaces, standing water, and the use of incompletely composted and unpasteurized organic matter or manure in growing media favor fungus gnat abundance, so avoid these situations. Commercial sources of peat and almost any organic-containing growing media that becomes wet prior to use or has been stored on soil or uncovered can be infested with fungus gnats. Keep growing media covered until use and pasteurize any potentially contaminated, organic-containing media with a kiln, steam, or other heating method before use when growing crops sensitive to fungus gnat damage. Keeping flats covered with sufficiently fine-mesh screens can exclude egg-laying adults from seedlings and young plants especially susceptible to fungus gnat damage.

Organically Acceptable Methods

Bacillus thuringiensis ssp. *israelensis* (Gnatrol), cultural controls including exclusion and sanitation, and the conservation and release of natural enemies are organically acceptable methods of fungus gnat control.

Monitoring and Treatment Decisions

Yellow sticky cards placed in greenhouses will capture adult fungus gnats. For more information, see Monitoring with Sticky Traps and Sticky Trap Monitoring of Insect Pests. Larval populations can be monitored with cubes or slices of potatoes pressed slightly into the soil. Inspect the underside of potato traps regularly to observe and count the fungus gnat larvae and assess changes in their relative abundance in response to your management actions. For more information on treatment decisions, see Establishing Action Thresholds.

Apply drenches to the top 1 inch of soil to kill larvae; avoid application of excessive spray that may leach or move insecticide too deeply into growing media. Pyrethrins and other adulticide aerosols, foggers, or sprays can quickly, but temporarily, reduce adult populations.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. *STEINERNEMA FELTIAE*
ENTOMOPATHOGENIC NEMATODE
(NemAttack)# — Label rates — NA — NA

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: Entomopathogenic (insect-killing), tiny roundworms. Commercially available for chemigation, drench, or spraying of planting media. Pathogenic only to insects. Requires high humidity or moist conditions and the absence of exposure to bright or direct light to be effective. Compatible with *Bacillus thuringiensis* spp. *israelensis* and releases of soil-dwelling natural enemies.

B. CYROMAZINE
(Citation) — 2.66 oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 17
COMMENTS: An insect growth regulator (IGR).

B. DIFLUBENZURON
(Adept) — Label rates — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 15
COMMENTS: An insect growth regulator (IGR). Apply as spray or drench to top 2 inches of soil.

B. S-KINOPRENE
(Enstar AQ) — Label rates — 4 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 7A
COMMENTS: An insect growth regulator (IGR). Apply prebloom. Also labeled for low volume use.

B. PYRIPROXYFEN
(Distance) — 3–6 fl oz/100 gal water spray
2 fl oz/100 gal water drench — 12 — NA

MODE-OF-ACION GROUP NUMBER[1]: 7C
COMMENTS: An insect growth regulator (IGR). Do not apply more than once per crop cycle.

C. *BACILLUS THURINGIENSIS* SSP. *ISRAELENSIS*
(Gnatrol)# — Light infestation: 3.2–6.4 oz/100 gal water
Heavy infestation: 13–26 oz/100 gal water — 4 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 11A
COMMENTS: A microbial. Do not apply with fertilizers or fungicides containing chlorine or copper. Not effective on shore flies. Compatible with entomopathogenic nematodes and releases of soil-dwelling natural enemies.

D.	AZADIRACHTIN (Azatin O)#	8 fl. oz/100 gal water	4	0
	(Ornazin 3% EC)	8 oz/100 gal	12	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A botanical and insect growth regulator (IGR). Must contact insect. Repeat applications as necessary. Only effective on immatures. Label permits low-volume application. For Ornazin do not exceed 22.5 oz/acre per application.

D.	CHLORFENAPYR (Pylon)	5.2–10 fl oz/100 gal water	12	0

MODE-OF-ACTION GROUP NUMBER[1]: 13
COMMENTS: A pyrrole. For use only in greenhouses.

E.	ACEPHATE (Acephate 97UP, Orthene Turf, Tree & Ornamental WSP, 1300 Orthene TR)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol for greenhouse use only. Orthene Turf, Tree, & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

E.	BIFENTHRIN (Attain TR, Talstar S Select)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Check label for allowed uses. Attain TR is a fogger for greenhouse use only.

E.	CYFLUTHRIN (Decathlon 20WP)	1.3 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Also effective against adults. Label permits low-volume application.

E.	FENPROPATHRIN (Tame 2.4EC Spray)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Also effective against adults.

E.	PERMETHRIN (Perm-UP 25 DF)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, and salvia. Label permits low-volume application. Do not apply more than 2 lb a.i./acre per year.

E.	*TAU*-FLUVALINATE (Mavrik Aquaflow)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Also effective against adults. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal.

F.	PYRETHRINS/PBO[2] (Pyrethrum TR)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A/—
COMMENTS: A botanical and synthetic synergist premix aerosol. Also effective against adults.

G.	ACETAMIPRID (TriStar 8.5 SL)	8.5–16.5 oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Apply as a foliar spray.			
G.	DINOTEFURAN (Safari 20G)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Can be applied as a drench or foliar spray.			
G.	IMIDACLOPRID (Marathon 1% Granular)	Label rates	12[3]	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Do not apply to soils that are water logged or saturated. Do not apply to bedding plants intended to be used as food crops.			
G.	THIAMETHOXAM (Flagship 25WG)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Can be applied as a drench or foliar spray.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 PBO = piperonyl butoxide.

3 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

GROUND (ROOT) MEALYBUGS (01/22)

Scientific Name: *Rhizoecus* spp.

DESCRIPTION OF THE PESTS

Ground mealybugs (family Rhizoecidae) are soil-dwelling insects that suck and feed on basal stems and roots. They develop through three life stages. Eggs hatch into nymphs that grow through several increasingly larger instars before maturing into adults. Adults grow up to 1/16- to 3/16 inch long. Nymphs resemble small adults.

At least three, difficult-to-distinguish species of ground mealybugs feed on food and ornamental crops in California: ground mealybug (*R. falcifer*), Kondo mealybug (*R. kondonis*), and Trinity ground mealybug (*R. bicirculus*). Adults and nymphs are elongate and covered with a thin layer of powdery, white wax. They have distinct abdominal segments and lack the marginal wax filaments found on Foliar-Feeding Mealybugs. In pots, ground mealybugs are concentrated on the outer portion of the rootball, between roots and the pot, but also occur throughout the root mass. The crawlers (mobile first instars) can occur on benches, containers, growing media, and anything that contacted infested plants, such as propagation tools and workers clothing and hands.

Adults can live 1 to 2 months. Adult females lay eggs in soil or give live birth to crawlers. Eggs usually hatch within 1 day of being laid. Crawlers disperse and are highly mobile, readily walking to infest nearby plants. One generation (egg to adult) at common soil temperatures requires about 2 to 4 months.

DAMAGE

White, powdery wax on the soil surface especially near plant stems or around the root ball can indicate the presence of ground mealybugs. Slow (stunted) plant growth, pale to yellowish or wilted foliage that may drop prematurely, and an overall decline in healthy appearance of plants are common symptoms of ground mealybug infestations, although other maladies can also cause these symptoms.

MANAGEMENT

Ground mealybugs commonly are introduced with new stock. Before moving new plants into production areas, remove a portion from their container and examine roots for white, powdery wax and the presence of slow-moving, oval, whitish insects. Similarly, inspect the roots of established plants if they appear to be declining. The presence of ants on plants or soil near basal stems can indicate that ground mealybugs or other phloem-feeding pests are present.

Rogue and discard infested plants, or effectively treat them with insecticide. Control ants, which can carry and spread the mealybugs among plants. Excellent sanitation practices, heat treatment, and soil-drench or systemic insecticides are the primary management methods.

Biological Control

Biological control has not been investigated.

Cultural Control

Discard infested plants and those nearby which also are likely to be infested. It is difficult to completely disinfest roots of these soil-dwelling pests; starting fresh with pest-free plants and growing media and clean production areas can be preferable to the uncertainty of whether plants can be entirely disinfested and the risk that ground mealybugs will continue to spread and damage more plants.

Where infestations are discovered, sanitize (e.g., employ disinfectants, hot water, or steam) the benches, pots, tools, and other equipment used in that vicinity as these may be contaminated with crawlers. Use new or freshly pasteurized (e.g., heat-treated) growing media when propagating plants. Keep growing areas clean. Promptly remove crop debris and weeds and dispose of them in covered containers. Do not allow water (e.g., irrigation runoff) from areas infested with ground mealybugs to drain to areas believed free of these pests because mealybug crawlers are easily spread with moving water.

Heat treatment

Submerging pots containing plants in 120°F until the internal root ball temperature reaches 115°F entirely disinfests them of root mealybugs and does not significantly adversely affect the plants according to

research with potted *Rhapis* palms in Hawaii. Aerated steam and hot water are highly effective in disinfesting mealybugs and numerous other pests from bulbs, corms, dormant stem cuttings, and tubers. First test small batches of each cultivar to determine control efficacy and plant tolerance to heat treatment before applying the method to large portions of the crop. A general recommendation for bulbs, corms, or rhizomes is to presoak them for 2 to 3 hours or overnight in 75°F water containing a wetting agent before immersing them in 111°F water for about 1-1/2 hours. Cool plant parts immediately afterward with clean, cold water, dry them thoroughly in warm air or sunshine, then store them under cool, low-humidity conditions until plants are used. See Control Pests by Heat Treatment of Plants in Nurseries for specific, heat-treatment guidelines by crop.

Organically Acceptable Methods
Controlling ants with sticky barriers, cultural controls especially pest-free stock, excellent sanitation, heat treatment, and botanical pyrethrins without piperonyl butoxide (PyGanic) are organically acceptable management methods.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A.	BUPROFEZIN (Talus 70DF)	12 oz/100 gal	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 16
COMMENTS: An insect growth regulator. Add narrow-range oil to the mix to improve efficacy if allowed by both labels; if so do not spray stressed plants and do not use with sulfur products. A maximum of two applications to each crop.

A.	S-KINOPRENE (Enstar AQ)	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 7A
COMMENTS: An insect growth regulator (IGR). Apply prebloom. Also labeled for low volume use.

B.	FLUPYRADIFURONE (Altus)	Label rates	12[2]	NA

MODE-OF-ACTION GROUP NUMBER[1]: 4D
COMMENTS: A butenolide. No more than one application per crop cycle.

B.	IMIDACLOPRID (Marathon 1% Granular)	Label rates	12[2]	NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Do not apply to soils that are waterlogged or saturated. Do not apply to bedding plants intended to be used as food crops.

C.	ACEPHATE (Orthene Turf, Tree & Ornamental WSP, Acephate 97UP)	Label rates	24	See label

MODE-OF-ACTION GROUP NUMBER[1]: 1B

COMMENTS: An organophosphate. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

C.	DIAZINON (Diazinon AG500)	Label rates	See comments	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. Only for outdoor use in nurseries. No more than one application per crop cycle. REI is 7 days for flowers and other ornamentals grown for cuttings; REI is 2 days for other ornamentals.

D.	BIFENTHRIN (Talstar S Select)	Label rates	12	See label

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

D.	CYFLUTHRIN (Decathlon 20WP)	1.9 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

D.	FENPROPATHRIN (Tame 2.4EC Spray)	16 fl oz/100 gal water	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

D.	PERMETHRIN (Perm-UP 25 DF)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

D.	*TAU*-FLUVALINATE (Mavrik Aquaflow)	4–10 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

LEAFHOPPERS AND SHARPSHOOTERS (01/22)

Scientific Names: Glassy-winged sharpshooter: *Homalodisca vitripennis* (=*H. coagulata)*
Aster leafhopper: *Macrosteles quadrilineatus* (=*M. fascifrons)*
Blue-green sharpshooter: *Graphocephala atropunctata*
Two-spotted leafhopper: *Sophonia rufofascia*

DESCRIPTION OF THE PESTS

Leafhoppers (family Cicadellidae) include sharpshooters, which generally are larger species. Leafhoppers develop through three life stages: eggs, nymphs, and adults. Nymphs resemble adults, but are smaller, wingless, and may differ in color. Leafhoppers are relatively long and slender and most are about ⅛ inch or less in length; sharpshooters can be up to ½ inch long, although many species are shorter. Species vary from brightly colored (blue-green sharpshooter, two-spotted leafhopper) to dull and mostly brown, gray, green, or tan (aster leafhopper, glassy-winged sharpshooter). Adults and nymphs when disturbed often jump or walk rapidly away sideways.

Glassy-winged sharpshooter adults are about ½ inch long and mostly dark brown with a yellow to whitish abdomen. The nymphs are grayish and develop through five increasingly larger instars. Nymphs blend with the color of smooth, gray bark even more so than adults. As they suck xylem sap, adults and nymphs excrete a large amount of liquid that leaves behind a whitish residue on leaves and other surfaces. The broad host range includes many food crops and ornamentals including bird-of-paradise, citrus, cottonwood, crape myrtle, eucalyptus, euonymus, hibiscus, oleander, olive, pittosporum, *Prunus* spp., sunflower, and xylosma.

Glassy-winged sharpshooter is found mostly in Southern California and the southern Central Valley. It overwinters as adults on evergreen hosts. Starting about late February, overwintered females migrate to host plants and lay eggs in a mass inserted under the surface of leaves. There are two generations per year in California.

The **aster leafhopper**, also called the six-spotted leafhopper, has three pairs of black spots on the front and top of its head. Adults are about ⅛ inch long with a light green to yellowish body that appears gray when at rest and covered by the wings. The wings have prominent veins and black markings on the abdomen, head, and thorax. Nymphs are pale gray, green, yellow, or whitish. The leafhopper overwinters mostly as eggs in plant tissue, although adults and nymphs may be found throughout the year. Up to six generations may occur during spring through fall.

Blue-green sharpshooter adult has green to bright blue head, thorax, and wings and yellow legs and abdomen. It is about ⅖ inch long. Nymphs are pale, and mostly whitish. The species occurs in coastal areas and has one generation a year in most of California; a second generation occurs in portions of Southern California. Adults become active in late winter to early spring and can become abundant in ornamental landscapes and weeds along stream banks and canyons and ravines where there is dense vegetation. As natural vegetation and weeds dry and die during spring, adults disperse into crops and other irrigated plantings. Eggs hatch from May through July with some of the nymphs becoming adults by mid-June.

Two-spotted leafhopper adults are about ¼ inch long and yellowish with a dark, reddish, lengthwise stripe along the back. Near the wing tips are two dark, eyelike spots that make it appear that the leafhopper is walking backwards. Nymphs are yellow. Two-spotted leafhopper feeds on dozens of species of ornamental plants and a few crops such as avocado.

DAMAGE

Leafhoppers have piercing-sucking mouthparts that puncture plant tissue to consume cell contents or sap. When abundant feeding causes noticeable bleaching or stippling of leaves, which may curl, dry and turn brown, and drop prematurely. Foliage may also become fouled with leafhoppers' clear and shiny to whitish excrement on which blackish sooty mold may grow. The pale cast skins of nymphs may stick to leaf surfaces. Even where leafhopper populations are commonly low in nurseries causing little or no damage, certain species can be serious pests vectoring plant pathogens.

Aster leafhopper and several other leafhoppers can transmit the pathogen that causes aster yellows disease, the most important phytoplasma affecting herbaceous ornamentals. Phytoplasmas cause abnormal shoot growth, dwarfing and yellowing of foliage and green shoots and greening of flower parts, which develop into leaflike structures. Clusters or tufts of spindly, yellow, upright shoots commonly develop around the base of infected plants, often on one side of the plant. Corms or tubers can mature early, be undersized, or have stunted roots if infected early during the current season. Corms or tubers infected during the previous season develop many thin, yellowish, and weak leaves, distorted flower spikes, and green blossoms.

The pathogen has several hundred hosts including many vegetable crops and weeds. Ornamental hosts of aster yellows include anemone, aster, calendula, candytuft, cassia, celosia, chrysanthemum, cosmos, gladiolus, godetia, gypsophila, marigold, nasturtium, petunia, primrose, Queen Anne's lace, ranunculus, sage, snapdragon, stock, strawflower, sweet William, and vinca.

Glassy-winged sharpshooter, blue-green sharpshooter, and certain other leafhoppers can transmit the *Xylella fastidiosa* bacterium to plants, which clogs the water-conducting tissues (xylem). *Xylella fastidiosa* plant diseases are variously named according to host plants. Some strains of *Xylella* harmless to some plants can be pathogenic to other hosts. Diseases caused by *X. fastidiosa* in California include alfalfa dwarf, almond leaf scorch, and Pierce's disease of grape. *Xylella* strains identified mostly in southern California cause oleander leaf scorch and death of liquidambar (sweet gum), oleander, olive, and purple-leaf plum. Numerous other woody ornamentals in the eastern United States are affected by *Xylella* strains not yet reported in California.

MANAGEMENT

Cultural controls including exclusion and insecticide application are the primary management methods for leafhoppers. No chemicals are effective at controlling the aster yellows phytoplasma or *Xylella* bacteria in ornamental crops.

In nurseries where glassy-winged sharpshooter is present, preventive insecticide application can be warranted or even required by regulation. Sites in areas known to be infested by glassy-winged sharpshooter are subject to California's Pierce's Disease Program, which requires specific management and pest inspection practices before plants can legally be moved from the nursery. Contact the local county agricultural commissioner's office to learn the current requirements of any plant quarantines that may apply to the crops being grown.

Biological Control

Leafhoppers and sharpshooters are fed upon by many parasitic wasps and predators, but these generally do not provide adequate biological control in greenhouses or nurseries. High levels of egg parasitism of glassy-winged sharpshooter are common later in the growing season due to several introduced *Cosmocomoidea* (=*Gonatocerus*) spp. wasps; these parasites' activities in landscapes and unmanaged vegetation help reduce the sharpshooter's abundance and migration into crops.

Cultural Control

Obtain insect- and pathogen-free stock from a quality supplier. Carefully inspect new plants and propagation stock for pests and dispose of or effectively treat infested plants. Promptly remove crop debris from growing areas and dispose it in covered containers. Control weeds that may be alternative hosts of both leafhoppers and plant pathogens they can vector. If such sources cannot be removed, avoid planting crops susceptible to leafhopper-vectored pathogens near these alternative hosts.

Effectively screen greenhouses and shade structures to exclude pests; use screens of sufficient surface area to provide adequate ventilation. Grow field crops in hoop houses or beneath floating row covers that are held above plant level to prevent egg laying through the mesh onto plants.

Reflective mulch. For field-grown crops, reflective mulch can greatly reduce the extent of leafhopper infestation. Apply the material in row middles at planting time or by entirely covering the soil surface and planting through holes in the mulch. Reflective mulch reduces the extent of infection from insect-vectored pathogens when crops are young and most susceptible to these pathogens. Reflective mulch can increase crop growth and cut-flower yield and reduce crops' need for irrigation by conserving soil moisture. See Reflective Mulches for more information.

Organically Acceptable Methods
Biological and cultural controls including row covers, reflective mulches, and exclusion netting are organically acceptable management methods. Certain formulations of the botanicals azadirachtin (Azatin), neem oil, and pyrethrins without piperonyl butoxide (PyGanic), certain formulations of the fermentation product spinosad (Entrust Naturalyte, Entrust SC), and certain narrow-range oils (Organic JMS Stylet-Oil) are acceptable for organic production.

Monitoring and Treatment Decisions
Leafhoppers are mostly inactive during the winter. Overwintered females begin egg laying in late winter to early spring, according to location and pest species. Begin monitoring for leafhoppers by late February and continue through September. Concentrate inspections in nursery borders where immigrating leafhoppers commonly are first observed. For nurseries where glassy-winged sharpshooter occurs or subject to California's Pierce's Disease Program (within its quarantine zones), make the first preventive insecticide application when adults are first detected, or otherwise as directed by regulations.

Place yellow sticky traps at canopy height around nursery borders and inside greenhouses near doors and vents. Deploy at least four traps per acre, or at least two per greenhouse or other structure. Check sticky cards at least once a week for adults of pest leafhoppers and sharpshooters. Apply insecticide if any adult glassy-winged sharpshooters are detected in the traps. If about five to ten leafhoppers or sharpshooters of other pest species are caught in sticky traps, an application may be warranted. For more information, see Monitoring With Sticky Traps and *Sticky Trap Monitoring of Insect Pests*.

Other monitoring methods include beat or shake sampling plant parts over an insect-collecting surface, shaking terminals into a sweep net, and visual inspection of plants and counting the pests. Beat or sweep net sampling for nymphs and adults is most effective when temperatures are cool (less than 60°F); at warmer temperatures insects tend to fly away before they can be counted. To conduct a beat or shake sample place a 2-foot square sheet of white cloth or stiff paper underneath the canopy to be sampled. Strike the canopy with a stick or shake it vigorously to dislodge insects, and count the those of concern that drop onto the sheet.

Visually inspect leaves and stems for all insect life stages and leafhopper damage symptoms. For example, glassy-winged sharpshooter egg masses can be more easily detected by examining the undersides of leaves backlight against a sunny sky. Note that leafhopper adults and nymphs tend to move to the far side of the leaf or stem, away from people or nearby motion they observe. Placing a hand close behind the stem being observed may cause the insects move to the front where they can be seen and identified.

The main considerations in deciding whether to apply insecticide are whether the site is regulated by California's Pierce's Disease Program, and if not, does the expected or potential economic damage caused by the pest equal or exceed the cost of management. For information on making application decisions, see Establishing Action Thresholds. Contact the local office of the county agricultural commissioner to learn whether your growing site is subject to California's Pierce's Disease Program or other quarantine programs, and if so follow current regulations.

Quarantine requirements. FOR SITES WHERE REGULATIONS OF THE California Pierce's Disease Program apply, the insecticides (and their mode-of-action codes) having the greatest value are neonicotinoids (4A), butenolides (4D), pyrethroids (3A), diamides (28), organophosphates (1A), and insect growth regulators (IGRs e.g., S-Kinoprene) in approximately that order.

Selected Products Registered for Greenhouse or Nursery Ornamentals

FOR SITES NOT WITHIN areas infested by glassy-winged sharpshooter and NOT subject to California Department of Food and Agriculture (CDFA) program regulations for Pierce's disease other insecticides options are available.

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A.	POTASSIUM SALTS OF FATTY ACIDS[2] (M-Pede)#	Label rates	12	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: An insecticidal soap. Must contact insect, so thorough coverage is important. Do not make more than three sequential applications. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants. Leafhopper suppression only.

B.	NARROW-RANGE OIL[2] (JMS Stylet Oil, Organic JMS Stylet Oil)#	1 oz/gal water	4	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: An oil and contact insecticide. Do not spray stressed plants. Target pest must be completely covered with spray. Do not use with sulfur products; check label for tank mix restrictions. Leafhopper suppression only.

C.	NEEM OIL[2] (Triact 70)#	1–2 gal/100 gal water	4	0

MODE-OF-ACTION GROUP NUMBER[1]: UNE
COMMENTS: A botanical oil. Do not spray stressed plants. Target pest must be completely covered with spray. Check label for plants that can be treated. May injure flowers.

D.	AZADIRACHTIN			
	(Azatin O)#	10–16 fl oz/100 gal water	4	0
	(Ornazin 3% EC)	Indoor: 10 oz/100 gal Outdoor: 10 oz/acre	12	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A botanical and insect growth regulator (IGR) for immature stages only. Must contact insect. Repeat applications as necessary. Leafhopper suppression only. Label permits low-volume application. For Ornazin do not exceed 22.5 oz/acre per application.

E.	BUPROFEZIN (Talus 70DF)	12 oz/100 gal	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 16
COMMENTS: An insect growth regulator for immature stages only. Add narrow-range oil to the mix to improve efficacy if allowed by both labels; if so do not spray stressed plants and do not use with sulfur products. A maximum of two applications per cycle.

E.	S-KINOPRENE (Enstar AQ)	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 7A
COMMENTS: An insect growth regulator for immature stages only. Apply prebloom. Also labeled for low volume use. For indoor use only

F.	PYRETHRINS/PBO[3] (Pyrethrum TR)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A/—
COMMENTS: An aerosol botanical and synthetic synergist premix.

F. PYRETHRINS
(PyGanic EC 5.0 II, PyGanic EC 1.4 II)# — Label rates — 12 — 0

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A botanical.

G. ACEPHATE
(Acephate 97UP, Orthene Turf, Tree & Ornamental WSP, 1300 Orthene TR) — Label rates — 24 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol organophosphate only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

G. CARBARYL*
(Carbaryl 4L) — 1qt/acre or 1qt/100 gal water — See label — NA

MODE-OF-ACTION GROUP NUMBER[1]: 1A
COMMENTS: A carbamate. Not for use in greenhouses. The REI is 18 days for ornamentals grown for cuttings (cut flowers or cut foliage) where production is in outdoor areas and where average annual rainfall is less than 25 inches a year.

H. BIFENTHRIN
(Talstar S Select) — 10.8–20 fl oz/acre — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

H. CYFLUTHRIN
(Decathlon 20WP) — 1.9 oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

H. FENPROPATHRIN
(Tame 2.4EC Spray) — 5.3–10.6 fl oz/100 gal water — 24 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

H. LAMBDA-CYHALOTHRIN
(Scimitar GC) — 1.5–5 fl oz/100 gal — 24 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. For greenhouse and nursery use. Do not apply more than 52.4 fl oz of concentrate/acre per year. Do not mix with EC formulations or oils.

H. PERMETHRIN
(Perm-UP 25 DF) — 6.4–12.8 fl oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, salvia. Label permits low-volume application. Do not apply more than 2 lb a.i./acre per year.

H. *TAU*-FLUVALINATE
(Mavrik Aquaflow) — 4–10 fl oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal.

I.	DINOTEFURAN (Safari 20 SG)	12–24 fl oz/100 gal water	12[4]	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid.			
I.	ACETAMIPRID (TriStar 8.5 SL)	8.5 oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid.			
I.	IMIDACLOPRID (Marathon 1% Granular)	Label rates	12[4]	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Do not apply to soils that are waterlogged or saturated. Do not apply to bedding plants intended to be used as food crops.			
J.	SPIROTETRAMAT (Kontos)	1.7–3.4 fl oz/100 gal water	24[4]	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 23 COMMENTS: An inhibitor of acetyl CoA carboxylase.			
J.	FLONICAMID (Aria)	2.1–4.3 fl. oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 29 COMMENTS: Affects mechanosensory functions. Do not make more than two consecutive applications; rotate with other modes of action.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

* Permit required from county agricultural commissioner for purchase or use.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Single doses of oils and potassium salts of fatty acids (soaps) can be used anytime as pesticide rotation without negatively impacting resistance management.

3 PBO = piperonyl butoxide.

4 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

LEAFMINERS (01/22)

Scientific Names: American serpentine leafminer: *Liriomyza trifolii*
Pea leafminer: *Liriomyza huidobrensis*
Vegetable leafminer: *Liriomyza sativae*
Phytomyza spp. and others

DESCRIPTION OF THE PESTS

Adult *Liriomyza* spp. are about 1/12 inch long and mostly black and yellow flies with clear wings. *Phytomyza* spp. adults are mostly blackish or gray on top with a white to yellowish abdomen. Females of both genera insert tiny eggs in leaves of numerous crop and weed hosts where the larvae feed within leaf tissue. Adult females also puncture leaf surfaces to feed on the oozing plant juices.

There are many types of leafmining insects in addition to *Liriomyza* and *Phytomyza* spp. flies (Agromyzidae). Leafminer pests of azalea and rhododendron include *Caloptilia azaleella*, a brown, gray, and silvery moth (Gracillariidae) with larvae up to ½ inch long. Chrysanthemum leafminers include *Chromatomyia syngenesiae*, *Liriomyza* spp., and *Phytomyza atricornis*, all agromyzid flies. Columbine leafminers include *Phytomyza* spp.; adults are commonly grayish. Manzanita and madrone are hosts to *Marmara arbutiella* (Gracillariidae), small brown and whitish moths with yellowish larvae with distinct, triangular-shaped segments. Orchids and cymbidium are attacked by larvae of a moth, *Pyroderces badia* (Cosmopterigidae). If it is uncertain what species of leafminer are the problem several can be collected, such as with an aspirator, and taken to the local office of the county department of agriculture or University of California Cooperative Extension for identification.

Larvae of *Liriomyza* and *Phytomyza* spp. are orangish or yellow and develop through three increasingly larger instars. Larvae widen and lengthen their mine as they grow up to about 1/10 inch long. *Liriomyza trifolii* mines are readily observed from the top of the leaf, while *Liriomyza huidobrensis* mines may only be apparent from the underside of the leaf. *Liriomyza huidobrensis* mines tend to follow the veins of the leaf.

At maturity, leafminer larvae commonly exit mines and pupate in growing media or topsoil. *Liriomyza* pupae are orange or yellow and those of *Phytomyza* are gray. Uncommonly pupae are observed on leaves. *Liriomyza* leafminers have multiple generations per year. For example, *Liriomyza trifolii* can complete 1 generation in about 1 month at common greenhouse temperatures, or in 14 days or 64 days at 95° and 59°F, respectively.

DAMAGE

Adults' feeding punctures in leaves turn white, resulting in numerous round pale blotches in foliage. The most obvious damage is from the larval mines that make foliage unsightly and when abundant render plants unmarketable. Although high populations of leafminers rarely if ever kill hosts, mining may slow crop growth and cause infested leaves to drop prematurely.

MANAGEMENT

Biological and cultural controls and insecticide applications are used to manage leafminers.

Biological Control

Parasitic wasps generally keep leafminer populations low in field-grown plants unless biological control is disrupted. Outbreaks of leafminers commonly occur when broad-spectrum, persistent, insecticides applied for other pests kill leafminers' natural enemies. To conserve natural enemies, control ants, reduce dustiness, and where feasible rely on cultural controls and selective and semi-selective insecticides for all pests as listed in Relative Toxicities of Pesticides Used in Floriculture and Nurseries to Natural Enemies and Honey Bees.

The *Liriomyza* larval parasites *Dacnusa sibirica* and *Diglyphus* spp. are commercially available and effective for controlling leafminers in greenhouses and shade structures that are adequately screened to contain the parasites and exclude in-migrating adult leafminers and other pests. For more information, see Biological Control, Protecting Natural Enemies and Pollinators, and Natural Enemy Releases for Biological Control of Crop Pests.

Cultural Control

Carefully inspect plants to ensure they are pest free before moving them to production areas; discard infested plants or leaves or effectively treat plants. Steam treat planting beds or otherwise pasteurize growing media to the recommended pasteurization temperature immediately after removing any infested crop

to kill any leafminer pupae in the soil before replanting beds. Steam is difficult to use in field soils but can be applied using a plowlike steam rake to raise the topsoil temperature to levels sufficient to kill most pests.

Keep growing areas and sites bordering crops free of weeds, which can host leafminers; *Liriomyza* and *Phytomyza* spp. leafminers feed on a wide variety of plant species and readily move among hosts. Promptly dispose of plant debris in covered containers. Exclude migrating adults by properly screening doors, vents, and other openings to greenhouses and screenhouses. Effective screens have an opening width of 600 microns (0.6 mm, or about 1/40 inch) or smaller and sufficient surface area to provide adequate ventilation.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. Certain formulations of the botanical azadirachtin (Azatin) and the fermentation product spinosad (Entrust Naturalyte, Entrust SC) are organically acceptable.

Monitoring and Treatment Decisions
Deploy yellow sticky traps in greenhouses to attract and capture adults. Place at least 1 trap per 10,000 sq. ft. of growing area. Monitor traps weekly; count and record the results. Change traps when they are fouled or have trapped too many insects to readily count. For side-by-side comparisons to help identify the captured insects, see *Sticky Trap Monitoring of Insect Pests*. For more information, see Monitoring with Sticky Traps and Establishing Action Thresholds.

Insecticide resistance is widespread in populations of *Liriomyza;* some products listed below may not be effective depending on the exposure history and pesticide tolerance of local leafminer populations. Rotate between effective products with a different mode of action every 1 to 2 months if ongoing applications are targeting leafminers. See Managing Pesticide Resistance for more information.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. AZADIRACHTIN
(Ornazin 3% EC) — Indoor: 10 oz/100 gal; Outdoor: 10 oz/acre — 12 — 0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A botanical and insect growth regulator (IGR). Do not exceed 22.5 oz/acre per application.

A. CYANTRANILIPROLE
(Mainspring GNL) — 2–8 fl oz/100 gal water — 4 — NA

MODE-OF-ACTION GROUP NUMBER[1]:28
COMMENTS: A ryanodine receptor modulator. Apply as a spray or drench.

B. CYROMAZINE
(Citation) — 2.66 oz/acre — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 17
COMMENTS: An insect growth regulator (IGR). Also effective against fungus gnat larvae. Labeled for low volume applications.

B. NOVALURON

	(Pedestal)	6–8 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15

C. ABAMECTIN

(Abamectin 0.15EC, Avid 0.15EC)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 6
COMMENTS: An avermectin. Add narrow-range oil to the mix to improve efficacy persistence if allowed by both labels; if so do not spray stressed plants and do not use with sulfur products. Apply as a spray. Label permits low-volume application. Do not apply through certain types of irrigation systems; consult label for restrictions.

D. SPINOSAD

(Conserve SC)	22 fl oz/100 gal water	4	NA
(Entrust)#	3.1 oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 5
COMMENTS: A microbial-derived insecticide. Adding narrow-range oil to the spray mix and using water with a pH of 6 to 8 can increase the translaminar (into leaf) movement and persistence.

E. AZADIRACHTIN

(Azatin O)#	6–16 fl oz/100 gal water	4	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A botanical and insect growth regulator (IGR). Must contact insect. Repeat applications as necessary. Label permits low-volume application.

F. ACEPHATE

(Orthene Turf, Tree & Ornamental WSP, 1300 Orthene TR)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

G. PERMETHRIN

(Perm-UP 25 DF)	6.4–12.8 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, and salvia. Label permits low-volume application. Do not apply more than 2 lb a.i./acre per year.

H. ACETAMIPRID

(TriStar 8.5 SL)	21.0–25.3 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Apply as a foliar spray. Label permits low-volume application. Do not apply through certain types of irrigation systems; consult label for restrictions.

H. DINOTEFURAN

(Safari 20G)	Label rate	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Can be applied as a drench or foliar spray.

H. IMIDACLOPRID

(Marathon 1% Granular)	Label rates	12[2]	NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Do not apply to soils that are waterlogged or saturated. Do not apply to bedding plants intended to be used as food crops.

H.	THIAMETHOXAM (Flagship 25WG)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Can be applied as a drench or foliar spray.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

LEAFROLLERS (01/22)

Scientific Names: Omnivorous leafroller: *Platynota stultana*
Fruittree leafroller: *Archips argyrospila*
Obliquebanded leafroller: *Choristoneura rosaceana*
Orange tortrix: *Argyrotaenia franciscana* (=*A. citrana*)
Light brown apple moth: *Epiphyas postvittana*
Amorbia: *Amorbia cuneana*

DESCRIPTION OF THE PESTS

Leafrollers (family Tortricidae) are named for the larval behavior of tying leaves together with silk to form a shelter in which they feed and commonly pupate. Leafrollers hatch from eggs as caterpillars, develop through several increasingly larger instars (commonly five larval stages), then become pupae from which adult moths emerge. Fruittree leafroller and omnivorous leafroller are the most common species infesting nurseries. These and other leafroller species pictured here side-by-side occur on various ornamental plants in California. When disturbed tortricid larvae commonly wriggle vigorously and drop suspended from plants on a silken thread; these larvae may climb back up the silk to again feed on the host or drift away to settle on nearby plants.

Except for fruittree leafroller, which lays eggs on bark, the adult females lay eggs on foliage overlapping in clusters that resemble fish scales. Except for those of fruittree leafroller, eggs are indistinguishable to species and may be placed on foliage of crops or alternate host weeds, such as common lambsquarters, curly dock, horseweed, little mallow, and various legumes.

Fruittree leafroller can be common in coastal areas and inland valleys. It has one generation per year; other leafrollers discussed here have several generations per year. Fruittree leafroller overwinters as eggs in flat masses on bark of scaffold limbs, trunks, and twigs, hatching in late winter through (in cooler growing areas) spring.

Larvae (caterpillars) are dark to pale green and present only during late winter through early summer. They have a black or brown head and dark prothoracic (area on top behind the head) shield. Fruittree leafroller larvae grow up to 1 inch long. The pupae are about ½ inch long and brownish to orange. They occur attached to foliage, in rolled leaves, or in litter or topsoil.

Adults (moths) appear in summer. They are about ¾ inch long and have mottled dark and light brown forewings. At rest adults appear bell shaped, a characteristic of tortricid adults.

Omnivorous leafroller is a pest mostly in inland valleys. Adults are up to ½ inch long and a mix of blackish, brown, gray, and tan. They can be active from late winter through fall. Omnivorous leafroller has four to six generations per year depending on climatic conditions.

The caterpillars grow up to ⅗ inch long and have a black or brown head and prothoracic shield. They vary in coloration, commonly brownish, cream colored, greenish, or yellowish. Mounds (tubercles) at the base of the bristles along top and sides are chalky white. The main blood vessel along the back is often visible through the cuticle as a faint dark stripe.

Obliquebanded leafroller is a pest mostly in inland valleys; it may be the most common leafroller found in the Central Valley of California where it has two to three generations per year. Adult forewing coloration varies from mostly reddish brown to a mix of blackish and orange; generally they have light and darker coloration in broad bands that alternate across the forewings.

Obliquebanded leafroller overwinters as larvae in the bud scales of twigs. They become active and begin feeding during May in warmer locations or early June in cooler areas. Larvae grow up to 1-¼ inches and are yellowish green caterpillars with brown or black heads. Larvae of obliquebanded leafroller appear about the same time in spring as those of fruittree leafroller and they resemble each other. However, the obliquebanded leafroller continues to be a problem throughout the growing season because it has multiple generations.

Orange tortrix occurs mostly in coastal areas and can be active throughout the year. It overwinters as larvae, which in winter may feed during warmer days. Adults at rest are bell shaped and vary from mostly

gray to mostly orangish. Larvae grow to about ½ inch long and vary in color from greenish to bright yellow or straw-colored or brown. The head and prothoracic shield are brown, gold, or straw-colored. A row of bristles projecting from the rear of the last abdominal segment (an anal comb) help to distinguish this species from many other caterpillar species.

Light brown apple moth is an introduced species that occurs in at least coastal areas where it feeds on various woody ornamentals. Adult coloration varies from dark to light brown or tan or a mix of these colors. Adult body length ranges from ¼ to ½ inch long.

The caterpillars are a medium to pale green and up to ¾ inch long. The head and prothoracic shield are black to brown or light green or yellowish. Consult the University of California's *Field Identification Guide for Light Brown Apple Moth in California Nurseries* (PDF) and the California Department of Food and Agriculture's *Light Brown Apple Moth Pest Profile* for more information on this species.

Amorbia, also called western avocado leafroller, occurs in coastal and inland locations. The adult forewings are mostly brown and tan with black markings. Larvae are dark green to yellowish green and up to 1 inch long. They are distinguished from other common leafrollers by the presence of short, black stripes on each side, above the head and above the first pair of legs.

DAMAGE

Leafrollers chew leaves and flower buds and web foliage together with silk. They generally are minor pests in nursery crops, but can be serious defoliating pests when broad-spectrum, persistent insecticides applied for other pests prevent their natural enemies from suppressing their populations. Most any broadleaved plant can be infested with one or more leafroller species. Hosts include ash, birch, boxelder, California buckeye, deciduous and live oaks, elm, locust, maple, poplar, rose, and willow.

MANAGEMENT

Conserve natural enemies, exclude egg-laying adult moths, and keep growing areas clean and weed free. Monitor host crops regularly and apply selective insecticides when direct control of caterpillars is warranted.

Biological Control

Conserve natural enemies, which generally keep leafroller populations low in field-grown crops when the application of persistence, broad-spectrum insecticides is avoided for all pests. Parasitic wasps and tachinid flies are especially common in leafroller larvae and pupae. *Trichogramma* spp. parasites commonly kill the eggs. Assassin bugs, green lacewing larvae, predaceous ground beetles, and certain other beetles are common predators of moth eggs and caterpillars.

To conserve natural enemies, avoid the use of carbamates, organophosphates, pyrethroids, and other persistent, broad-spectrum insecticides for all pests. Where feasible rely on products that conserve (preserve) natural enemies, especially *Bacillus thuringiensis*. See Biological Control, Protecting Natural Enemies and Pollinators, and Relative Toxicities of Pesticides Used in Floriculture and Nurseries to Natural Enemies and Honey Bees for more information.

Cultural Control

Control weeds around growing areas because each leafroller species feeds on numerous alternative hosts. Leafroller adults commonly migrate into crops from nearby unmanaged vegetation, such as during spring when winter annual weeds dry and die. Promptly remove crop debris and weeds and dispose of them in covered containers. Screen greenhouses, shade houses, and seedling flats to exclude the egg-laying adults; use a sufficient surface area of screening to provide adequate ventilation. Floating row covers exclude leafrollers during field production if the mesh is held above plants (e.g., with hoops) to prevent egg laying though the fabric onto plants. To reduce moth attraction to growing areas at night, switch from always-on night lighting to motion-activated security lights.

Organically Acceptable Methods

Biological and cultural controls are organically acceptable management methods. Entomopathogenic nematodes (e.g., *Heterorhabditis* and *Steinernema* spp.), and the microbial insecticides *Bacillus thuringiensis* ssp. *aizawai*, Bt ssp. *kurstaki*, and certain spinosad formulations (Entrust Naturalyte, Entrust SC) are acceptable for organic production.

Monitoring
Inspect host plants at least weekly for moth eggs and caterpillars and chewed, rolled, or webbed foliage. If one or a few species of leafroller have historically been problems, deploy several sticky traps baited with the pheromone of those species. Well-maintained traps alert you early to the presence of adults and help in timing insecticide application. Since there commonly is not a direct relationship between the abundance of moths in traps and the number of larvae infesting plants, base any decision to apply insecticide on the presence of caterpillars and moth eggs on crop plants or the history of leafroller problems. See Establishing Action Thresholds for more information.

Optimize control for minimum damage by treating at larval hatch or shortly after. For fruittree leafroller that overwinters as eggs on bark, flag the location of several egg masses and inspect them regularly during late winter and early spring. Apply a selective or semi-selective insecticide when emergence holes are observed in eggs and inspection of nearby plant parts reveals caterpillars are present.

Treatment Decisions
Bacillus thuringiensis (Bt) selectively controls caterpillars that eat treated foliage. Unlike some insecticides it does not disrupt biological control or induce outbreaks of other pests such as spider mites. Insect growth regulators (IGRs) and spinosad are semi-selective controls for caterpillars and certain other types of pests.

Spray foliage at high pressure to help move insecticide into rolled or webbed foliage that partly protects caterpillars. Begin application while most caterpillars are young (early instars) when coverage is best and caterpillars are least protected by webbing and rolled leaves. To improve scouts' ability to detect these pests and improve spray coverage, avoid overcrowding plants.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A.	*BACILLUS THURINGIENSIS* SSP. *KURSTAKI*[2] (Deliver)#	0.25–1.5 lb/100 gallons	4	0
	MODE-OF-ACTION GROUP NUMBER[1]: 11A COMMENTS: A microbial. Most effective against early instars.			
A.	*BACILLUS THURINGIENSIS* SSP. *AIZAWAI*#[2] (Xentari)#	Label rates	4	0
	MODE-OF-ACTION GROUP NUMBER[1]: 11A COMMENTS: A microbial. Most effective against early instars.			
B.	CHLORANTRANILIPROLE (Acelepryn)	2–16 fl oz/100 gal water	4	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 28 COMMENTS: A diamide. Do not apply more than 38 fl oz per acre per year.			
B.	NOVALURON (Pedestal)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 15 COMMENTS: An insect growth regulator (IGR). Use no more than twice per year. Do not exceed 36 oz/acre per year. Do not use on poinsettia.			

B.	TEBUFENOZIDE (Confirm 2F)	Label rates	4	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 18 COMMENTS: An insect growth regulator (IGR). Only for Christmas trees and certain food crops.			
B.	CYANTRANILIPROLE (Mainspring GNL)	2–8 fl oz/100 gal water	4	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 28 COMMENTS: A ryanodine receptor modulator. Apply as a spray or drench.			
B.	METHOXYFENOZIDE (Intrepid 2F)	4–16 fl oz/acre	4	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 18 COMMENTS: An insect growth regulator (IGR).			
C.	SPINOSAD (Conserve SC) (Entrust)#	6 fl oz/100 gal water 1 oz/100 gal water	4 4	NA NA
	MODE-OF-ACTION GROUP NUMBER[1]: 5 COMMENTS: A spinosyn.			
D.	PYRETHRINS/PBO[3] (Pyrethrum TR)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A/– COMMENTS: A botanical and synthetic synergist premix aerosol.			
E.	PYRETHRINS (PyGanic EC 5.0 II, PyGanic EC 1.4 II)#	Label rates	12	0
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A botanical.			
F.	AZADIRACHTIN (Azatin O)#	4–16 fl oz/100 gal water	4	0
	MODE-OF-ACTION GROUP NUMBER[1]: – COMMENTS: A botanical and insect growth regulator (IGR). Must contact insect. Repeat applications as necessary. Label permits low-volume application.			
G.	CARBARYL* (Carbaryl 4L)	Label rates	See label	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 1A COMMENTS: A carbamate. Not for use in greenhouses. The REI is 18 days for ornamentals grown for cuttings (cut flowers or cut foliage) where production is in outdoor areas and where average annual rainfall is less than 25 inches a year.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

* Permit required from county agricultural commissioner for purchase or use.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Bt *aizawai* and Bt *kurstaki* applied separately can be useful in rotation with other modes of action because some populations of diamondback moth exhibiting resistance to one Bt subspecies may have little or no resistance to the other Bt.

3 PBO = piperonyl butoxide

LYGUS BUGS (01/22)

Scientific Names: Western tarnished plant bug: *Lygus hesperus*
Pale legume bug: *Lygus elisus*

DESCRIPTION OF THE PESTS

Lygus spp. are plant bugs (family Miridae) that pierce and suck buds and shoot terminals with their needlelike mouthparts. *Lygus* develop through three life stages as with all true bugs (Heteroptera). After eggs hatch, nymphs develop through five increasingly larger instars before becoming adults. Adult plant bugs characteristically have a flattened upper side with a conspicuous triangular or heart-shaped area (scutellum) between the base of the wings.

At least 19 species of *Lygus* occur in California. Pale legume bug and especially western tarnished plant are common pests. Adults at rest are ⅛ to 5/16 inch long and about half as wide. Coloration varies and generally is darker for individuals overwintering as adults. Use *A Field Key to the Most Common Lygus Species Found in Agronomic Crops of the Central San Joaquin Valley of California* (PDF) to identify the crop-feeding *Lygus* to species.

Western tarnished plant bug adults are mostly yellowish to greenish brown with black and sometimes orange or red. Adults have more than two dark blotches or spots on the upper surface of the thorax immediately behind the head (pronotum).

Pale legume bug adults may or may not have two dark spots on the pronotum. Their body is mostly pale green or yellowish green with black or dark brown. At rest the adult's body can appear grayish viewed through the translucent wings.

Lygus eggs are 1/25 inch (1 mm) and oblong, slightly curved, and flattened on one end. They are laid singly in soft plant tissue of hosts that include numerous ornamentals, tree fruit and nuts, vegetable crops, and various broadleaved weeds and grasses. For example in gerbera eggs are laid below the inflorescence embedded in the involucre, the whorl (rosette) of bracts that surround the flower head. Eggs hatch about 1 week after being laid.

Nymphs resemble small, wingless adults. Wing pads (developing wings) become increasingly apparent and large in older instars. Pale legume bug nymphs are pale green to yellowish. Nymphs of western tarnished plant bug are mostly green, orangish, or yellow. First instars are especially pale-colored to whitish. Five small, black spots become increasingly apparent on the upper surface of older instars of *L. elisus*, *L. hesperus*, and certain other plant bugs.

Lygus bug nymphs may be mistaken for aphids because of their green or yellowish color and similar size and shape. However, aphids that feed openly on plants generally have two rear-pointing tubes (cornicles) on top of the abdomen and the antennae are generally held backwards over the body. Lygus bug nymphs lack cornicles, generally point their antennae forward, and move more rapidly than aphids.

Lygus bug adults and nymphs can be confused with numerous other true bugs including some beneficial types, and several bug species commonly can occur on the same plants. See Insects Confused with Lygus for side-by-side comparisons of common look-alikes, which include:

- bigeyed bugs, *Geocoris* spp. and others
- black grass bugs, *Irbisia* spp.
- buckeye bug, *Neurocolpus longirostris*
- calocoris bug, *Closterotomus* (=*Calocoris*) *norvegicus*
- false chinch bug, *Nysius raphanus*
- psallus plant bug, *Psallus vaccinicola*
- tomato bugs, *Tupiocoris* (=*Cyrtopeltis*) spp.

In greenhouses heated during winter and with supplemental lighting and suitable host plants, *Lygus* can reproduce and feed throughout the year. Outdoors during winter *Lygus* spp. occur as inactive adults under bark, in crop debris, and in natural and weedy vegetation. Adults become active in late winter or early spring when they resume feeding and other activities. Adults are most abundant May through August; populations commonly migrate into irrigated crops from drying, unmanaged vegetation. Outdoors

in California, depending upon species, host plants and location, pest *Lygus* spp. have up to seven generations per year.

DAMAGE

Low numbers of Lygus bugs can cause economic damage from feeding on shoot tips and developing buds, especially flower buds. Where Lygus bugs fed, as tissue grows flower buds and blossoms discolor, distort, become spotted, or fail to mature. Damage to the plant results from a combination of the bugs' puncture-feeding wounds and toxic saliva. Dark feces may be deposited on blossoms and leaves.

In gerbera for example, damage results in fewer flowers overall and flowers that do mature exhibit petal spotting and reduced petal size, which renders the plants unmarketable. Practices such as the application of broad-spectrum, persistent insecticides to control Lygus bugs can disrupt integrated pest management for other major pests in the crop.

Lygus feed and reproduce on more than 300 plant species. Common cultivated hosts include alfalfa, black-eyed peas, canola, celery, cotton, eggplant, gerbera, potato, strawberry, tomato, and tree fruit and nuts. Wild hosts include California burclover, California poppy, chickweed, common groundsel, curly dock, filaree, lambsquarters, little mallow (cheeseweed), lupines, pigweed, milk thistle, mullein, mustards, pineapple weed, redmaids, shepherd's purse, stinkweed, wild mustard, and wild radish.

MANAGEMENT

To successfully manage lygus bugs

- Control weeds near crops by discing or mowing, especially during winter and spring.
- Effectively exclude the pests from crops using row covers and screening.
- Keep growing areas clean and promptly remove and dispose of crop and weed residue in covered containers away from production areas.
- Monitor for the presence of Lygus bug nymphs on weed hosts and for adults migrating into crops, such as with yellow sticky traps or sweep netting around borders and visual inspection of hosts beginning late winter through at least spring. Monitor landscape plantings around growing areas which may be sources of Lygus bugs and include these plants in your management.
- Time insecticide sprays to control Lygus bugs before they cause significant damage. Various insecticides effectively kill the early instars, which might be applied to unmanaged vegetation near growing areas to control migrants. Insecticides are less effective for controlling the highly mobile *Lygus* adults, and many products that can be used adversely affect beneficial natural enemies and may induce outbreaks of spider mites.

Biological Control

Biological control of Lygus bugs generally is not sufficiently effective in crops. Tolerance for damage is very low and adults constantly migrate in during the growing season. Natural enemies of Lygus bugs can still be very important in native and unmanaged vegetation where they may substantially reduce the numbers that migrate into crops.

Anaphes iole is a parasitic wasp of *Lygus* eggs. It occurs in coastal-grown crops and surrounding natural and unmanaged vegetation. This blackish wasp is less than 1/25 inch (1 mm) long and its larval stage feeds inside and kills eggs of Lygus bugs. *Peristenus* spp. are parasites of *Lygus* nymphs. *Peristenus relictus* is a ⅛ inch long blackish to dark brown wasp that occurs in some production areas. Tachinid flies such as *Hyalomyiopsis* (=*Alophorella*) *aeneoventris* glue their eggs on or insert them into the Lygus bug's body. Eggs hatch into maggotlike larvae that feed inside and kill the bugs. Predators that feed on Lygus bugs, mostly on the nymphs, include bigeyed bugs, damsel bugs, green lacewings, minute pirate bugs, and various spiders.

Cultural Control

Control weeds near greenhouses and nurseries to help prevent spring buildup of Lygus bugs that migrate into irrigated crops. Since overwintering adult *Lygus* lay eggs in weeds that hatch about March, control weeds by March or early April before Lygus bugs become adults and able to migrate into crops when the weeds dry or are mowed. Spraying adults with insecticide or weeds with herbicide to prevent movement will be much less effective than mowing or discing under cover crops and weeds, especially legumes, before they flower and while Lygus bugs are still immatures.

Trap crops
One cultural approach is to plant early-flowering 'trap crop' hosts (such as alfalfa) bordering cultivated areas to attract migrating Lygus bug adults away from crops; the trap crop is treated periodically while Lygus bugs are in the nymphal stage and disced or mowed before *Lygus* mature into the next generation of adults. This approach requires careful monitoring and well-timed management to prevent the trap crop from becoming a reservoir of these migratory pests.

Vacuuming bugs
Some growers have used suction devices (bug vacs) to control Lygus bugs for many years. Consistent vacuuming once or twice weekly can manage low to moderate numbers of Lygus bugs in crops. Research has shown that an efficient bug-vac can reduce adult numbers by 75% and nymphs by 10% to 50%, but efficiency can vary considerably. If Lygus bug numbers are high, vacuum machines alone will not reduce damage to an acceptable level. Vacuums may increase problems with powdery mildews and gray molds by spreading their spores. If vacuuming crops where these pathogens have been a problem, coordinate with the application of effective fungicides for the pathogens. Vacuums may also remove parasites and general predators important for the control of other pests.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. Certain formulations of the botanical azadirachtin (Azatin), potassium salts of fatty acids (insecticidal soaps), the microbial insecticides *Beauveria bassiana*, and *Isaria fumosorosea* are organically acceptable.

Monitoring and Treatment Decisions
Avoid introducing Lygus bugs in stock plants. Hold incoming stock in a separate (quarantine) area for 3 to 4 weeks before moving new plants to production areas. This allows time for Lygus bug eggs to hatch and nymphs, as well as other pests, to become visible for inspection. Reject infested shipments and work with suppliers to address quality issues.

Lygus bugs can cause economic damage even from one day of feeding. Monitor frequently to detect these pests as soon as possible. For example, beginning in February inspect hosts for the first appearance of nymphs and to determine the need for management.

One strategy is to closely inspect large plots of single-variety crop plantings that in previous growing seasons have been damaged by Lygus bugs. During warm spring weather especially, regularly monitoring hosts to best time control actions for nymphs is key to avoiding economic losses. Include weeds bordering crops by regularly examining them as immature flower buds develop mid-winter through spring.

To visually inspect hosts for Lygus bug adults and nymphs
1. Tap or shake young flower buds and shoot tips over a white sheet of paper (e.g., on a clip board) to dislodge bugs from plants; they will be easily visible on the collecting (paper) surface. This is best done on cool mornings. Sweep netting can be used in some crop and non-crop areas.
2. Keep records of the number of Lygus bugs per sample on each monitoring date throughout the year.
3. Note Lygus bugs' feeding preferences to determine which cultivars are most attractive or susceptible and where to focus monitoring and control efforts.

Eggs are inconspicuous and not a useful stage for monitoring. Control decisions are also not usually based upon damage symptoms because of the delay in symptom appearance, but symptoms can be an indicator of the effectiveness of past management strategies.

Apply an effective insecticide immediately when *Lygus* nymphs are observed on crops. When adults are observed, treat within 3 days and then again 5 days later or as needed.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. *BEAUVERIA BASSIANA*

(BotaniGard ES)	0.5–2 qt/100 gal spray volume	4	0
(Mycotrol ESO)#	0.5–2 qt/100 gal spray volume	4	0

MODE-OF-ACTION GROUP NUMBER[1]: UNF

COMMENTS: An insect pathogenic fungus. Apply every 7 days if warranted. Do not tank mix with most fungicides; wait 48 hours after application to apply a fungicide.

A. *ISARIA FUMOSOROSEA*

(Ancora)#	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: An insect pathogenic fungus. Do not tank mix with most fungicides; wait 48 hours after application to apply a fungicide.

B. POTASSIUM SALTS OF FATTY ACID[2]

(M-Pede)#	Label rates	12	0

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: An insecticidal soap. Must contact insect, so thorough coverage is important. Do not make more than three sequential applications. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.

C. AZADIRACHTIN

(Azatin O)#	10–16 fl oz/100 gal water	4	0

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: A botanical and insect growth regulator (IGR). Must contact insect, targets only immature stages. Repeat applications as necessary. Label permits low-volume application.

D. NOVALURON

(Pedestal)	6–8 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15

COMMENTS: An insect growth regulator (IGR). Use no more than twice per year. Do not exceed 36 oz/acre per year. Do not use on poinsettia.

D. FLONICAMID

(Aria)	2.1–4.3 fl. oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 29

COMMENTS: Affects mechanosensory functions. Do not make more than two consecutive applications; rotate with other modes of action.

E. CARBARYL*

(Carbaryl 4L)	1qt/acre or 1qt/100 gal water	See label	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1A

COMMENTS: A carbamate. Not for greenhouse use. The REI is 18 days for ornamentals grown for cuttings (cut flowers or cut foliage) where production is in outdoor areas and where average annual rainfall is less than 25 inches a year.

E.	MALATHION (Malathion 8)	1 pt/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. Not for greenhouse use. Potentially effective only against first three instars (younger nymphs). High levels of resistance to this and other organophosphates occur in some populations of lygus bug.

E.	ACEPHATE (Acephate 97UP)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate.

F.	BIFENTHRIN (Talstar S Select)	5–10 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

F.	CYFLUTHRIN (Decathlon 20WP)	1.9 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

F.	FENPROPATHRIN (Tame 2.4EC Spray)	5.3 fl oz/100 gal water	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

G.	ACETAMIPRID (TriStar 8.5 SL)	8.5–16.5 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Apply as a foliar spray.

G.	THIAMETHOXAM (Flagship 25WG)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Can be applied as a drench or foliar spray.

G.	FLUPYRADIFURONE (Altus)	Label rates	See label	NA

MODE-OF-ACTION GROUP NUMBER[1]: 4D
COMMENTS: A butenolide. No more than one application per crop cycle.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

Acceptable for use on organically grown ornamentals.

* Permit required from county agricultural commissioner for purchase or use.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Single doses of soaps or oils can be used anytime as pesticide rotation without negatively impacting resistance management.

PSYLLIDS (01/22)

Scientific Name: Eugenia psyllid: *Trioza eugeniae*
Ficus leaf-rolling psyllid: *Trioza brevigenae*
Olive psyllid: *Euphyllura olivina*
Peppertree psyllid: *Calophya rubra*
Redgum lerp psyllid: *Glycaspis brimblecombei*

DESCRIPTION OF THE PESTS

Psyllids are leafhopper-like insects that suck phloem sap as both adults and nymphs. Adults are about 1/12 inch (2 mm) long and at rest hold their wings steeply pitched rooflike over the abdomen. Over 160 psyllid species occur in California. Note that Asian citrus psyllid (*Diaphorina citri*), the vector of the citrus-killing bacterial disease Huanglongbing (*Candidatus* Liberibacter asiaticus) is a quarantine pest requiring special management. Contact the local county agricultural commissioner for the requirements pertaining to nurseries producing citrus and related hosts of Asian citrus psyllid. See *UC IPM Pest Management Guidelines: Citrus* for an overview of Asian citrus psyllid.

Eugenia psyllid feeds only on eugenia (*Syzygium paniculatum*). Feeding by nymphs causes foliage to redden and appear blistered on the upper surface and pitted beneath. Adults are mostly dark brown with a white band around the abdomen. The tiny, golden eggs are laid primarily along the edges of young leaves. Nymphs are orangish to yellow when young and mostly dark brown when older. Psyllids are most abundant when new foliage is produced in the late winter and spring, but reproduction and all psyllid stages can occur year-round.

Ficus leaf-rolling psyllid infests *Ficus microcarpa* and was first found in California in 2016. It attacks young, newly emerging foliage, causing leaves to roll tightly inward completely or partially from one or both margins. Nymphs are 1/25 inch (1 mm) long and feed within rolled leaves. They are dark grayish-tan initially, becoming brownish to brownish green. Older instars have fringing skirts of long, white, waxy filaments. Adults are 1/20 inch long with a brownish head and brownish-green thorax. The abdomen is green on young adults and changes to brown on older adults. Adults occur mostly outside of rolled leaves and are commonly seen wagging their rear end. As nymphs feed within tightly rolled leaves, this species may be particularly difficult to control without systemic insecticides (e.g., acephate, imidacloprid). For more information see *Ficus Leaf-Rolling Psyllid Introduced in Southern California*.

Olive psyllid infests mock privet (*Phillyrea latifolia*), olive (*Olea europaea*) including fruitless cultivars, and Russian olive (*Elaeagnus angustifolia*). Adults are mostly tan with a bluish-green abdomen. Nymphs can be difficult to observe because they feed covered in fluffy, white wax they excrete. They produce abundant, white wax on leaves and twigs and cause premature leaf drop. If applying insecticide, target the first generation, typically present during March to April. Olive psyllids are more difficult to control during their second generation (May to June) and later in the season when their waxy deposits and plant damage are most apparent.

Peppertree psyllid feeds only on California pepper tree (*Schinus molle*), also called Peruvian pepper tree. Adults are pale greenish or tan. Females deposit their tiny eggs on leaf axils and growing tips throughout the year. The orangish nymphs feed on any succulent plant part, causing the plant to form a pit and deform and discolor around where each nymph feeds. One psyllid generation requires only a few weeks during warm weather. The species has multiple generations per year and all life stages can occur throughout the year in coastal areas.

Redgum lerp psyllid infests over two dozen *Eucalyptus* spp., especially river red gum (*E. camaldulensis*), flooded gum (*E. rudis*), and forest red gum (*E. tereticornis*). Nymphs are brownish, orange, or yellow and produce a roundish cover (lerp), which resembles an armored scale cover. Lerps are whitish, hemispherical caps on leaves that grow up to 1/8 inch in diameter. Nymphs feed beneath a lerp enlarge it as they grow or move and form a new covering. Adults are about ⅛ inch long, slender, and light green, with orangish and yellow blotches.

Females lay tiny, yellowish, ovoid eggs mostly on succulent leaves and shoots. Population increases follow the production of new plant growth, but all psyllid life stages can occur on both new and mature foliage. Redgum lerp psyllid has several generations each year and all stages can be present throughout the year in coastal areas. Because some nymphs form and abandon multiple lerps and the nymphs

underneath are commonly parasitized as evidenced by a small rounded hole in the lerp covering, the number of lerps on leaves does not correspond to the actual number of psyllids present. For more information see *Pest Notes: Eucalyptus Redgum Lerp*.

At least six psyllid species infest eucalyptus in California, but some psyllids strongly prefer or are only found on certain *Eucalyptus* spp. For example, lemongum psyllid (*Cryptoneossa triangula*) and spottedgum lerp psyllid (*Eucalyptolyma maideni*) are abundant only on *Eucalyptus citriodora* and *E. maculata*.

DAMAGE

Similar to aphids, psyllids suck phloem sap and excrete sticky honeydew that attracts ants and induces the growth of blackish sooty mold. High psyllid populations can slow plant growth and cause premature leaf drop. Eugenia psyllid and peppertree psyllid nymphs cause foliage to form pitlike depressions where they feed; infested leaves discolor and appear distorted. Nymphs of redgum lerp psyllid foul leaf surfaces with their caplike waxy covering. Olive psyllid covers foliage and green stems with flocculent, white wax.

MANAGEMENT

Biological and cultural controls and insecticide application can manage pest psyllids.

Biological Control

Natural enemies of psyllids include brown lacewings, green lacewings, lady beetles, and minute pirate bugs. Especially important are tiny parasitic wasps with maggotlike larvae that feed inside and mummify and kill psyllid nymphs. Natural enemies provide good biological control of eugenia psyllid and peppertree psyllid in landscape situations. The introduced *Tamarixia schina* wasp leaves a roundish emergence hole in peppertree psyllid nymphs it has killed. These emergence holes can be observed by examining the parasitized nymphs under leaves. Eugenia psyllid nymphs are commonly parasitized by the *Tamarixia dahlsteni* wasp. In coastal areas an introduced parasitic wasp, *Psyllaephagus bliteus*, substantially reduces the abundance of redgum lerp psyllid, but the parasites is less effective in interior locations that experience hot summers.

To take advantage of biological control, avoid the application of broad-spectrum, persistent insecticides for all pests in the crop. When insecticide is warranted choose the selective, semi-selective, and short persistence pesticides as identified in Relative Toxicities of Pesticides Used in Floriculture and Nurseries to Natural Enemies and Honey Bees. Control ants that harass or kill the parasites and predators of pest insects. Control dust that interferes with the ability of natural enemies to locate and kill pests. See Protecting Natural Enemies and Pollinators for more suggestions.

Cultural Control

The crop species grown determines whether psyllids can become a problem. For lists of eucalyptus species that are lightly or not at all infested by psyllids in comparison with those highly infested and damage by these pests, consult *Pest Notes: Eucalyptus Redgum Lerp Psyllid*.

Provide plants optimal cultural care to improve their tolerance of pest damage. Avoid frequent irrigation of hosts of olive psyllid to the extent compatible with desired crop growth, and provide good soil drainage.

If eugenia are regularly sheared (e.g., grown as topiary plants), well-timed pruning of new growth removes a substantial portion of the psyllid population, and in combination with parasite conservation and the application of compatible insecticides can greatly improve plant appearance. Prune terminals after maximum spring growth appears or about 3 weeks after the first peak in adult psyllid density as determined by weekly branch beating, foliage inspection, or sticky trapping. Leave eugenia clippings as mulch near the shrubs for at least 3 weeks to allow parasites within psyllid nymphs to emerge. About 1 week after shearing tips, inspect plants; if psyllids are present spray them with one of the organically acceptable insecticides or an insect growth regulator (IGR). Repeat the shear, monitor, and spray strategy through the growing season as warranted according to plant growth and psyllid abundance.

Organically Acceptable Methods

Biological and cultural controls are organically acceptable management methods. Some formulations of the botanicals azadirachtin (Azatin), neem oil, and pyrethrins without piperonyl butoxide (PyGanic), and potassium salts of fatty acids (insecticidal soap) are organically acceptable.

Monitoring and Treatment Decisions
Visually inspect hosts on a regular basis to detect psyllids and other pests. Beat or shake sample plant parts over an insect-collecting surface to detect psyllids and some of their important natural enemies. Yellow sticky cards are useful to detect psyllid presence, migration into growing areas, and whether the abundance of psyllids appears to be increasing or decreasing. See Establishing Action Thresholds, Monitoring with Sticky Traps, and *Sticky Trap Monitoring of Insect Pests* for more information.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. POTASSIUM SALTS OF FATTY ACIDS[2]

(M-Pede)#	Label rates	12	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: An insecticidal soap. Must contact insect, so thorough coverage is important. Do not make more than three sequential applications. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.

B. NARROW-RANGE OIL[2]

(JMS Stylet Oil, Organic JMS Stylet Oil)#	1 oz/gal water	4	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: An oil and contact insecticide. Do not spray stressed plants. Target pest must be completely covered with spray. Check label for plants that can be treated. Do not use with sulfur products; check label for tank mix restrictions.

C. NEEM OIL[2]

(Triact 70, Trilogy)#	1–2 gal/100 gal water	4	0

MODE-OF-ACTION GROUP NUMBER[1]: UNE
COMMENTS: A botanical oil with unknown mode of action. Do not spray stressed plants. Target pest must be completely covered with spray. Check label for plants that can be treated. May injure flowers.

D. AZADIRACHTIN

(Azatin O)#	Label rates	4	0
(Ornazin 3% EC)	Outdoor: 8 oz/acre	12	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A botanical and insect growth regulator (IGR). Must contact insect. Targets immature stages only. Repeat applications as necessary. Label permits low-volume application. Do not exceed 22.5 oz/acre per application.

E. PYRIPROXYFEN

(Distance)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 7C
COMMENTS: An insect growth regulator (IGR). Do not apply more than twice per crop or per 6 months.

F. PYRETHRINS

(PyGanic EC 5.0 II, PyGanic EC 1.4 II)#	Label rates	12	0

MODE-OF-ACTION GROUP NUMBER[1]: 3A

COMMENTS: A botanical. Must contact insect, so thorough coverage is important.

G. ACEPHATE
(Acephate 97UP, Orthene Turf, Tree & Ornamental WSP) — Label rates — 24 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

H. BIFENTHRIN
(Talstar S Select) — 10.8–20 fl oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

H. CYFLUTHRIN
(Decathlon 20WP) — 1.9 oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

H. FENPROPATHRIN
(Tame 2.4EC Spray) — Label rates — 24 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

H. LAMBDA-CYHALOTHRIN
(Scimitar GC) — Label rates — 24 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Apply at 7-day intervals if warranted. Do not apply more than 52.4 fl oz of concentrate/acre per year. Do not mix with EC formulations or oils.

H. PERMETHRIN
(Perm-UP 25 DF) — Label rates — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, and salvia. Label permits low-volume application. Do not apply more than 2 lb a.i./acre per year.

H. *TAU*-FLUVALINATE
(Mavrik Aquaflow) — 4–10 fl oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal.

I. IMIDACLOPRID
(Marathon 1% Granular) — Label rates — 12[3] — NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Do not apply to soils that are waterlogged or saturated. Do not apply to bedding plants intended to be used as food crops.

I. THIAMETHOXAM
(Flagship 25WG) — Label rates — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 4A
COMMENTS: A neonicotinoid. Apply as a foliar spray.

I.	DINOTEFURAN (Safari 20G)	Label rate	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Can be applied as a drench or foliar spray.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Single doses of oils and potassium salts of fatty acids (soaps) can be used anytime as pesticide rotation without negatively impacting resistance management.

3 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

SHORE FLY (01/22)

Scientific Name: *Scatella stagnalis*

DESCRIPTION OF THE PEST

Shore fly (family Ephydridae) is a common problem in greenhouses and nurseries where there is algae, excess irrigation, and prolonged wet surfaces. The adult is a stout, dark gray fly about 1/12 inch (2 mm) long. Adults have short antennae and short legs and at rest they hold both wings overlapping the body. Adults' overall appearance at rest resembles the common fruit fly, except the body is darker and the large eyes are blackish. Each of the translucent gray wings has three pale spots, which appear to be five, pale blotches when the wings overlap at rest. Note that fungus gnats and moth flies can also be problems in overly wet conditions. Learn how to distinguish the adults and larvae of these from shore flies.

Females lay tiny, oblong eggs in algal scum where the larvae feed. Shore fly larvae have no distinct head capsule and the body is opaque yellow to whitish. The pale-colored larvae have a forked, breathing tube with fringed tips at the tail end that is held at the water surface. The elongate pupae also have a forked breathing tube and are initially pale but become dark brown as they age.

DAMAGE

Shore flies can be especially abundant in frequently irrigated greenhouses and overly wet greenhouses. Numerous adults are a nuisance to workers and customers. Although neither adults or larvae feed on plants, the adults can be contaminated with spores of plant-pathogenic fungi and may spread these around growing areas. Dark specks of adult feces are deposited on plants, reducing aesthetic quality.

MANAGEMENT

Shore flies become abundant due to overly wet environmental conditions and certain cultural practices. Properly manage algae, irrigation, and weeds to avoid problems with shore flies. Prevent growing-area surfaces from being wet for prolonged periods. Manage irrigation and drainage systems well to prevent drips and puddles. Treat to control algae. Pesticides alone are unlikely to solve a shore fly problem.

Biological Control

Biological control of shore flies has not been investigated.

Cultural Control

Keep production areas free of algae and weeds. Especially prevent overwatering, standing water, and prolonged wet surfaces.

Organically Acceptable Methods

Cultural controls are organically acceptable management methods. Some formulations of the botanical pyrethrins without piperonyl butoxide (PyGanic) and spinosad (for adults: Naturalyte, Entrust SC) are organically acceptable.

Monitoring and Treatment Decisions

Yellow sticky cards placed in greenhouses will capture adult shore flies especially when placed horizontally, although when abundant the activity of adult shore flies is obvious. See Monitoring with Sticky Traps and *Sticky Trap Monitoring of Insect Pests* for more information.

Because shore flies do not feed on plants, insecticide application may not be warranted unless other pests are also the target. Aerosols and foggers may be better at controlling adults than sprays, but for this pest proper cultural and environmental controls are the most effective practices.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A.	SODIUM CARBONATE PEROXYHYDRATE (GreenCleanPro)	0.5–2 lb/1,000 ft sq	See label	NA

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: For application to non-porous surfaces to control algae. Keep spray away from plants.

A.	HYDROGEN PEROXIDE, PEROXYACETIC ACID various products	Label rates	0	NA

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: Application rate is for use in and around greenhouses. See label for allowed uses.

B.	CYROMAZINE (Citation)	2.66 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 17
COMMENTS: An insect growth regulator (IGR). Larval efficacy. Also controls fungus gnats.

B.	DIFLUBENZURON (Adept)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15
COMMENTS: An insect growth regulator (IGR). Larval efficacy. Also controls fungus gnats.

B.	PYRIPROXYFEN (Distance)	3–6 fl oz/100 gal water spray 2 fl oz/100 gal water drench	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 7C
COMMENTS: An insect growth regulator (IGR). Larval efficacy. Also controls fungus gnats. Do not apply more than twice per crop or per 6 months. Do not apply through any type of irrigation system.

B.	S-KINOPRENE (Enstar AQ)	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 7A
COMMENTS: An insect growth regulator (IGR). Larval efficacy. Also controls fungus gnats. Apply prebloom. Also labeled for low volume use.

C.	SPINOSAD (Conserve SC) (Entrust)#	6 fl oz/100 gal water 1 oz/100 gal water	4 4	NA NA

MODE-OF-ACTION GROUP NUMBER[1]: 5
COMMENTS: A spinosyn.

C.	AZADIRACHTIN (Azatin O)#	Label rates	4	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A botanical and insect growth regulator. Must contact insect. Also controls fungus gnats. Repeat applications as necessary. Only effective on larvae. Label permits low-volume application.

D.	PYRETHRINS/PBO[2] (Pyrethrum TR)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A/—
COMMENTS: A botanical aerosol. Also controls adult fungus gnats.

E.	ACEPHATE (1300 Orthene TR, Orthene Turf, Tree & Ornamental WSP)	Label rates	24	See label

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: Adult efficacy. Also controls fungus gnats. 1300 Orthene TR is an organophosphate aerosol for greenhouse use only. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

E.	BIFENTHRIN (Attain TR, Talstar S Select)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Adult efficacy. Also controls fungus gnats. Check label for permitted uses. Attain TR is a fogger for greenhouse use only.

E.	CYFLUTHRIN (Decathlon 20WP)	1.3 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Adult efficacy. Also controls fungus gnats. Label permits low-volume application.

E.	FENPROPATHRIN (Tame 2.4EC Spray)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Adult efficacy. Also controls fungus gnats.

E.	PERMETHRIN (Perm-UP 25 DF)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. In greenhouses labeled only for roses. Adult efficacy. Also controls fungus gnats. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, and salvia. Label permits low-volume application. Do not apply more than 2 lb a.i./acre per year.

E.	*TAU*-FLUVALINATE[6] (Mavrik Aquaflow)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Adult efficacy. Also controls fungus gnats. Label permits low-volume application.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.
\# Acceptable for use on organically grown ornamentals.
— Unknown.
NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 PBO = piperonyl butoxide.

SNAILS AND SLUGS (01/22)

Scientific Names:

Amber snail: *Novisuccinea* spp., *Succinea* spp.
Banded slug: *Lehmannia poirieri*
Brown garden snail: *Cornu aspersum =Helix aspersa =Cantareus aspersus*
Cellar glass-snail: *Oxychilus cellarius*
Garden slug: *Arion hortensis*
Gray garden slug: *Deroceras reticulatum =Agriolimax reticulatus*
Greenhouse slug: *Milax gagates*
Threebanded garden slug: *Ambigolimax valentianus =Lehmannia valentiana*
White garden snail: *Theba pisana*

DESCRIPTION OF THE PESTS

Snails and slugs are mollusks with similar anatomy and biology, except slugs lack an external shell. As they feed and move, slugs and snails secrete mucus, which dries to form a silvery to whitish trail that indicates these pests' presence. Note that fungus gnat larvae also leave silvery trails on growing media, which when abundant can resemble trails of slugs and snails.

Snails and slugs are active mostly at night and on cool, cloudy, damp, and foggy days. On sunny days, they hide from the heat and sunlight. The only daytime clues to their presence may be chewing damage to plants and silvery to whitish trails. In mild winter areas of Southern California and coastal locations, snails and slugs are active throughout the year. During cold weather, snails and slugs hibernate in the topsoil. During hot, dry periods, snails seal their shell opening with a parchment-like membrane, often attached to containers, fences, trunks, or walls.

Snails and slugs are hermaphrodites; they have both female and male reproductive parts. But generally they must mate with another mollusk of the same species in order to lay viable eggs. Brown garden snails mature in about 2 years, whereas some slugs reach reproductive maturity in about 3 to 6 months.

Brown garden snail is the most common snail pest. It has a spiraling shell up to 1-1/4 inches in diameter. The shell is patterned brown, gray, tan, and yellow in bands, flecks, and swirls. Where calcium is abundant in their food or soil, the shells will be hard. However, where calcium is low, shells may be quite fragile. Adult brown garden snails can lay about 80 eggs per month in shallow depressions in growing media and topsoil, but clutches (groups of eggs) may be smaller, often 10 to 20 eggs. The spherical to teardrop-shaped eggs are 1/8 inch in diameter and initially white, but become browner as they develop. The eggs may be mistaken for certain slow-release fertilizers.

Amber snails have an elongate shell up to 4/5 inch long that is translucent and mostly brown or yellowish-orange(amber colored). These semiaquatic snails occur mostly in the wetter portions of growing areas. Several *Novisuccinea* and *Succinea* species can be present and they are not reliably distinguishable to species. These snails generally feed on algae on the bench or pot, but will also feed on tender leaves and petals.

Cellar glass-snail has a shiny, pale brown, translucent shell up to 1/2 inch wide. The body on top is pale blue. Cellar glass-snail is an omnivore; its food includes dead and living plants, earthworms, fungi, other snails and slugs and their eggs, and sowbugs.

White garden snail has coloration and a shell shaped similar to brown garden snail, but overall it is more pale and smaller at maturity. White garden snails are about 1/2 to 3/5 inch in diameter at maturity, and rarely grow up to 1 inch. In California this introduced pest is established in San Diego County and has been found in Los Angeles and Orange counties.

Slugs of various species can be pests in greenhouses and nurseries. These include, garden slug, gray garden slug (gray field slug, or milky slug), greenhouse slug, threebanded garden slug, and tramp slug. For more information consult *California Pest Snails and Slugs*, *Slugs: A Guide to the Invasive and Native Fauna of California*, and *Terrestrial Mollusc Tool*.

DAMAGE

Snails and slugs chew and feed on algae, decaying organic matter, and various living plants. They chew irregular holes in leaves or entirely clip off succulent plant parts. They sometimes chew flowers, fruit, roots, and tender bark. They make shiny to whitish trails on plants and other surfaces where their dark to pale feces may also be found. Because they prefer humid or moist conditions and prefer to feed on succulent plant parts, they are primarily pests of herbaceous and low-growing plants and seedlings. Quarantines prohibit the sale and shipment among counties and states of plants infested with the introduced brown garden snail, white garden snail, other exotic snails or slugs, and commonly all mollusks.

MANAGEMENT

Employ a combination of methods for effective snail and slug management:

- Eliminate where feasible the places where snails and slugs can hide during the day. Boards, debris, stones, leafy branches growing close to the ground, weedy areas, and dense ground covers such as ivy are ideal sheltering spots. Reducing hiding places allows fewer snails and slugs to survive.
- Inspect regularly the remaining places where slugs and snails seek shelter. The survivors will congregate there for spot control, such as by handpicking. Brown garden snails are often found on nursery containers. Slugs may be found under containers.
- Switch from sprinkler to drip irrigation to reduce humidity and surface moisture, making the habitat less favorable for mollusks.
- Where possible, do not grow plants on wooden benches and pallets. These stay moist for a long time, tend to be good sites for growth of algae on which mollusks feed, and provide snails and slugs places to hide between the bench or pallet and containers.

Biological Control

Snails and slugs have many natural enemies, including parasitic flies in the families Sciomyzidae and Phoridae, mites, nematodes, pathogens, *Scaphinotus* spp. and other predaceous ground beetles, staphylinid beetles such as devil's coach horse (*Ocypus olens*), and small vertebrates such as birds, snakes, toads, and turtles. But natural enemies do not provide satisfactory control of mollusks in production nurseries.

The omnivorous decollate snail (*Rumina decollata*) is commercially available for biological control of pest snails in Fresno, Imperial, Kern, Los Angeles, Madera, Orange, Riverside, Santa Barbara, San Bernardino, San Diego, Ventura, and Tulare counties. Because of the potential impact of the decollate snail on certain endangered and native mollusks, it cannot be released outside of the above counties.

Decollate snail release in commercial nurseries is not recommended because all plants must be snail-free. In addition to feeding on other snails, decollate snails feed on some seedlings and succulent, small plants. Before shipping plants, any decollate and other snails must be removed.

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Cultural Control

Carefully inspect new plants and propagation stock to ensure they are pest free. Reduce hiding places that allow snails and slugs to survive and thrive. Use good sanitation and keep growing areas free of

clutter and weeds. Grow plants off the ground and on metal benches and not on anything made of wood. Switch from overhead irrigation to drip to reduce the wetness of growing areas that favors pest mollusks. Increase the frequency between irrigations to the extent compatible with good plant growth. Irrigate early in the day so surfaces are drier by evening when mollusks become active. Apply copper bands or screens on benches to inhibit the movement of snails and slugs from the ground to plants on benches.

Handpicking
Handpicking can be very effective if done thoroughly on a regular basis and in combination with reducing the places where mollusks can hide. Snails and slugs can be controlled and monitored using trap boards positioned throughout the nursery as discussed below. Crush and dispose of mollusks in covered containers away from crops. Snails and slugs may also be killed before disposal by dropping in a bucket with soapy water or diluted ammonia (5 to 10% solution). Do not apply salt to destroy snails and slugs as salt can increase soil salinity.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. Bordeaux mixture, copper sulfate, and iron phosphate are organically acceptable molluscicides.

Chemical Control
Baits are effective when used properly in combination with cultural management practices. Note that baits will kill predatory decollate snails if they are present. The active ingredient of most baits is ferric sodium EDTA, iron phosphate, or metaldehyde. Growers report that iron phosphate appears to be more effective and persistent where humidity is commonly high, plants are watered overhead, or rainfall is common. Monitor to determine where to apply the bait. In commercial nurseries to be most effective bait is scattered throughout planting beds and places where snails hide. The timing of any baiting is critical; baiting is less effective during cold, dry, and hot times of the year because snails and slugs are less active then. Because snails and slugs are more likely to travel and encounter any bait when soil is moist, apply bait after an irrigation.

Bordeaux mixture. Properly mixed copper sulfate and hydrated lime mixture (Bordeaux mixture) can be brushed or sprayed on trunks or bench legs to repel snails and slugs. One treatment should last about a year. Adding a commercial spreader-sticker may increase the persistence of Bordeaux mixture through two seasons.

Copper barriers. Slugs and snails will not cross copper unless the surface is fouled with debris or becomes heavily oxidized. Copper flashing or vertical copper screens can be erected around planting beds to prevent in-migration of mollusks. The screen should be 6 inches tall and buried several inches below the soil to prevent slugs from crawling underneath. Copper screens can be placed between the bench-support legs and the bench to prevent snails and slugs under the bench from reaching the top where the pots are located. Copper foil or screen wrapped around planting boxes and bench legs can repel snails for months or longer.

Monitoring and Treatment Decisions
Regularly inspect growing areas for slugs and snails around chewed plants on cloudy, cool, damp days or around sunrise or sunset. During the day, scout beneath dense foliage, under benches and under and on pots, in nearby weeds, under edges of nursery mats, and other protected locations that are dark, moist, and near growing media, organic litter, or the ground. Slugs commonly are found under pots and in growing media. Snails are commonly found attached to the less-exposed sides of plant containers.

Amber snails tend to remain on the surface of planting medium. Look for these on pot surfaces and where moist planting medium and dry areas (e.g., the container) meet, generally around the inner lip or head space of containers.

Snails and slugs seek cover during daylight and can be trapped under slightly raised boards positioned throughout the nursery. Traps can be made of lumber about of 12 x 15 inches or any convenient size or similar material. Raise traps off the ground with 1-inch runners to facilitate pest movement to the shaded underside. After counting and recording the number of mollusks trapped, scrape off snails and slugs daily and dispose of them by crushing or killing in soapy water or dilute ammonia solution as described above.

A method of both control and monitoring that is effective for the brown garden snail is to place an attractive bait (e.g., containing metaldehyde) in small piles strategically around the growing areas. Nearby snails will be drawn to the bait overnight and will quickly die. The next morning, the number of dead snails can be counted to help identify locations where snails are most abundant. As with the trap-board method above, repeated over time the use of bait piles allows comparisons of whether brown garden snail numbers are increasing or decreasing. If dogs wander the nursery, they may feed on and be poisoned by exposed metaldehyde bait; place the metaldehyde in a way that it is accessible to the snails but not the dogs, such as in a commercial bait trap.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. IRON PHOSPHATE

(Sluggo Slug and Snail Bait)#	24–44 lb	0	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: Can be more effective and persistent during prolonged wet conditions in comparison with metaldehyde. Reapply as bait is consumed or at least every 2 weeks while snails and slugs are active.

B. METALDEHYDE

(Durham Ornamental 3.5)	1 lb	12	NA
(Metarex 5)	8–25 lb	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: Reapply at 21 day intervals while snails and slugs are active. Broadcast per label instructions; do not apply in piles or strips unless using as a monitoring method.

C. METHIOCARB*

(Mesurol 75W)	2 lb/100 gal	24	0

MODE-OF-ACTION GROUP NUMBER[1]: Carbamate (1A)
COMMENTS: Danger signal word. Can only be applied twice in a cropping cycle. Do not apply or allow to drift to blooming crops or weeds. Should only be used as a rescue treatment.

D. SODIUM FERRIC EDTA

(Ferroxx)	5–20 lb	0	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: For terrestrial uses only. Do not allow water from treated fields that flooded to enter surface waters or drinking waters. Do not contaminate water when disposing of equipment wash water or rinse water. Spot apply near pots instead of broadcasting. May damage contacted, succulent leaves.

E. BORDEAUX MIXTURE#

0.5:0.5:100	1 lb	See label	—

MODE-OF-ACTION GROUP NUMBER[1]: Multi-site contact (M 01)
COMMENTS: Apply only as a dilute spray to plant containers and nearby surfaces. Do not mix with microbial pesticides; contact with bacterial or fungal pesticides prevents efficacy of the microbial products. Can be phytotoxic to plant tissues. For how to prepare Bordeaux mixture see Bordeaux Mixture.

F. COPPER SULFATE

(Cuproxat FL)#	1 pt/100 gal	48	—

MODE-OF-ACTION GROUP NUMBER[1]: Multi-site contact (M 01)
COMMENTS: Apply only as a dilute spray to plant containers and nearby surfaces. Do not mix with microbial pesticides; contact with bacterial or fungal pesticides prevents efficacy of the microbial products

G. COPPER OXIDE

(Nordox)	1 lb/100 gal	24	0

MODE-OF-ACTION GROUP NUMBER[1]: Multi-site contact (M 01)
COMMENTS: Apply only as a dilute spray to plant containers and nearby surfaces. Do not mix with microbial pesticides; contact with bacterial or fungal pesticides prevents efficacy of the microbial products.

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‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

Acceptable for use on organically grown ornamentals.

* Permit required from county agricultural commissioner for purcase or use

— Unknown.

SOFT SCALES (01/22)

Scientific Names: Brown soft scale: *Coccus hesperidum*
Hemispherical scale: *Saissetia coffeae*
Black scale: *Saissetia oleae*
Green shield scale: *Pulvinaria psidii*

DESCRIPTION OF THE PESTS

Soft scales (Coccidae) infest numerous species of broadleaved perennials. These phloem-sucking insects develop through three life stages: eggs, nymphs, and adults. They do not resemble most other insects. Adult females are ⅕ inch long or less and circular to oval. Adult females and settled nymphs are wingless and lack a separate head or other easily recognizable body parts. Mature females can be raised in profile, domelike or hump shaped. The surface of soft scales is part of their body, unlike the cover of armored scales that can be removed to reveal the insect beneath.

Adult males are rarely seen and apparently do not exist in certain species. They are tiny, delicate, whitish to yellow insects with one pair of wings and long antennae. The elongate, pale cases of male puparia of certain species are sometimes abundant in groups on bark. Most soft scales have one generation per year, although brown soft scale has several.

Eggs are produced beneath the body of the female. The mobile, first instars (crawlers) walk to new sites or disperse with wind, moving water, and as contaminants on propagation tools and workers. After settling to feed, soft scales remain attached, feeding at the same spot for much of their life. On deciduous hosts they move to bark to overwinter, generally during the second instar. If the quality of the host plant declines, nymphs and pre-ovipositional females may be able to walk slowly to settle and feed elsewhere.

Black scale nymphs are brown to yellowish. Adult females are 1/12 to ⅕ inch long and dark brown to blackish. During the late second instar, nymphs develop a raised ridge on top that expands to form an H-shape. Older nymphs become mottled dark and gray and develop a leathery texture. Once egg laying starts, black scale adult females become globular and hardened and the H-shape ridge on the back disappears.

Brown soft scale adult females are 1/16 to ⅕ inch long and slightly raised in profile. Adult females and nymphs vary in color from yellowish green to dark or pale brown, and can be mottled in coloration or uniformly colored.

Hemispherical scale adult females are 1/12 to ⅙ inch long and dark brown, hard, smooth, rounded domes. Nymphs are oval and a paler brown.

Green shield scale nymphs and females are light brownish to yellow-green. Mature females are about ⅙ inch long, excluding their egg mass. Each mature, female green shield scale produces an egg mass of flocculent, pale wax that becomes apparent around the margin of her body. Even after green shield scales stop feeding and have died, this pale wax may persist on plant parts.

DAMAGE

Soft scales suck and feed on phloem sap and excrete copious sticky honeydew, followed by growth of blackish sooty mold, which fouls plants. Honeydew attracts ants that protect scales from their parasites and predators, and carry scales between plants. Green shield scale ovisac wax persists a long time on plant surfaces.

MANAGEMENT

Biological and cultural controls and insecticide application can manage soft scales.

Biological Control

Most soft scale species can be well controlled by various predators and parasites. Especially important are parasitic wasps (*Aphytis*, *Coccophagus*, *Encarsia*, *Metaphycus*, and others) that feed as larvae inside scales. Parasitism is evident in scale covers from emergence holes of adult wasps. Immature parasites are sometimes visible through the surface of scales' body. Scales can be differently colored when parasitized, such as scale nymphs that normally are brown to yellowish may turn black when parasitized.

Scales are preyed upon by brown lacewings, green lacewings, predatory bugs, and various lady beetles including *Chilocorus*, *Hyperaspis*, and *Rhyzobius* spp. Lady beetles can easily be overlooked because many species are relatively small, the adults are commonly colored and shaped like scales, and the larvae often feed beneath scales. The mealybug destroyer, *Cryptolaemus montrouzieri*, is an effective predator of green shield scale because this scale produces waxy ovisacs that attract the lady beetle and induce it to lay eggs.

To take advantage of scale biological control, effectively control ants, reduce dustiness around growing areas, and avoid or minimize the application of persistent, broad-spectrum insecticides for all pests. See Relative Toxicities of Pesticides Used in Floriculture and Nurseries to Natural Enemies and Honey Bees to learn which insecticides are most compatible with biological control.

Cultural Control
Start production with pest-free stock. Rogue and dispose of plants with abundant scales to avoid the risk of spreading throughout production areas. Control weeds and promptly remove and dispose of weeds and crop residue in covered containers. Exclude windblown crawlers of scales and other pests by covering openings to the greenhouse with fine mesh screens of sufficient surface area to provide adequate ventilation. Prune out and discard heavily infested plant parts, then apply insecticide if pesticide-susceptible life stages (generally crawlers and settled nymphs) are present.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. The botanical neem oil and certain narrow-range oils (Organic JMS Stylet Oil) are organically acceptable.

Monitoring and Treatment Decisions
Visually inspect plants for scales, honeydew and sooty mold to locate infestations, which may indicate applications are needed only to spots where scales occur. Watch for ants on and around plants, which may be attracted to and tending soft scales or other phloem-sucking insects. Insecticide application generally is warranted when pesticide-susceptible scale stages are present.

Crawlers and early instars are most susceptible to insecticides. For soft scales with only one generation annually, most crawlers will emerge within a period of several weeks during spring. To monitor crawler activity to time applications use traps of double-sided sticky tape wrapped around twigs in late winter near where overwintering scales are observed. Since not all crawlers emerge at the same time, multiple applications can be warranted depending on the duration of crawler emergence and the pesticide used. See Establishing Action Thresholds and Sticky Tape Traps for more information.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A.	NARROW-RANGE OIL[2] (JMS Stylet Oil, Organic JMS Stylet Oil)#	1 oz/gal water	4	0
	MODE-OF-ACTION GROUP NUMBER[1]: — COMMENTS: An oil and contact insecticide. Do not spray stressed plants. Target pest must be completely covered with spray. Check label for plants that can be treated. Do not use with sulfur products; check label for tank mix restrictions.			
A.	NEEM OIL[2] (Triact 70, Trilogy)#	1–2 gal/100 gal water	4	0
	MODE-OF-ACTION GROUP NUMBER[1]: UNE			

COMMENTS: A botanical oil and contact insecticide. Do not spray stressed plants. Target pest must be completely covered with spray. Check label for plants that can be treated. May injure flowers.

A. POTASSIUM SALTS OF FATTY ACIDS[2]
(M-Pede)# — Label rates — 12 — 0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A soap. Must contact insects, so thorough coverage is important. Do not make more than three sequential applications. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.

B. BUPROFEZIN
(Talus 70DF) — 14 oz/acre — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 16
COMMENTS: An insect growth regulator (IGR). Add narrow-range oil to the mix to improve efficacy if allowed by both labels; if so do not spray stressed plants and do not use with sulfur products. A maximum of two applications per cycle.

B. FLONICAMID
(Aria) — 2.1–4.3 fl oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 29
COMMENTS: Affects mechanosensory functions. Do not make more than two consecutive applications; rotate with other modes of action.

B. PYRIPROXYFEN
(Distance) — 8–12 fl oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 7C
COMMENTS: An insect growth regulator (IGR). Do not apply more than twice per crop or per 6 months. Do not apply through any type of irrigation system.

B. S-KINOPRENE
(Enstar AQ) — Label rates — 4 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 7A
COMMENTS: An insect growth regulator (IGR). For use only in greenhouses, lathhouses, and shadehouses. Apply prebloom. Also labeled for low volume use.

C. ACEPHATE
(Acephate 97UP, Orthene Turf, Tree & Ornamental WSP, 1300 Orthene TR) — Label rates — 24 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

C. MALATHION
(Malathion 8) — Label rates — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. Not for greenhouse use.

C. CARBARYL*
(Carbaryl 4L) — Label rates — See label — NA

MODE-OF-ACTION GROUP NUMBER[1]: 1A
COMMENTS: A carbamate. Not for use in greenhouses. The REI is 18 days for ornamentals grown for cuttings (cut flowers or cut foliage) where production is in outdoor areas and where average annual rainfall is less than 25 inches a year.

D.	ACETAMIPRID (TriStar 8.5 SL)	8.5–16.5 oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Apply as a foliar spray. Do not apply through certain types of irrigation systems; consult label for restrictions.			
D.	FLUPYRADIFURONE (Altus)	10.5–14.0 fl oz/acre	12[3]	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4D COMMENTS: A butenolide. No more than one application per crop cycle.			
D.	IMIDACLOPRID (Marathon 1% Granular)	Label rates	12[3]	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Do not apply to soils that are waterlogged or saturated. Do not apply to bedding plants intended to be used as food crops.			
D.	DINOTEFURAN (Safari 20G)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Can be applied as a drench or foliar spray.			
D.	THIAMETHOXAM (Flagship 25WG)	Label rates	See label	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Apply as a foliar spray.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Single doses of oils and potassium salts of fatty acids (soaps) can be used anytime as pesticide rotation without negatively impacting resistance management.

3 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

THREAD-FOOTED (TARSONEMID) MITES (01/22)

Scientific Names: Cyclamen mite: *Phytonemus* (=*Steneotarsonemus*) *pallidus*
Broad mite: *Polyphagotarsonemus latus*
Bulb scale mite: *Steneotarsonemus laticeps*

DESCRIPTION OF THE PESTS

Adults of these three species of thread-footed mites (family Tarsonemidae) are 1/125 inch (0.2 mm) long or smaller; viewing them requires magnification of 20X to 40X. Their characteristic damage to crops is generally the basis for recognizing these pests are present and warrant management. The life stages of tarsonemids are egg, larva, nymph (or pseudopupa), and adult.

Eggs are oval and about 1/250 inch (0.1 mm) long. Larvae and nymphs are colorless to white and have three pairs of legs. Adult tarsonemids have four pairs of legs. They are named thread-footed mites for the long, thin appendage on the rear leg especially in males. Males use this to pick up and carry an immature female (nymph, or pseudopupa) on their back so they can mate as soon as she matures.

Cyclamen mite adults are oblong and pale yellowish brown. Adults and nymphs feed mostly enclosed in crevices of buds, tips of succulent terminals, and unfolding (immature) leaflets. Development is favored by temperatures ranging 60° to 80°F and high relative humidity (80 to 90%).

Broad mite is more stout (wider relative to its length) and smaller than cyclamen mite. Female broad mites are oblong to roundish and have a lengthwise, pale stripe along the back that is lacking in cyclamen mite. Broad mite eggs have rows of white, peglike protrusions on upper surface that are not present in the colorless cyclamen mite eggs. Broad mite can often be found on underside of old and young leaves, especially during humid conditions. Eggs generally are laid on the surface of plant parts such as in depressions. Cyclamen mite mostly feeds and oviposits within crevices or folds of plants' immature tissues. Both species can complete 1 generation in 1 to 3 weeks at typical growing-season temperatures.

Bulb scale mites closely resemble cyclamen mites; they are oval, colorless when young, and pale, translucent brown when mature. Bulb scale mites occur mostly in groups between the scales of bulbs and around the neck where the leaves and flower stems emerge from bulbs. The mites overwinter between bulb scales, then during the growing season feed on the emerging immature leaf and flower tissue. Bulb scale mites have several generations per year, completing 1 generation in about 7 weeks in the field during the growing season. Note that bulb scale mites are a different type of mite than bulb mites (*Rhizoglyphus* spp., Acaridae); bulb mites are larger species and visible to the naked eye.

DAMAGE

Broad mite and cyclamen mite cause generally similar types of damage. Affected leaves become distinctly cupped, thickened, and undersized. Leaves grow unusually close together, having shortened internodes. Portions of leaves can be brown or yellow and necrotic. The actual culprit may be distinguished by the feeding sites as described above. Examine infested tissue under magnification to confirm the species based on their distinctly different eggs and adult females.

When **cyclamen mite** feeds on vegetative (e.g., leaf) or flower buds they may be killed or new growth can be dramatically stunted and distorted. Hosts include African violet, alstroemeria, alyssum, begonia, carnation, chrysanthemum, exacum, fuchsia, gerbera, impatiens, kalanchoe, larkspur, schefflera, and others.

Broad mite damage occurs more widely on leaves and flowers. It typically causes bronzing, distortion, and stunting of leaves and stems of herbaceous plants and sometimes pale flecking on petals. Hosts of broad mite include African violet, begonia, chrysanthemum, gerbera, impatiens, and zinnia.

Bulb scale mites infest bulbs of *Amaryllis* (*Hippeastrum*) and daffodil (*Narcissus*). Their feeding causes brownish, longitudinal streaks and sometimes horizontal cracks, notched edges, or both in leaves. Leaves and flowers become severely distorted and die prematurely. Cutting infested bulbs in cross-section reveals patches of brown, necrotic tissue from mite feeding. Basal and bulb rots (e.g., caused by *Fusarium oxysporum*) and bulb and stem nematodes (*Ditylenchus* spp.) also cause brownish discoloration in bulbs, but commonly in ring patterns following the circumference of bulb scales; browning from bulb mites is more blotchy and scattered.

MANAGEMENT

Releasing predaceous mites, cultural practices especially heat treatment, excellent sanitation, and applying certain acaricides (miticides) can control these pests.

Biological Control

Neoseiulus spp. and other predaceous mites commonly prey on tarsonemid mites. These commercially available predators have been effectively released to greatly reduce damage by broad mite and cyclamen mite. For more information, see Biological Control and Natural Enemy Releases for Biological Control of Crop Pests.

Cultural Control

Carefully inspect new plants and stock to ensure that they are free of infestation. Quarantine new plants in a separate growing area until tissue has grown for several weeks and any pests present or their damage become more apparent. Disinfest plants if they may be infested. Immersing stock in 110.3°F water for 30 minutes or holding plants at 100% relative humidity and 110.3°F for 1 hour can entirely eliminate thread-footed mites. For more information, see Pests Controlled by Heat Treatment of Plants in Nurseries.

Use excellent sanitation in growing areas. Consider roguing (discarding) infested older plants and those nearby. Disinfest or steam clean benches and containers (if heat tolerant), then treat (e.g., with heat) other plants in that production area that may also have become colonized by these mites. Thread-footed mites readily walk between plants and growing-area surfaces and can spread on moving air, on whiteflies (broad mite), and on contaminated propagation tools, water, and workers. Since broad mite and cyclamen mite also feed on a large variety of weed species, keep production areas free of weeds that can serve as mite hosts. Promptly remove and dispose of crop residue and weeds in covered containers.

Organically Acceptable Methods

Biological and cultural controls are organically acceptable management methods. The botanical neem oil, certain narrow-range oils (Organic JMS Stylet Oil), and sulfur dust or spray are organically acceptable.

Monitoring and Treatment Decisions

Visually inspect hosts for damage symptoms characteristic of thread-footed mites as part of a weekly scouting program. On known hosts damage symptoms are generally the basis for taking control actions as the mites are microscopic and difficult to observe. Submit samples for diagnosis if the cause of damage is uncertain. For example with African violet damage from foliar nematodes and boron deficiency can resemble injury from thread-footed mites.

Rely primarily on cultural controls (e.g., excellent sanitation) and heat treatment. Predaceous mites can be released after treating infested plants with heat. Thread-footed mites are difficult to control with contact miticides in part because of the difficulty in getting good coverage on the underside of foliage and in protected plant parts where the mites feed.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Most of these products are not for bulb scale mite.

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A.	WETTABLE SULFUR (Microthiol)#	Label rates	See label	See label

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A mineral. May be phytotoxic, especially at higher temperatures. Do not use with oils.

A.	SULFUR DUST (Dusting sulfur)#	Label rates	See label	See label

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A mineral. May be phytotoxic, especially at higher temperatures. Do not use with oils.

B.	POTASSIUM SALTS OF FATTY ACIDS[2] (M-Pede)#	Label rates	12	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A pesticidal soap. Must contact mites, so thorough coverage is important. Do not make more than three sequential applications. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.

C.	NARROW-RANGE OIL[2] (JMS Stylet Oil, Organic JMS Stylet Oil)#	1 oz/gal water	4	0

MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: An oil and contact miticide. Do not spray stressed plants. Target pest must be completely covered with spray. Check label for plants that can be treated. Do not use with sulfur products; check label for tank mix restrictions.

D.	NEEM OIL[2] (Triact 70, Trilogy)#	1–2 gal/100 gal water	4	0

MODE-OF-ACTION GROUP NUMBER[1]: UNE
COMMENTS: A botanical oil and contact insecticide. Do not spray stressed plants. Target pest must be completely covered with spray. Check label for plants that can be treated. May injure flowers.

E.	ABAMECTIN (Abamectin 0.15EC, Avid 0.15EC)	4 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 6
COMMENTS: An avermectin. Add narrow-range oil per label to the mix to improve efficacy persistence if allowed by both labels; if so do not spray stressed plants and do not use with sulfur products. Apply as a spray. Label permits low-volume application. Do not apply through certain types of irrigation systems; consult label for restrictions.

F.	CHLORFENAPYR (Pylon)	2.6–5.2 fl oz/100 gal water	12	0

MODE-OF-ACTION GROUP NUMBER[1]: 13
COMMENTS: An inhibitor of arthropod energy metabolism. Greenhouse use only. Do not exceed three applications per crop cycle.

F.	PYRIDABEN (Sanmite SC Miticide)	6.4–9.6 oz/acre	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 21A
COMMENTS: An inhibitor of arthropod energy metabolism. Rotate to at least two different modes of action between applications of pyridaben. Do not use fertilizers containing boron or apply through any type of irrigation system. Do not exceed 10.6 oz/acre per application.

F.	FENAZAQUIN (Magus)	12–24 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 21A

COMMENTS: An inhibitor of arthropod energy metabolism. Do not make more than one application per crop.

F.	SPIROTETRAMAT (Kontos)	1.7–3.4 fl oz/100 gal water	24[3]	NA

MODE-OF-ACTION GROUP NUMBER[1]: 23
COMMENTS: An inhibitor of acetyl CoA carboxylase.

F.	SPIROMESIFEN (Savate)	1–4 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 23
COMMENTS: An inhibitor of acetyl CoA carboxylase. Apply as a spray. Do not apply through any kind of irrigation system.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Single doses of oils and potassium salts of fatty acids (soaps) can be used anytime as pesticide rotation without negatively impacting resistance management.

3 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

THRIPS (01/22)

Scientific Names: Western flower thrips**:** *Frankliniella occidentalis*
Greenhouse thrips: *Heliothrips haemorrhoidalis*
Cuban laurel thrips: *Gynaikothrips ficorum*
Myoporum thrips: *Klambothrips myopori*
Weeping fig thrips: *Gynaikothrips uzeli*

DESCRIPTION OF THE PESTS

Thrips are tiny, slender insects about 1/50 to 1/16 inch (0.5 to 1.5 mm) long. Adults have four wings that at rest are folded over the abdomen. The wings appear featherlike in flight. They have numerous, microscopic hairs along the front and rear margins that allow thrips to be carried easily on air currents. If it is uncertain whether the thrips found are a species that can damage crops several can be collected, such as with an aspirator, and taken to the local office of the county department of agriculture or University of California Cooperative Extension for identification, which requires expert preparation and examination of microscopic characters as illustrated here for flower thrips versus onion thrips.

Thrips have six life stages: egg, first instar and second instar (called nymphs or larvae), third instar (prepupa, or propupa), fourth instar (pupa), and adult. They have multiple generations per year. Adult females either insert eggs into plant tissue (western flower thrips), lay eggs openly on foliage (greenhouse thrips), or oviposit on tissue within folds distorted by their feeding (Cuban laurel thrips, myoporum thrips). Only adults and the first two instars feed.

Western flower thrips is the most economically important pest thrips and the most common of the *Frankliniella* spp., all of which are commonly called flower thrips. Western flower thrips feeds on numerous hosts, causing direct feeding damage. It also transmits a complex of tospoviruses including *Impatiens Necrotic Spot Virus* and *Tomato Spotted Wilt Virus*, which can severely damage or kill numerous herbaceous plant species. Adults have pale wings and body coloration that varies greatly from entirely black, orange, yellow, or whitish to a mix of pale-colored head and thorax with a dark abdomen. First instars are white. Older instars commonly are orange to yellow. During the prepupal and pupal stages eye spots and wing pads become apparent.

During winter and spring dark forms predominate outdoors; paler forms predominate during summer and fall or throughout the year in heated greenhouses with supplemental light. The presence of dark forms in greenhouses indicates thrips are probably migrating into growing areas.

Western flower thrips adults and nymphs are fast-moving and commonly feed in crevices of tissues such as in buds, flowers, and growing tips, but may also feed on the surface of leaves of some hosts. Damage may appear as pale scarring or stunting. Buds feed upon before they open develop into distorted and necrotic tissue as they grow. Western flower thrips also feeds on pollen and spider mites. The prepupa and pupa occur in growing media or soil beneath infested plants. Females lay male eggs if unmated and female eggs after mating. Development from egg to adult ranges from about 11 days at 77° to 87°F to 44 days at 50° to 60°F**.**

Greenhouse thrips are slow-moving insects that feed openly in groups on foliage, commonly on the underside. Adult greenhouse thrips are black with translucent to whitish wings. Legs of adults and nymphs are yellow to whitish. Nymphs are yellow or whitish overall, but blackish gut contents commonly are visible through the body surface. Adults and feeding-stage nymphs commonly hold a droplet of dark feces at the tip of their abdomen.

Cuban laurel thrips infests *Ficus* spp., especially Indian laurel fig. Its presence is easy to recognize from the tightly rolled and podlike terminals enclosing the thrips. Note that ficus leaf-rolling psyllid causes similar damage. Cuban laurel thrips are most abundant outdoors from about October through December. Feeding over the winter results in newly galled foliage apparent by midsummer.

Cuban laurel thrips adults are black and nymphs are yellow, closely resembling weeping fig thrips. Eggs are oval, beige to whitish, and laid on the leaf surface commonly within galled tissue.

Myoporum thrips adults are black with whitish wings and nymphs are orangish. Feeding causes myoporum terminals to become galled i.e., tightly bunched, and twisted. All life stages can be found within the galled terminal growth where the thrips reproduce and feed. Terminal distortion can occur year-round, but new growth in the spring is especially susceptible.

Weeping fig thrips adults are black and nymphs are translucent to pale tan or yellow. This thrips and its damage closely resemble those of Cuban laurel thrips. Note that ficus leaf-rolling psyllid causes similar damage. Eggs of weeping fig thrips are oval, whitish, and laid on the leaf surface within galled tissue. It infests *Ficus benjamina*, but not *Ficus microcarpa*.

DAMAGE

Thrips pierce plant cells and suck out the contents. Cuban laurel thrips, myoporum thrips, and weeping fig thrips also discolor and distort (gall) foliage. These thrips do not kill hosts, but their aesthetic damage can make plants unmarketable.

Greenhouse thrips feeding leaves patches of brownish, yellow, or whitish leaf tissue. Their black specks of feces foul leaf surfaces. Stippling on foliage of numerous field and greenhouse crops from greenhouse thrips can be confused with damage from spider mites. However, unlike with mites, greenhouse thrips feeding and sometimes that of western flower thrips and other thrips species is accompanied by black, varnishlike specks of excrement on foliage. Spider mite damage is often accompanied by silken webbing and cast skins. In both cases the culprits are often found on close examination.

Western flower thrips on many hosts primarily feeds on pollen and can be found in the flowers of virtually any species of dicot. On other plants it may feed on immature flower petals and leaves, causing damage that becomes apparent as tissue grows. Crops susceptible to tospoviruses vectored by *Frankliniella* spp. and infected when young can die prematurely or fail to develop to a marketable growth stage.

Western flower thrips direct-feeding damage includes blossom streaking or color break, discolored patches of foliage, leaf spotting, and tissue distortion. Feeding damage may cause premature senescence of flowers, such as African violets where blossoms may be prematurely pollinated. On orchids, western flower thrips feeding and egg laying will leave translucent, pimplelike spots on leaves and petals and buds may fail to open and may drop prematurely (e.g., on *Phalaenopsis*). Tospovirus infections can result in a wide variety of symptoms (and occasionally be asymptomatic) including brown and yellow necrotic leaves, distorted leaves, ring spots on foliage, gray or whitish lesions, and various others.

MANAGEMENT

Exclusion and sanitation are key strategies for preventing thrips damage. Releasing commercially available natural enemies may be effective if done early and combined with other compatible practices. Insecticide resistance is a major problem with western flower thrips, so rotate applications among modes of action of known effective insecticides and do not rely on insecticides alone. Rogue and dispose of galled plants and those otherwise with obvious thrips damage, then treat all the nearby plants with an effective insecticide. For plant-galling species (Cuban laurel thrips, myoporum thrips, weeping fig thrips), a preventive application of insecticide that kills on contact or through ingestion can be warranted while highly susceptible succulent terminals are present. Consider growing cultivars resistant to thrips; for example, *Ficus microcarpa* 'Green Gem' is less extensively damaged by Cuban laurel thrips than other *F. microcarpa* cultivars.

Biological Control

In coastal locations a high proportion of greenhouse thrips nymphs can be parasitized by a tiny wasp, *Thripobius semiluteus*. Resident populations of parasitic wasps and predaceous minute pirate bugs, mites, and thrips prey on plant-feeding thrips, but naturally occurring parasites and predators cannot provide satisfactory pest control in greenhouses and nurseries.

Certain predators are commercially available for thrips control; combine their use with compatible cultural controls and selective pesticides. For biological control to be effective, avoid application of broad-spectrum, persistent insecticides and miticides for all pests in the crop and consider whether environmental conditions are favorable for the natural enemies. Several species of minute pirate bugs (e.g., *Orius* spp.) and predatory mites (*Neoseiulus* spp., *Stratiolaelaps scimitus* =*Hypoaspis miles*) can be purchased and released. Minute pirate bugs also feed on aphids, small caterpillars, mites, and various other pests. General recommendations are to release *Orius* at a rate of 2,000 to 4,000 per acre several times during early crop growth when hosts are most susceptible to thrips damage. *Neoseiulus cucumeris* are released weekly at a rate of 10 to 50 mites per plant. *Neoseiulus* also feed on spider mite eggs and pollen. See Protecting Natural Enemies and Pollinators for information on how to improve biological control.

Stratiolaelaps scimitus is a soil-dwelling predator that feeds on thrips prepupae and pupae, larvae and pupae of fungus gnats, and certain other small arthropods. *Stratiolaelaps* are generally released on soil soon after planting and are most effective when there is plant-to-plant contact that facilitates movement of the predators. For more information, see Biological Control, Natural Enemy Releases for Biological Control of Crop Pests, and Relative Toxicities of Pesticides Used in Floriculture and Nurseries to Natural Enemies and Honey Bees and Miticides.

Cultural Control
Carefully inspect new plants and propagation stock to ensure they are pest free. Greenhouse thrips and western flower thrips have numerous hosts including some weeds, so keep production areas free of weeds that may serve as reservoirs. Screens covering greenhouse vents and other openings can exclude thrips, but the material must be of sufficiently small pore size (145 microns, 0.145 mm, about 1/200 inch). Some larger fine-mesh screens can exclude most thrips. When retrofitting fine-mesh screens be sure to provide sufficient surface area for adequate air movement to ensure the ventilation system can accommodate the reduced flow caused by fine screening; or modify the system as needed. Install double doors with positive ventilation (air constantly flowing outwards) to reduce pest movement into growing enclosures.

Reflective mulch
For field-grown crops, applying reflective mulch in row middles or entirely covering the soil surface and planting through holes in the mulch can greatly reduce the extent of thrips infestation of young plants. Reflective mulch also reduces the infection from insect-vectored viruses when crops are young and most susceptible to these plant pathogens. Reflective mulch can increase crop growth and cut-flower yield while reducing need for irrigation by conserving soil moisture. See Reflective Mulches for more information.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. Certain formulations of the botanicals azadirachtin (Azatin), neem oil, and pyrethrins without piperonyl butoxide (PyGanic), the microbial *Beauveria bassiana* and spinosad (Entrust Naturalyte, Entrust SC), certain narrow-range oils (Organic JMS Stylet-Oil), and potassium salts of fatty acids (insecticidal soap) are acceptable for organic production.

Monitoring and Treatment Decisions
Blue sticky cards are most attractive to western flower thrips. But yellow cards are generally recommended because they attract and capture greenhouse thrips, western flower thrips, and the adults of various other pest species, and insects are easier to identify and count on the yellow surface. Place yellow sticky cards vertically in the crop canopy with the lower one-third of the trap below the top level of leaves and the upper two-thirds above the top of the leaf canopy. Raise traps as the crop grows to maintain them at the proper height, which is optimal for capturing thrips. For more information, see Monitoring with Sticky Traps and *Sticky Trap Monitoring of Insect Pests*.

Research in California greenhouse roses suggests that three yellow sticky traps per cultivar is adequate. In greenhouses with many different cultivars, place traps among the most susceptible varieties. In large greenhouses of the same or similar cultivars, deploy at least 8 traps per 100,000 sq. ft. In other crops, place at least one card per 10,000 sq. ft.

Consider applying an effective insecticide if an average of 5 to 10 greenhouse thrips plus western flower thrips per card per week are trapped. Most effective insecticides must be applied at least two times about 5 to 7 days apart to control western flower thrips. Note there may be several species of thrips present on a sticky card, but these suggested thresholds apply only to western flower thrips and greenhouse thrips counted together. There are no research-based thresholds for Cuban laurel thrips, myoporum thrips, or weeping fig thrips in nurseries. If these species are trapped in growing areas containing their hosts, a preventive insecticide application may be warranted. A general application strategy is to apply foliar insecticides that kill thrips early in the cropping cycle, before crop damage is observed. When crop damage is observed, cull affected plants and apply a systemic insecticide (e.g., acephate or a neonicotinoid) to the remaining crop. See Establishing Action Thresholds for more information.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.			
A. CINNAMALDEHYDE			
(Cinnacure A3005)	Label rates	4	0
MODE-OF-ACTION GROUP NUMBER[1]: —			
COMMENTS: A botanical-based synthetic. Use product within 10 days of breaking seal. Do not apply to stressed plants or new transplants until roots are well established.			
A. NARROW-RANGE OIL[2]			
(JMS Stylet Oil, Organic JMS Stylet Oil)#	1 oz/gal water	4	0
MODE-OF-ACTION GROUP NUMBER[1]: —			
COMMENTS: An oil and contact insecticide. Do not spray stressed plants. Target pest must be completely covered with spray. Check label for plants that can be treated. Do not use with sulfur products; check label for tank mix restrictions.			
A. NEEM OIL[2]			
(Triact 70, Trilogy)#	1–2 gal/100 gal water	4	0
MODE-OF-ACTION GROUP NUMBER[1]: UNE			
COMMENTS: A botanical with unknown mode of action. Do not spray stressed plants. Check label for list of plants that can be treated. May injure flowers. Target pest must be completely covered with spray. Best for thrips on foliage.			
A. POTASSIUM SALTS OF FATTY ACIDS[2]			
(M-Pede)#	Label rates	12	0
MODE-OF-ACTION GROUP NUMBER[1]: —			
COMMENTS: An insecticidal soap. Must contact insect, so thorough coverage is important. Do not make more than three sequential applications. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.			
B. *BEAUVERIA BASSIANA*			
(BotaniGard 22WP)	1–2 lb/100 gal spray volume	4	0
(BotaniGard ES)	1–2 qt/100 gal spray volume	4	0
(Mycotrol ESO)#	1–2 qt/100 gal spray volume	4	0
MODE-OF-ACTION GROUP NUMBER[1]: UNF			
COMMENTS: An insect pathogenic fungus. Apply every 7 days if warranted. Do not tank mix with most fungicides and wait 48 hours after application to apply a fungicide.			
C. AZADIRACHTIN			
(Azatin O)#	12–16 fl oz/100 gal water	4	0
(Ornazin 3% EC)	Indoor: 8 oz/100 gal water Outdoor: 10 oz/acre	12	0
MODE-OF-ACTION GROUP NUMBER[1]: —			
COMMENTS: A botanical and insect growth regulator (IGR). Must contact insect. Repeated applications as necessary. Label permits low-volume application. Do not exceed 22.5 oz/acre per application.			

D.	NOVALURON (Pedestal)	6–8 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15
COMMENTS: Use no more than twice per year. Do not exceed 36 oz/acre per year. Do not use on poinsettia.

D.	FLONICAMID (Aria)	2.1–2.9 fl. oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 29
COMMENTS: Affects mechanosensory functions. Do not make more than two consecutive applications; rotate with other modes of action.

D.	CYANTRANILIPROLE (Mainspring GNL)	2–8 fl oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: 28
COMMENTS: A diamide. For use only in greenhouses. Do not apply more than 32 fl oz per acre per crop.

D.	PYRIDALYL (Overture 35 WP)	8 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15
COMMENTS: A pyridalyl of unknown mode of action. Only for use in greenhouses.

D.	CHLORFENAPYR (Pylon)	5.2–10 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 13
COMMENTS: A pyrrole. For use only in greenhouses.

D.	TOLFENPYRAD (Hachi-Hachi SC)	14–32 fl oz/100 gal water	12	0

MODE-OF-ACTION GROUP NUMBER[1]: 21A
COMMENTS: An inhibitor of arthropod energy metabolism. Do not make more than two applications per crop.

E.	SPINOSAD (Conserve SC) (Entrust)#	11 fl oz/100 gal water 1.7 oz/100 gal water	4 4	NA NA

MODE-OF-ACTION GROUP NUMBER[1]: 5
COMMENTS: A microbial by product. Add narrow-range oil to the mix and use water with a pH of 6 to 8 to increase the translaminar (into leaf) movement and efficacy persistence; if so do not spray stressed plants and do not use with sulfur products.

F.	ABAMECTIN (Abamectin 0.15EC, Avid 0.15EC)	8 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 6
COMMENTS: An avermectin. Add narrow-range oil to the mix to improve efficacy persistence if allowed by both labels. Do not spray stressed plants and do not use with sulfur products. Apply as a spray. Label permits low-volume application. Do not use through any type of irrigation system.

G.	ACEPHATE (Acephate 97UP, Orthene Turf, Tree & Ornamental WSP, 1300 Orthene TR)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

G.	METHIOCARB* (Mesurol 75W)	0.5–1 lb/100 gal water	24	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 1A COMMENTS: A carbamate. Do not make more than two applications per crop.			
H.	PYRETHRINS/PBO[3] (Pyrethrum TR)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A/— COMMENTS: A botanical and synthetic synergist premix aerosol. Induces thrips to move; if applied in coordination with other pesticides, can increase thrips exposure to insecticide and efficacy of control.			
I.	ACETAMIPRID (TriStar 8.5 SL)	12.5–25.3 oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Apply as a foliar spray. Do not apply through certain types of irrigation systems; consult label for restrictions.			
I.	IMIDACLOPRID (Marathon 1% Granular)	Label rates	12[4]	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Do not apply to soils that are waterlogged or saturated. Do not apply to bedding plants intended to be used as food crops.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Single doses of oils and potassium salts of fatty acids (soaps) can be used anytime as pesticide rotation without negatively impacting resistance management.

3 PBO = piperonyl butoxide.

4 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

TWOSPOTTED SPIDER MITE (01/22)

Scientific Name: *Tetranychus urticae*

DESCRIPTION OF THE PEST

Twospotted spider mites suck the contents of plant cells, causing bleached, stippled, or otherwise discolored foliage. They also make silken strands on plant parts, especially when populations are high. The mites have globular bodies that are 1/50 inch (0.5 mm) or less in diameter. Adults have two dark blotches on the body and overall coloration that varies from gray to green or yellowish. Overwintering females may turn pink to orange during fall to early spring.

Spider mites develop through five life stages. Females lay round eggs that hatch into six-legged larvae. Larvae develop into eight-legged protonymphs, then deutonymphs, then adults. Spider mites have many generations per year and their abundance can increase rapidly when temperatures are warm. Egg to adult development requires about 28 or 8 days when temperatures average 60° and 82°F, respectively.

DAMAGE

Twospotted mite feeding initially causes tiny, pale specks (stippling) on leaves. As feeding continues foliage can become pale green, yellowish, or whitish in large patches. Leaves may eventually turn brownish in large patches or overall and drop prematurely. On the underside of leaves where mites generally feed their pale cast skins and webbing may be visible, which also reduce crop aesthetic quality. Plants may grow slowly or remain undersized if heavily infested. Plants severely infested when young may die.

MANAGEMENT

Biological and cultural controls and certain miticides (acaricides) are used to control spider mites.

Biological Control

Mite predators include bigeyed bugs, brown lacewings, green lacewings, larvae of predaceous midges, rove beetle adults and larvae, spider mite destroyer lady beetle, minute pirate bugs, and sixspotted thrips. Predatory mites are the most important biological control agents, commonly keeping spider mite populations low in outdoor crops. To conserve natural enemies, avoid the application of broad-spectrum, persistent insecticides and miticides and control ants and dust. See Relative Toxicities of Pesticides Used in Floriculture and Nurseries to Natural Enemies and Honey Bees to learn which pesticides are compatible with biological control.

Several species of predatory mites are commercially available for release. *Phytoseiulus persimilis* may be the most commonly used in greenhouses and nurseries. The best results have been obtained with periodic releases beginning early in the crop cycle when spider mite populations are low. Consider whether environmental conditions are favorable for the predators to be effective. For more information, see Biological Control and Releasing Natural Enemies for Biological Control of Agricultural Pests.

Cultural Control

Carefully inspect new plants and propagation stock to ensure they are pest free. Rogue or effectively treat infested crop plants. Since spider mites feed on many different plants, keep production areas clean and free of weeds that can harbor infestations. Dispose of crop debris and weeds in covered containers .

Organically Acceptable Methods

Biological and cultural controls are organically acceptable management methods. The botanical neem oil, certain narrow-range oils (Organic JMS Stylet-Oil), and potassium salts of fatty acids (insecticidal soap) are acceptable for organic production.

Monitoring and Treatment Decisions

Monitor crop plants regularly for mites and their feeding damage. Look for cast skins, foliage bleaching, silken fibers, and other changes in foliage appearance that are characteristic of mite feeding. At least weekly inspect the undersides of (especially lower) leaves with a 10X hand lens to detect mite presence. Sticky cards traps are not effective for monitoring these wingless pests.

Most miticides must be applied more than once to provide effective control. Follow label directions regarding reapplication times. And for guidelines on when to treat see Establishing Action Thresholds.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A. CINNAMALDEHYDE
(Cinnacure A3005) — Label rates — 4 — 0
MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A botanical-based synthetic. Use product within 10 days of breaking seal. May be phytotoxic to tender new plant growth. Do not apply to stressed plants or new transplants until roots are well established.

A. NARROW-RANGE OIL[2]
(JMS Stylet Oil, Organic JMS Stylet Oil)# — 1 oz/gal water — 4 — 0
MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: An oil and contact miticide. Do not spray stressed plants. Target pest must be completely covered with spray. Check label for plants that can be treated. Do not use with sulfur products; check label for tank mix restrictions.

A. NEEM OIL[2]
(Triact 70, Trilogy)# — 1–2 gal/100 gal water — 4 — NA
MODE-OF-ACTION GROUP NUMBER[1]: UNE
COMMENTS: A botanical oil and contact insecticide. Do not spray stressed plants. Target pest must be completely covered with spray. Check label for plants that can be treated. May injure flowers.

A. POTASSIUM SALTS OF FATTY ACIDS[2]
(M-Pede)# — Label rates — 12 — 0
MODE-OF-ACTION GROUP NUMBER[1]: —
COMMENTS: A soap. Must contact mites, so thorough coverage is important. Do not make more than three sequential applications. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.

B. BIFENAZATE
(Floramite) — 4–8 fl oz/100 gal water — 12 — NA
MODE-OF-ACTION GROUP NUMBER[1]: 20D
COMMENTS: An inhibitor of energy metabolism. Do not make sequential applications; rotate to at least two different modes of action between applications of bifenazate. Controls mite adults and nymphs; has some ovicidal activity.

C. HEXYTHIAZOX
(Hexygon IQ) — 4–8 oz/100 gal water — 12 — NA
MODE-OF-ACTION GROUP NUMBER[1]: 10A
COMMENTS: A mite growth inhibitor. Effective for mite eggs and immatures. Use only once per crop or once per year.

D. FENPYROXIMATE
(Akari 5SC) — 16–32 fl oz/100 gal water — 12 — NA
MODE-OF-ACTION GROUP NUMBER[1]: 21A
COMMENTS: An inhibitor of arthropod energy metabolism. Do not apply more than 10 gal spray/1000 sq ft per application. Do not exceed 48 oz/crop or growing season..

D. CYFLUMETOFEN
(Sultan) 13.7 fl oz/100 gal water 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 25
COMMENTS: An inhibitor of arthropod energy metabolism.

D. FENAZAQUIN
(Magus) 12–24 oz/100 gal water 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 21A
COMMENTS: An inhibitor of arthropod energy metabolism. Do not make more than one application per crop.

D. ETOXAZOLE
(Eschaton 5 WDG) Label rates See label NA

MODE-OF-ACTION GROUP NUMBER[1]: 10B
COMMENTS: A mite growth inhibitor. Do not apply more than two times per crop or within a six month period. Check label for allowed uses.

D. CLOFENTEZINE
(Notavo) Label rates 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 10A
COMMENTS: A mite growth inhibitor. Do not apply through any type of irrigation system.

D. ACEQUINOCYL
(Shuttle O) 6.4–12.8 fl oz/acre 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 20B
COMMENTS.: An inhibitor of mite energy metabolism. Do not apply more than 25.6 fl oz per acre per year.

E. PYRIDABEN
(Sanmite SC) 6.4–9.6 oz per acre 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 21A
COMMENTS: An inhibitor of arthropod energy metabolism. Rotate to at least two different modes of action between applications of pyridaben. Do not use fertilizers containing boron or apply through any type of irrigation system.

F. CHLORFENAPYR
(Pylon) 2.6–5.2 fl oz/100 gal water 12 0

MODE-OF-ACTION GROUP NUMBER[1]: 13
COMMENTS: An inhibitor of arthropod energy metabolism. Greenhouse use only. Do not exceed two applications per crop.

G. ABAMECTIN
(Abamectin 0.15EC, Avid 0.15EC) 8 fl oz/100 gal water 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 6
COMMENTS: An avermectin. Add narrow-range oil to the mix to improve efficacy persistence if allowed by both labels; if so, do not spray stressed plants and do not use with sulfur products. Apply as a spray. Label permits low-volume application. Do not apply through certain types of irrigation systems; consult label for restrictions.

H. BIFENTHRIN

(Attain TR, Talstar S Select) Label rates 12 NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
A pyrethroid. Check label for permitted uses. Attain TR is a fogger for greenhouse use only.

H. FENPROPATHRIN

	(Tame 2.4EC Spray) MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid.	8–16 fl oz/100 gal water	24	NA
H.	*TAU*-FLUVALINATE (Mavrik Aquaflow) MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal.	4–10 fl oz/100 gal water	12	NA

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Single doses of oils and potassium salts of fatty acids (soaps) can be used anytime as pesticide rotation without negatively impacting resistance management.

WEEVILS (01/22)

Scientific Names: Black vine weevil: *Otiorhynchus sulcatus*
Fuller rose beetle: *Naupactus* (=*Asynonychus*) *godmani* (syn. *Naupactus cervinus, Pantomorus cervinus*)

DESCRIPTION OF THE PESTS

Weevils, or snout beetles (family Curculioninae), as adults have an elongated head, elbowed antennae, and hard-surfaced body. At least 600 weevil species occur in California. They commonly are flightless, nocturnal, and mostly dark colored, black, brown, or grayish. The grublike larvae and pupae are pale yellow to whitish.

Black vine weevil adults and mature larvae are ½ inch long. Adults are blackish with pale flecks (scales) on the forewings. Adult females lay eggs in or on soil. Larvae and pupae occur in soil; larval feeding on roots causes the primary, economic damage.

Fuller rose beetle adults are brown to grayish weevils about ⅜ inch long. Fuller rose beetle's oblong, yellowish eggs are laid in groups above ground in protected plant parts or in or on soil. Larvae chew on roots but do not seriously damage most hosts. Adult chewing and feeding on above-ground parts is the primary damage from Fuller rose beetle.

DAMAGE

Adult weevils feed on foliage and flowers at night. The edges of blossoms and leaves appear notched or ragged or plant parts may be clipped off. Unless adult populations are high, this damage does not usually threaten the health of established plants, but can make nursery crops unmarketable. Black vine weevil larvae chewing roots and the root crown of container plants and field-grown trees and shrubs can cause serious damage, sometimes girdling plants around the soil line or severely wounding crowns of herbaceous perennials and killing the host.

MANAGEMENT

Periodic monitoring of host plants, growing weevil-resistant plant species and varieties, and applying entomopathogenic nematodes and insecticides are the main methods for managing weevils.

Where plants are well established and relatively large and can tolerate some foliar damage, pesticide application can be delayed until about 3 weeks after first detecting adult weevils or damage, typically during late winter through spring. Weevils need to feed for about this period before they are able to lay eggs. Weevils are susceptible to most broad-spectrum, persistent insecticides (e.g., carbamates, organophosphates, pyrethroids) labeled for control of foliage-chewing insects.

To target larvae, beginning about 6 weeks after adult weevils or their chewing damage are first observed that growing season, soil can be drenched with nematodes or systemic insecticide. Drenching with nematodes can be repeated as long as soil or growing medium is well drained (e.g., high in organic matter, sandy), moist, and warm.

Biological Control

Weevils are susceptible to several insect pathogens, parasites, and predators. For example, Fuller rose beetle eggs are commonly parasitized by a tiny blackish wasp, *Fidiobia citri.* However, resident natural enemies are usually insufficient to satisfactorily control weevils in nursery crops.

Cultural Control

Consider growing plant varieties that are more resistant to weevil damage. See table Hybrid Rhododendrons Resistant To Feeding Injury By Adult Root Weevils for suggestions. Where soil has been infested with weevil larvae and pupae, steam treat planting beds or otherwise pasteurize growing media immediately after removing any infested crop to kill any weevils in the soil before replanting beds. Steam heat is difficult to use in field soils but can be applied using a plowlike steam rake to raise the topsoil temperature to levels sufficient to kill most pests.

Hybrid Rhododendrons Resistant to Feeding Injury by Adult Root Weevils.

Rhododendron hybrid	Rating	Rhododendron hybrid	Rating
P. J. Mezzitt	100	Rainbow	76
Jock	92	Point Defiance	76
Sapphire	90	Naomi	76
Rose Elf	89	Pilgrim	76
Cilpimense	88	Letty Edwards	76
Lucky Strike	83	Odee Wright	76
Exbury Naomi	81	Moonstone	73
Virginia Richards	81	Lady Clementine Mitford	72
Cowslip	80	Candi	72
Luscombei	80	Graf Zeppelin	71
Vanessa	80	Snow Lady	71
Oceanlake	80	Loderi Pink Diamond	71
Dora Amateis	79	Faggetter's Favourite	70
Crest	79		

Ranked from highly resistant (100 rating) to moderately resistant (70) to the weevils *Dyslobus* spp., *Nemocestes incomptus*, *Otiorhynchus singularis*, *O. sulcatus*, and *Sciopithes obscures*.
From Antonelli AL, Campbell RL. 1984. *Root Weevil Control on Rhododendrons* (PDF). Wash. State Univ. Exten. Bull. 0970.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. Botanical pyrethrins without piperonyl butoxide (PyGanic) and entomopathogenic nematodes are organically acceptable.

Monitoring and Treatment Decisions
Regularly inspect the buds, flowers, and foliage of hosts for feeding damage and pests. Adults can be monitored 1 to 2 hours after dark by sweeping foliage with a net or by beat or shake sampling of branches onto a light-colored sheet or tray. Adults can be monitored using pitfall traps or trap boards on the soil or by burlap bands or corrugated cardboard wrapped around trunks; inspect these for adults that sought shelter during the day. Sift through loose soil at the base of plants where the adults hide during the day. Temporarily remove plants from their containers to inspect the root ball and crown, which may reveal the presence of larvae and their chewing damage.

Target adult weevils when applying insecticide. Persistent, broad-spectrum insecticides that kill on contact or through ingestion will control the night-feeding adults if thoroughly sprayed on foliage. If some chewing damage to aboveground parts can be tolerated, delay application until 3 weeks after adults or their damage are first observed. Egg laying lasts about 6 to 8 weeks, so repeated application can be warranted depending on the insecticide applied and if adults are still present.

Application of a systemic insecticide to control root feeding larvae is of uncertain effectiveness. Drenching containers and around the base of small trees and shrubs in the field with entomopathogenic nematodes (*Heterorhabditis* and *Steinernema* spp.) when larvae or pupae are present can be done in well-drained soils and growing media that is warm and kept moist but not soggy.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.

A.	*HETERORHABDITIS* AND *STEINERNEMA* SPP. ENTOMOPATHOGENIC NEMATODES (NemaSeek, NemAttack)#	Label rates	NA	NA

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: Entomopathogenic (insect-killing), tiny roundworms to control soil-dwelling larvae and pupae. Commercially available for chemigation, drench, or spraying of planting media. Require high humidity or moist conditions and the absence of exposure to bright or direct light to be effective.

A.	*METARHIZIUM ANISOPLIAE*			
	(Met 52 Granular Bioinsecticide)	1.5–3 lb/cubic yard of growing media	0	NA

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: An insect pathogenic fungus. Incorporate the product into growing media before planting.

A.	*ISARIA FUMOSOROSEA* APOPKA STRAIN 97			
	(Ancora)	14–28 oz/100 gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: An insect pathogenic fungus. Apply as a soil drench.

A.	*BEAUVERIA BASSIANA*			
	(BotaniGard ES)	8 fl oz/1,000 ft sq of growing media	4	0
	(Mycotrol ESO)#	Label rates	4	0

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: An insect pathogenic fungus. Apply as a soil drench. Irrigate after making an application.

B.	ACEPHATE			
	(Acephate 97 WDG, Orthene Turf, Tree & Ornamental WSP)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B

COMMENTS: An organophosphate. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

B.	CARBARYL*			
	(Carbaryl 4L)	Label rates	See label	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1A

COMMENTS: A carbamate. Not for use in greenhouses. The REI is 18 days for ornamentals grown for cuttings (cut flowers or cut foliage) where production is in outdoor areas and where average annual rainfall is less than 25 inches a year.

. . . PLUS . . .

	NARROW-RANGE OIL			
	(JMS Stylet Oil)#	1 oz/gal water	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: An oil and contact insecticide. Do not spray stressed plants..

B	MALATHION			
	(Malathion 8)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B

COMMENTS: An organophosphate. Not for greenhouse use.

C.	PYRETHRINS/PBO[2]			
	(Pyrethrum TR)	Label rates	See label	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A

COMMENTS: A botanical and synthetic synergist premix. Label permits low-volume application.

C. PYRETHRINS

	(PyGanic EC 5.0 II, PyGanic EC 1.4 II)#	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A botanical.			
D.	BIFENTHRIN (Talstar S Select)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid. Label permits low-volume application.			
D.	CYFLUTHRIN (Decathlon 20 WP)	1.9 oz/100 gal water	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid. Label permits low-volume application.			
D.	FENPROPATHRIN (Tame 2.4 EC Spray)	10.67 fl oz/100 gal water	24	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid.			
D.	PERMETHRIN (Perm-UP 25 DF)	Label rates	12	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 3A COMMENTS: A pyrethroid.			
E.	IMIDACLOPRID (Marathon 1% Granular)	Label rates	12[3]	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Do not apply to soils that are waterlogged or saturated. Do not apply to bedding plants intended to be used as food crops.			
E.	FLUPYRADIFURONE (Altus)	2.8–3.7 oz/100 gal	12[3]	NA
	MODE-OF-ACTION GROUP NUMBER[1]: 4D COMMENTS: A butenolide. For larvae only. No more than 28 fl oz per acre per year.			

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

* Permit required from county agricultural commissioner for purchase or use.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 PBO = piperonyl butoxide.

3 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

WHITEFLIES (01/22)

Scientific Names: Greenhouse whitefly: *Trialeurodes vaporariorum*
Silverleaf whitefly**:** *Bemisia argentifolii*
Giant Whitefly: *Aleurodicus dugesii*
Ficus whitefly: *Singhiella simplex*

DESCRIPTION OF THE PESTS

Whiteflies (family Aleyrodidae) suck phloem sap and feed in groups on succulent shoots and the underside of leaves. Whiteflies develop through three life stages. Eggs hatch into mobile first instar (crawlers). After first instars (nymphs) settle to feed, whiteflies become immobile. Nymphs develop through four, increasingly larger instars. After maturing to the fourth instar (also called a pupa) a winged adult emerges.

Adult whiteflies have an orangish to yellow body and translucent wings that are thinly covered with powdery, white wax. At rest the adult resembles a tiny, whitish housefly or moth. Adults of many species at rest are about 1/16 inch long from head to wing tips, but giant whitefly adults are about 3/16 inch long.

Numerous whitefly species can infest ornamental crops in California. Whiteflies are identified to species by the appearance of older nymphs and especially fourth instars (pupae), including body coloration, spiracles (breathing tubes), and waxy projections. The adults of some species have dark wing markings that can also help determine the species. For side-by-side illustrations discriminating the adults and pupae of eight whitefly species that can infest flower and nursery crops see here. For a photo collage of whitefly adults and pupae and lists of their common ornamental host plants in California see *Pest Notes: Whiteflies*.

Bemisia spp. and greenhouse whitefly are the most common pest species. Greenhouse whitefly holds its wings relative flat (parallel to leaf surfaces). *Bemisia* adults generally hold wings more steeply pitched, rooflike over the body. This generally results in relatively more of the yellowish body of *Bemisia* being visible through a gap between wings unlike adult greenhouse whiteflies when viewed from above. Their distinctly different pupae best help to differentiate these species.

Whitefly eggs are oval, 1/100 inch (0.2 mm) long, and laid openly on plants. Eggs may occur singly on plant tissue or grouped in circles or crescents. When first laid eggs are pale green, yellowish, or white. Eggs darken to grayish before hatching. Whiteflies have multiple generations per year.

Greenhouse whitefly pupae are oval, pale whitish, and elevated in profile with edges perpendicular to the plant surface. The lower perimeter has a fringe of short filaments and the upper surface has relatively long, projecting filaments. Development from egg to adult takes about 21 to 26 days at 81°F.

Silverleaf and sweetpotato whiteflies is a group (complex) of species that cannot be separated by appearance, but they may differ in important ways. Sweetpotato whitely (*Bemisia tabaci* Q biotype) is highly resistant to numerous insecticides. Silverleaf whitefly (*Bemisia tabaci* B biotype, or *Bemisia argentifolii*) generally is less resistant to insecticides.

Bemisia pupae are oval, yellowish, slightly tapered at the rear end, and have few to no obvious marginal filaments. Tiny filaments may project from the top surface of nymphs, especially on hairy leaves; but these filaments are not obvious to the naked eye, especially in comparison with the long filaments of greenhouse whitefly. Development from egg to adult takes about 16 and 31 days when temperatures average 86° and 68°F, respectively.

Giant whitefly is larger than most whiteflies. Adults can be up to 3/16 inch long and have multiple grayish blotches on their whitish wings. Nymphs produce pendulous, long, hairlike filaments of wax up to 2 inches long that give infested foliage a bearded appearance and may be mistaken for a leaf fungus. The pupae are oval and raised in profile with sides perpendicular to the leaf surface. Adults and immatures can feed on over 60 plant species. Hosts most commonly infested include aralia, begonia, hibiscus, giant bird of paradise, mulberry, orchid tree, and xylosma. Introduced parasites have greatly reduced its abundance.

Ficus whitefly especially infests *Ficus microcarpa*, but also occurs on other fig species. Adults are about 1/16 inch long with grayish brown markings on whitish wings. The pale brown to yellow eggs occur

mostly along the main vein on the underside of leaves. Nymphs resemble a scale insect. They are pale green to tan, flat, oval, and semi-transparent, blending with the color of the surrounding leaf surface.

DAMAGE

Similar to aphids and psyllids, whitefly adults and nymphs suck phloem sap and excrete sticky honeydew. Honeydew attracts ants and supports the growth of blackish sooty mold (fungi). High populations of adults can annoy workers and customers. Whitefly feeding can stunt (slow) plant growth and cause heavily infested leaves to die and drop prematurely. Salivary secretions of *Bemisia* spp. and certain other whiteflies can cause physiological abnormalities in plants, such as white stem malady on poinsettia caused by *Bemisia* feeding.

MANAGEMENT

Manage whiteflies with biological and cultural controls and the application of effective insecticides. Pesticide resistance is especially a problem with *Bemisia tabaci* Q biotype; certain scientific laboratories can perform genetic tests to identify which biotype(s) of *Bemisia tabaci* are present to help in selecting controls. When employing insecticides, rotate to a different mode of action every 21 days or sooner. Include insecticides such as insecticidal soap, horticultural oil, and microbials to minimize selection for pesticide resistance. For a detailed discussion of effective insecticide use, see *Chemical Class Rotations for Control of Bemisia tabaci (Hemiptera: Aleyrodidae) on Poinsettia and Their Effect on Cryptic Species Population Composition* (PDF).

Biological Control

Numerous species of parasitic wasps (e.g., *Encarsia* and *Eretmocerus* spp.) feed on whiteflies and generally cause the populations of most whitely species to remain low in the field. Predators of whiteflies include adults and larvae of small lady beetles, bigeyed bugs, brown lacewings, dustywings, green lacewings, minute pirate bugs, and larvae of syrphid flies. Former pests now controlled by introduced natural enemies include ash whitefly (*Siphoninus phillyreae*) and bayberry whitefly (*Parabemisia myricae*). In many situations giant whitefly and woolly whitefly (*Aleurothrixus floccosus*) are also satisfactorily controlled by parasitic wasps.

Where broad-spectrum, residual (persistent) insecticides are avoided for all pests, resident natural enemies will be more effective. Certain natural enemies can be purchased and released to control particular whiteflies. *Encarsia formosa*, a black and yellowish parasitic wasp about 1/16 inch (1.5 mm) long, is highly effective for controlling greenhouse whitefly. Begin any releases when greenhouse whiteflies are first observed or even before and in any case before populations are high. When greenhouse whiteflies are first observed and early during the crop production cycle, a general recommendation is to release 2 to 5 adult parasites per plant per week for 8 to 10 weeks. Greenhouse whitefly pupae normally are pale yellowish to white, but turn black when parasitized by *Encarsia formosa*. Unlike the irregular slit left when an adult whitefly emergences, emerging parasitic wasps leave a circular exit hole in whitefly pupae they have killed.

Adults and larvae of the *Delphastus pusillus* lady beetle and certain other natural enemies may also be available for release to help control particular whiteflies. Consult *The Biology and Management of the Silverleaf Whitefly, Bemisia argentifolii Bellows and Perring (Homoptera: Aleyrodidae) on Greenhouse Grown Ornamentals* from UC Riverside for details on using natural enemies to manage *Bemisia*. For more information, see Biological Control, and Releasing Natural Enemies for Biological Control of Agricultural Pests.

Cultural Control

Carefully inspect new plants and propagation stock to ensure they are pest free. Rogue or effectively treat infested plants. Practice excellent sanitation. Keep production areas free of weeds, which can serve as hosts for whitefly populations. Promptly remove and dispose of crop debris and weeds in covered containers.

Exclude adult whiteflies by growing field crops beneath floating row covers or exclusion netting held above the plant canopy or in screened hoop houses. Cover greenhouse vents and other openings with screens with a pore width of 405 microns (0.405 mm, about 4/250 inch) or smaller. Install double doors with positive-pressure ventilation (air constantly flowing outwards) to reduce pest movement into growing enclosures.

Reflective mulch

For field-grown crops, applying reflective mulch in row middles or entirely covering the soil surface and planting through holes in the mulch can greatly reduce the extent of whitefly infestation while plants are small. Reflective mulch also reduces the extent of infection from insect-vectored viruses when crops are young and most susceptible to these plant pathogens. Reflective mulch can increase crop growth and cut-flower yield and reduce need for irrigation by conserving soil moisture. See REFLECTIVE MULCHES for more information.

Organically Acceptable Methods
Biological and cultural controls are organically acceptable management methods. Certain formulations of the botanically derived azadirachtin (Azatin), neem oil, and pyrethrins without piperonyl butoxide (Py-Ganic), the microbials *Beauveria bassiana* and *Isaria fumosorosea*, certain narrow-range oils (Organic JMS Stylet-Oil), and potassium salts of fatty acids (insecticidal soap) are acceptable for organic production.

Monitoring and Treatment Decisions
Place yellow sticky traps throughout growing areas to capture and monitor the relative abundance of adult whiteflies. In crops most susceptible to whiteflies, deploy 1 trap per 1,000 sq. ft. of growing area. In crops less susceptible, 1 trap per 10,000 sq. ft. of growing area can be sufficient. Also visually inspect crop foliage at least weekly for whitefly adults, eggs, nymphs, and pupae. Using a 10X hand lens can increase the chance of seeing the early instars most susceptible to insecticides. Examine both the underside of leaves and the tips of green shoots for whiteflies. For more information, see Monitoring with Sticky Traps and *Sticky Trap Monitoring of Insect Pests*.

Action thresholds vary with the crop. For example, cut flowers such as gerbera can tolerate more whiteflies than poinsettias since only the gerbera flowers are harvested and marketed. For more information, see Establishing Action Thresholds.

Selected Products Registered for Greenhouse or Nursery Ornamentals

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)
Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest integrated pest management (IPM) value listed first—the most effective and least harmful to natural enemies, honey bees, and the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the product label. Before using a pesticide for the first time or on a new crop or cultivar, treat a few plants and check for phytotoxicity periodically before deciding whether to apply that product more extensively.			
A. NARROW-RANGE OIL[2] (JMS Stylet Oil, Organic JMS Stylet Oil)#	1 oz/gal water	4	0
MODE-OF-ACTION GROUP NUMBER[1]: — COMMENTS: An oil and contact insecticide. Do not spray stressed plants. Target pest must be completely covered with spray. Do not use with sulfur products; check label for tank mix restrictions.			
A. NEEM OIL[2] (Triact 70, Trilogy)#	1–2 gal/100 gal water	4	0
MODE-OF-ACTION GROUP NUMBER[1]: UNE COMMENTS: A botanical with unknown mode of action. Do not spray stressed plants. Target pest must be completely covered with spray. Repeat application as necessary. Check label for plants that can be treated. May injure flowers.			
A. POTASSIUM SALTS OF FATTY ACIDS[2] (M-Pede)#	Label rates	12	0

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: A soap. Must contact insect, so thorough coverage is important. Do not make more than three sequential applications. Test for phytotoxicity. Do not spray new transplants or newly rooted cuttings. Do not add adjuvants.

B. *BEAUVERIA BASSIANA*

(BotaniGard ES	0.5–1.0 qt/100 gal spray volume	4	0
(BotaniGard 22WP)	0.5–1.0 lb/100 gal spray volume	4	0
(Mycotrol ESO)#	0.5–1.0 lb/100 gal spray volume	4	0

MODE-OF-ACTION GROUP NUMBER[1]: UNF

COMMENTS: An insect pathogenic fungus. Apply every 7 days if warranted. Do not tank mix with most fungicides; wait 48 hours after application to apply a fungicide.

B. *ISARIA FUMOSOROSEA*

(Ancora)#	Label rates	4	NA

MODE-OF-ACTION GROUP NUMBER[1]: UNF

COMMENTS: An insect pathogenic fungus.

C. AZADIRACHTIN

(Azatin O)#	6–16 fl. oz/100 gal water	4	0
(Ornazin 3% EC)	Indoor: 10 oz/100 gal water Outdoor: 8 oz/acre	12	0

MODE-OF-ACTION GROUP NUMBER[1]: —

COMMENTS: A botanical and insect growth regulator (IGR). Must contact insect. Repeat applications as necessary. Label permits low-volume application.

D. BUPROFEZIN

(Talus 70DF)	6 oz/acre	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 16

COMMENTS: An insect growth regulator. Add narrow-range oil to the mix to improve efficacy if allowed by both labels; if so do not spray stressed plants and do not use with sulfur products. A maximum of two applications per cycle.

D. DIFLUBENZURON

(Adept)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15

COMMENTS: An insect growth regulator (IGR). Reduces whitefly abundance. May damage poinsettias if used over labeled rate. Also effective on fungus gnat larvae and Lepidoptera larvae (caterpillars).

D. NOVALURON

(Pedestal)	6–8 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 15

COMMENTS: An insect growth regulator (IGR). Use no more than twice per year. Do not exceed 52 oz/acre per year. Do not use on poinsettia.

D. PYRIPROXYFEN

(Distance)	6–8 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 7C

COMMENTS: An insect growth regulator (IGR). Do not apply more than twice per crop or per 6 months.

D. S-KINOPRENE
(Enstar AQ) — Label rates — 4 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 7A
COMMENTS: An insect growth regulator. Apply prebloom. Also labeled for low volume use.

E. PYMETROZINE
(Endeavor) — 2.5–5.0 oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 9B
COMMENTS: Affects mechanosensory functions. Apply as foliar spray at 7 to 14 day intervals if warranted. For outdoor use, do not apply more than 48 oz/acre per year; for indoor use, do not use more than 100 oz/acre per year.

E. PYRIFLUQUINAZON
(Rycar) — 3.2 fl oz/100 gal water — 12 — See label

MODE-OF-ACTION GROUP NUMBER[1]: 9B
COMMENTS: Affects mechanosensory functions. Only for greenhouse use. Do not apply more than 12.8 fl oz per crop cycle. Do not harvest cut flowers for 48 hours after spraying.

F. SPIROTETRAMAT
(Kontos) — Label rates — See label — NA

MODE-OF-ACTION GROUP NUMBER[1]: 23
COMMENTS: An inhibitor of lipid biosynthesis. Apply as a drench.

G. ABAMECTIN
(Abamectin 0.15EC, Avid 0.15EC) — 8 fl oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 6
COMMENTS: An avermectin. Add narrow-range oil to the mix to improve efficacy persistence if allowed by both labels; if so do not spray stressed plants and do not use with sulfur products. Apply as a spray. Label permits low-volume application. Do not apply through certain types of irrigation systems; consult label for restrictions.

G. CYANTRANILIPROLE
(Mainspring GNL) — 2–8 fl oz/100 gal water — See label — NA

MODE-OF-ACTION GROUP NUMBER[1]: 28
COMMENTS: A ryanodine receptor modulator. Apply as a spray or drench.

H. PYRIDABEN
(Sanmite SC) — 6.4–9.6 oz/acre — See label — NA

MODE-OF-ACTION GROUP NUMBER[1]: 21A
COMMENTS: An inhibitor of arthropod energy metabolism. Rotate to at least two different modes of action between applications of pyridaben. Do not use fertilizers containing boron or apply through any type of irrigation system. Do not exceed 10.6 oz/acre per application.

H. TOLFENPYRAD
(Hachi-Hachi SC) — Label rates — 12 — 0

MODE-OF-ACTION GROUP NUMBER[1]: 21A
COMMENTS: An inhibitor of arthropod energy metabolism. For early instars. Do not make more than two applications per crop.

H. FENAZAQUIN
(Magus) — 18–24 oz/100 gal water — 12 — NA

MODE-OF-ACTION GROUP NUMBER[1]: 21A
COMMENTS: An inhibitor of arthropod energy metabolism. Do not make more than one application per crop.

H. SPIROMESIFEN

	(Savate)	2–4 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 23
COMMENTS: An inhibitor of arthropod energy metabolism. Apply as a spray. Do not apply through any kind of irrigation system.

I.	ACEPHATE (Acephate 97UP, Orthene Turf, Tree & Ornamental WSP, 1300 Orthene TR)	Label rates	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. 1300 Orthene TR is an aerosol only for greenhouse use. Orthene Turf, Tree & Ornamental WSP is labeled only for a limited number of nursery crops; consult label for permitted uses. Phytotoxic to some chrysanthemum varieties. Can stunt new growth in roses. Do not use through any type of irrigation system.

I.	MALATHION (Malathion 8)	1 pt/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 1B
COMMENTS: An organophosphate. Not for greenhouse use.

J.	BIFENTHRIN (Attain TR, Talstar S Select)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Check Attain label for permitted uses. Attain TR is a fogger for greenhouse use only.

J.	CYFLUTHRIN (Decathlon 20WP)	1.9 oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application.

J.	FENPROPATHRIN (Tame 2.4EC)	10.6–16 fl oz/100 gal water	24	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid.

J.	PERMETHRIN (Perm-UP 25 DF)	6.4–12.8 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Direct application to blooms may cause browning of petals. Marginal leaf burn may occur on dieffenbachia, pteris fern, and salvia. Label permits low-volume application. Do not apply more than 2 lb a.i./acre per year.

J.	*TAU*-FLUVALINATE (Mavrik Aquaflow)	4–10 fl oz/100 gal water	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A pyrethroid. Label permits low-volume application. Also labeled as a cutting dip at 5 fl oz/100 gal.

K.	PYRETHRINS/PBO[3] (Pyrethrum TR)	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A/—
COMMENTS: A botanical and synthetic synergist premix aerosol.

K.	PYRETHRINS (PyGanic EC 5.0 II, PyGanic EC 1.4 II)#	Label rates	12	NA

MODE-OF-ACTION GROUP NUMBER[1]: 3A
COMMENTS: A botanical.

L.	ACETAMIPRID (TriStar 8.5 SL)	8.5–16.5 oz/100 gal water	12	NA	
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Apply as a foliar spray. Do not apply through certain types of irrigation systems; consult label for restrictions.				
L.	DINOTEFURAN (Safari 20G)	Label rates	12	NA	
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Apply as a foliar spray.				
L.	IMIDACLOPRID (Marathon 1% Granular)	Label rates	12[4]	NA	
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Do not apply to soils that are waterlogged or saturated. Do not apply to bedding plants intended to be used as food crops.				
L.	THIAMETHOXAM (Flagship 25WG)	Label rates	See label	NA	
	MODE-OF-ACTION GROUP NUMBER[1]: 4A COMMENTS: A neonicotinoid. Apply as a foliar spray.				
L.	FLUPYRADIFURONE (Altus)	Label rates	12[2]	NA	
	MODE-OF-ACTION GROUP NUMBER[1]: 4D COMMENTS: A butenolide. No more than one application per crop cycle.				

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest.

\# Acceptable for use on organically grown ornamentals.

— Unknown.

NA Not applicable.

1 Rotate pesticides with a different mode-of-action group number, and do not use products with the same mode of action more than twice per season to help prevent the development of resistance. For example, organophosphates have a group number of 1B; pesticides with a 1B group number should be alternated with pesticides that have a group number other than 1B. Mode-of-action group numbers for acaricides (miticides), insecticides, nematicides, and molluscicides are assigned by the Insecticide Resistance Action Committee (IRAC).

2 Single doses of oils and potassium salts of fatty acids (soaps) can be used anytime as pesticide rotation without negatively impacting resistance management.

3 PBO = piperonyl butoxide.

4 If the product is drenched, soil injected, or soil incorporated workers may enter the treated area at anytime if there will be no contact with anything that has been treated.

Nematodes

(Section reviewed 3/21)

Foliar nematodes: *Aphelenchoides fragariae* and *A. ritzemabosi*
Root-knot nematode: *Meloidogyne* spp.

DESCRIPTION OF THE PESTS

Nematodes are typically tiny (usually microscopic), unsegmented roundworms. At maturity, they commonly are 1/100 to 1/25 inch (0.25 to 1 mm) long. Depending on the type of nematode, they feed on or inside bulbs, leaves, seeds, stems, or roots. Root-knot nematodes (*Meloidogyne* spp.) are the most prevalent nematodes attacking floricultural and nursery crops. Foliar nematodes (*Aphelenchoides* spp.) and lesion nematodes (*Pratylenchus* spp.) can also cause problems. However, there are numerous other nematodes, both ectoparasitic (feed externally on plants) and endoparasitic (enter plant tissues to feed and reproduce) that can attack floricultural and nursery crops. Because growing media used in containers is commonly pasteurized, soil-dwelling nematodes primarily cause problems in field crops.

Plant-parasitic nematodes generally hatch from an egg and develop through four juvenile stages before maturing into adults. Most species are active at temperatures from about 60° to 85°F. Feeding stages pierce plant cells and withdraw the contents. They also inject enzymes and other chemicals that breakdown cells and can change the appearance and physiology of plants. Tissues injured by nematode feeding become increasingly susceptible to infection by pathogenic bacteria, fungi, and oomycetes. Certain species of plant-parasitic nematodes vector some plant viruses.

Root-knot Nematodes

Root-knot nematodes occur throughout California and most of the United States. The second-stage larvae occur in soil, are mobile, and can enter roots. Once inside the roots, they become immobile near vascular cells where they induce feeding sites (giant cells). While the root swells to form galls, within those structures the nematodes further develop through three molts into mature females. Each of those pear-shaped females can produce up to 400 eggs in a protective gelatinous mass that protrudes from the surface of roots. Second-stage larvae hatch from eggs to repeat the cycle, or eggs can remain viable in the soil and hatch during the next crop or growing season. The time from root invasion to egg development is determined mostly by temperature, but also depends on the nematode species and host crop.

Root-knot nematodes are the most common pests of plants grown in warm, sandy, irrigated soils. The particular *Meloidogyne* species that are active can depend on cropping history, geographical location, and seasonal temperature. Although *Meloidogyne* species generally have a broad host range, there are differences between species, so cropping history can influence the species of root-knot nematodes present. See the University of California (UC), Davis Nemaplex website for more information.

To tentatively diagnose an infestation, dig the plants up after they have grown for about 4 to 6 weeks in soil above 65°F. Wash or gently tap the soil from their roots and examine the roots for swellings and gnarled, restricted root growth. Cut open any galls and use a hand lens or binocular microscope to examine galls for the presence of pinhead-sized, shiny white females that look like tiny pearls. For confirmation of infection by root-knot nematodes, send roots or soil or both to a nematology laboratory.

Foliar Nematodes

Foliar nematodes, also called bud and leaf nematodes, prefer moderate temperatures and moist or humid conditions. *Aphelenchoides fragariae* and *A. ritzemabosi* are the leaf-infesting nematodes that attack ornamental plants in California. Ferns, strawberries, tropical foliage plants, and vegetatively propagated ornamentals are important hosts of *A. fragariae*. Foliar nematode damage in California occurs mostly in certain greenhouses and in fields along coastal areas where humidity is high and ornamental hosts and strawberries are grown. Foliar nematodes are tiny, about 1/50 to 1/25 inch (0.5–1 mm) long, and samples must be sent to a nematode diagnostic laboratory to confirm an infestation.

Foliar nematodes infest new plants by swimming in a water film up stems and along the surface of moist plant tissue. After entering leaves through stomata, females lay their eggs in intracellular spaces in leaves.

Foliar nematodes can mature from egg to adult in about 2 weeks, allowing many generations to develop during one growing season. Foliar nematodes can also live for a few months in soil or decomposing organic material by feeding on fungi. They typically overwinter in dormant buds, plant terminals, and soil in dead leaves that drop from infested plants. In slowly drying leaf tissue, adults of *A. ritzemabosi* can enter a desiccated, resting stage that allows them to survive for several years until moist conditions induce them to resume activity. See the UC Davis Nemaplex website for more information.

To make an initial diagnosis, tear symptomatic tissue into small pieces and place it in a glass dish. Add just enough water to immerse the plant tissue, then cover the dish to reduce evaporation. After 24 hours, carefully examine the water under strong light using a 10X hand lens or, preferably, a binocular microscope providing higher magnification. Nematodes will appear as tiny strands moving in the water.

SYMPTOMS AND DAMAGE

Root-knot nematodes

Root-knot nematodes cause galls or swellings on the roots of many broadleaf plants. Many weeds host root-knot nematodes. Some grasses and cereals (monocots) can be infested and are suitable hosts, but root symptoms (galls) on these crops are generally not obvious. Severely infected roots may subsequently be attacked by a variety of decay- or disease-causing microorganisms, including bacteria, fungi, and oomycetes. Aboveground symptoms are usually nonspecific, characteristic of a poorly functioning root system, and may include stunted growth, wilting, and yellowing.

Although beneficial nitrogen-fixing bacteria often form nodules on the roots of legumes such as cassia, sweet pea, and vinca, these nodules rub off roots easily, whereas galls caused by root-knot nematodes are truly swellings of the roots. Also, a thumbnail can easily be pressed into a bacterial gall, but not into a gall of root-knot nematodes. To provide identification, collect galled roots and surrounding soil and send them to a nematode diagnostic laboratory.

Foliar nematodes

Foliar nematode damage can be confused with symptoms caused by certain bacteria, fungi, viruses, nutrient deficiencies, or chemical injuries. Nematodes may interact with certain bacteria or fungi to cause severe foliar blight.

Foliar nematode damage usually begins as yellowish leaf spots that eventually turn dark green to blackish brown. Discoloring typically starts near the leaf base and spreads outward. The lesions are often angular because nematodes in leaves are initially contained between the veins. Because monocots have parallel veins, discoloring on them occurs in streaks.

If young leaves or shoots are infested, they may remain undersized, become bushy or distorted, and produce little or no marketable foliage or flowers. Damaged foliage may become brittle or shrivel and drop prematurely. Damage usually appears beginning in spring (or winter in coastal areas) and becomes most severe by summer.

SAMPLING NEMATODES

The best time to sample nematodes for the next crop is at or around the harvest of the current crop when plants with damage symptoms are available for testing. Nematodes of most pest species are usually concentrated near or in plant roots. Unless your nematology laboratory recommends other procedures, the following method can be used. Divide the field into areas of uniform plant growth and similar soil characteristics and cropping history. Take several soil subsamples from locations scattered throughout each uniform field area. Each subsample can be about 1 pint of soil. Collect moist (not soggy) soil from the plant root zone or the upper 6 to 18 inches of soil if no crop is present. Thoroughly mix the subsamples to make a composite sample and send about 1 pint of soil for testing. Repeat this sampling procedure for each field area. If plants have symptoms, dig them up along with their roots and surrounding soil and place them in a bag for testing. Also, bag separately at least one or two plants and soil sampled from a healthy-looking part of the field and send them for comparison testing.

Label each sample with field location, current crop, cropping history, crop injury observed, and your name, address, and phone number. Seal samples in plastic to prevent them from drying out and keep them cool at about 50° to 60°F until the material reaches the laboratory. Laboratories should report the genus of the nematodes that were found, the number of nematodes per unit of soil, and the extraction

efficiency. It is important to know the laboratory's method (and the method's efficiency) for extracting nematodes from soil. Certain techniques are not adequate for detecting the presence of specific genera of nematodes, or they provide only qualitative results, which tell you that nematodes are present but not whether they are abundant enough to cause damage.

MANAGEMENT OF FOLIAR NEMATODES

Grow plants in soilless media or pasteurize media before use. Propagate only nematode-free stock. Foliar nematodes are typically introduced into growing areas in cuttings, seedlings, and other vegetative propagation material that may be asymptomatic. Take cuttings only from the tops of long, vigorous growth to reduce the likelihood that it is infested.

If the plants tolerate heat without damage, cuttings can be disinfected by dipping them in hot water at 122°F for 5 minutes or at 111°F for 30 minutes. Foliar nematodes infesting Easter lilies may be controlled by dipping bulblets in 125°F water for 10 minutes before planting. However, treatment at the same temperature for 20 minutes results in severe damage to the crop. Thus, to avoid damage to plants, it is critical to control both temperature and exposure time accurately.

Employ proper sanitation by removing plant debris, promptly disposing of all infested plants, and eliminating weeds that can host foliar nematodes (e.g., goldenrod, groundsel, and sneezeweed) from around growing areas. To reduce the risk that foliar nematodes will spread throughout the crop by traveling in a water film on plant surfaces, avoid crowding plants and using overhead irrigation .

MANAGEMENT OF ROOT KNOT AND OTHER SOIL-DWELLING NEMATODES

Rotating crops, employing good cultural practices and excellent sanitation, pasteurizing growing media, and fumigating field soil before planting are the most important strategies for preventing and managing most soil-dwelling nematodes. Soil amendments and biological control products may sometimes suppress nematode populations. Post-plant nematicides for use in soil around established plants may be permissible (check the label). But it is generally more effective to employ preventive measures before planting.

Sanitation and Cultural Practices

Avoid introducing nematode-infested plants into growing areas. To minimize the risk of introducing nematodes with the planting stock, use only good-quality stock from a reliable supplier and, if available, from participants in the California Department of Food and Agriculture (CDFA) Nursery Services Program. Use growing media known to be free of nematodes or pasteurize growing media before use. Dispose of infested plants when found and avoid moving soil from around infested plants to healthy plants. Do not allow irrigation water from around infested plants to run off onto healthy plants, as this spreads nematodes.

Unless the soil is treated first, do not plant susceptible crops in field soils where nematodes have previously been a problem. In particular, do not replant the same plant genera into the old site; rotate crops by replanting with different genera more tolerant of, or resistant to, the specific nematodes present.

Provide crops with proper cultural care so that they are vigorous and better able to tolerate feeding by nematodes and other pests. More frequent irrigation of drought-stressed plants can reduce damage caused by root-knot nematodes, but it does not reduce the abundance of nematodes.

Heat Pasteurization

Pasteurizing media with heat, such as aerated steam, can control nematodes and other pests or pathogens in container mix and greenhouse beds. Special tractor-drawn steam rakes are available, but except for raised beds, steam is difficult to use in field soils. The heat generated by decomposer microorganisms during composting of container media can control certain nematodes, but preparing pathogen-free compost requires careful management and monitoring.

Solarization

In sunny, warm climates, field solarization before planting can temporarily reduce nematode populations in the upper 12 inches of soil. Solarization involves covering moist, bare soil or container mix with single or double layers of clear plastic for several weeks during hot weather. In some cases, incorporating amendments (such as compost or green manure) or applying lower than normal rates of fumigant

pesticides in combination with solarization can provide better control than using any single method. Correct use of "double-tent" solarization can completely eradicate plant-parasitic nematodes, most other pathogens, and weed seeds from containerized growth media. See the table of Some Flower and Nursery Crop Nematodes Controlled by Solarization of Container Mix for which nematodes are controlled in this situation. See CDFA's Nursery Inspection Procedures Manual (NIPM Item 7) and UC's Using Solarization to Disinfect Soil for Containerized Production (PDF) for details.

Some Flower and Nursery Crop Nematodes Controlled by Solarization of Container Mix	
Common name	**Scientific name**
citrus	*Tylenchulus semipenetrans*
dagger	*Xiphinema* spp.
ring	*Criconemella* (=*Criconemoides*) *xenoplax*
root knot	*Meloidogyne hapla*
root knot	*Meloidogyne incognita*
root knot	*Meloidogyne javanica*
root lesion	*Pratylenchus* spp.
stem and bulb	*Ditylenchus dipsaci*

Source: Stapleton, J., L. Ferguson, and M. McKenry. 1998. Using solarization to disinfect soil for containerized production (PDF). *U.C. Plant Protection Qtr. 8(1 & 2): 7-9* (https://ucanr.edu/sites/kac/files/123909.pdf).

Hot Water Dips
Hot water dips can reduce the number of nematodes and certain other pests infesting bulbs, corms, and rhizomes of crops such as amaryllis, daffodil, gladiolus, lily, and tulip. The temperature and time needed to provide sufficient control depend on the nematode species and crop variety. Exceeding the proper temperature or exposure time can damage plants, but insufficient temperatures or exposure time may not kill the nematodes. Cool plants immediately afterward with clean, cold water, then dry thoroughly in warm air or sunshine. Consider making a fungicide application after the heat treatment. After heat treatment, store the plant material under cool, low-humidity conditions until plants are used.

Amendments and Biological Control
Although amendments and biological control microorganisms reduce plant-parasitic nematodes in certain situations, sufficient control has been unreliable. The reasons for this variable effectiveness are not well known. To provide a basis for comparison, growers using amendments and biological control products should consider leaving several randomly selected areas of their fields untreated or treated with more conventional methods or both.

Soil amendments used for nematode control can be placed into four categories: animal-based, inorganics, plant-based, and microbial. Except for inorganics (such as ammonium sulfate fertilizer and powdered rock), nematode suppression from most amendments is at least partly the result of biological control. Incorporating animal manure, compost, crop residue, and organic fertilizers increases the organic matter content of the soil. It improves water and nutrient availability to plants, reduces plant stress, and can encourage higher numbers of nematode predators and parasites. Some residues can produce by-products with nematicidal properties upon degradation. However, organic amendments sometimes contain contaminants such as weed seeds, especially in non-composted or incompletely composted materials, and their effectiveness is largely limited to the depth of material incorporation.

Barley, certain legumes such as clover and vetch, French marigold, perennial rye, and other plants with bioactive properties are grown as crop rotations, cover crops, or trap crops in some row crops. These plants may sometimes reduce populations of certain soil-dwelling plant-parasitic nematodes by producing chemicals that kill or repel nematodes, stimulate premature egg hatch, suppress nematode growth, or disrupt the attraction between nematodes seeking to mate. However, crops suppressive to one species of nematode often host other nematode species. Rotating specific marigold cultivars with crops such as lilies grown for bulb production has been somewhat successful in controlling certain nematodes. The marigolds must be left in the soil, either through cultivation or by mowing the tops and leaving the roots underground. However, this practice is generally not recommended because phytotoxicity to lilies and other crops is commonly observed when they are grown in rotation after incorporating marigolds into the soil.

Several biologically-based (microbial) nematicides are registered in California. Their efficacy for controlling root-knot nematodes has been studied in vegetable crops in Southern California. These field experiments found their effectiveness to be inconsistent at best.

Organically Acceptable Methods
Certain amendments and biological control products, anaerobic soil disinfestation, cultural practices, heat pasteurization, hot water dips, sanitation, and solarization are organically acceptable management methods.

Fumigants
A soil fumigant can be used in certain situations to reduce nematode populations before planting. Before using a fumigant, be sure that nematodes or other soil pests are the cause of your problem by having a laboratory test performed or by having an expert examine your plants and soil. Consider alternatives before using a nematicide. Be sure the nematicide is registered for that crop or growing situation. Follow label directions strictly; the improper application is not only illegal but often ineffective and may be hazardous. Fumigants such as 1,3-dichloropropene* and metam sodium* are a source of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone. (*Permit required from county agricultural commissioner for purchase or use.)

Fumigate only as a last resort when other management strategies have not been successful or are not available. Soil fumigants may only be applied by a regulated, commercial applicator. Consult UC's *Field Fumigation: Pesticide Application Compendium*, Vol. 9, the Department of Pesticide Regulation's *Addendum to the Field Fumigation Study Guide* (PDF), and the office of the local county agricultural commissioner for more information.

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. **The following are ranked with the pesticides having the greatest IPM value listed first—the most effective and least harmful to the environment are at the top of the table.** When choosing a pesticide, consider information relating to air and water quality, resistance management, and the pesticide's properties and application timing. Always read the label of the product being used.

Preplant

A. 1,3-DICHLOROPROPENE*§/CHLOROPICRIN*§
(InLine, Telone C-35) — Label rates — See label — NA
COMMENTS: Multipurpose liquid fumigant for the preplant treatment of soil to control plant-parasitic nematodes, symphylans, and certain soil-borne pathogens using drip irrigation systems only. Use of a tarp seal is mandatory for all applications of this product.

B. 1,3-DICHLOROPROPENE*§
(Telone EC) — Label rates — 5 days — NA
COMMENTS: Liquid fumigant for the preplant treatment of soil against plant-parasitic nematodes and certain other soil pests in cropland using drip irrigation systems only.

C. CHLOROPICRIN*§
(Tri-Clor, Tri-Clor EC) — Label rates — See label — NA

D. METAM SODIUM*§
(Vapam HL, Sectagon-42) — Label rates — See label — NA
COMMENTS: Contact your farm advisor for advice on the most effective application method for a particular situation.

E. METAM POTASSIUM*§
(K-PAM HL) — Label rates — See label — NA
COMMENTS: Contact your farm advisor for advice on the most effective application method for a particular situation.

F. ETHOPROP*§
(Mocap EC) — Label rates — 72 — NA
COMMENTS: Apply just before planting. Make only one application per crop.

G. 1,3-DICHLOROPROPENE*§
(Telone II) Label rates 5 days NA
COMMENTS: Liquid fumigant for the preplant treatment of soil against plant-parasitic nematodes and certain other soil pests in cropland using drip irrigation systems only.

H. DAZOMET
(Basamid G) Label rates See label NA
COMMENTS: Granular fumigant for preplant treatment of soil or substrates against (some) plant-parasitic nematodes.

I. CHLORFENAPYR
(Pylon) Label rates 12 hrs NA
COMMENTS: Nematicide and Miticide only for greenhouse ornamentals and vegetables. For managing foliar nematodes (*Aphelenchoides* spp.) ONLY; not for control of other plant-parasitic nematodes.

‡ Restricted entry interval (REI) is the number of hours or days from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases the REI exceeds the PHI. The longer of these two intervals is the minimum time that must elapse before harvest may occur.

* Permit required from county agricultural commissioner for purchase or use.

§ Do not exceed the maximum rates allowed under the California Code of Regulations Restricted Materials Use Requirements, which may be lower than maximum label rates.

NA Not applicable.

Weeds
(Section reviewed 7/20)

COMMON AND SCIENTIFIC NAMES OF WEEDS IN FLORICULTURE AND NURSERIES (7/20)

Weeds are broadly divided into broadleaf plants (dicotyledons) or narrowleaf plants (monocotyledons). Most narrowleaf plants are grasses, but this group also includes sedges, such as yellow nutsedge, which are important weeds. Another way to classify weeds is by when they germinate and grow. Many common weed species are winter annuals, germinating mainly in fall, growing through winter and spring, and dying as summer approaches. Summer annuals germinate in spring, grow through summer and die as the temperature drops in the fall. Irrigation can alter the germination time of weeds and prolong the life span of some annuals and delay their senescence. A few weeds complete a life cycle in 2 years and are referred to as biennials (e.g., bristly oxtongue). Some of the worst weed species are perennials; weeds that live for 2 years or more. These include bermudagrass, creeping woodsorrel, and nutsedge that persist through their vegetative propagules (stolons, rhizomes, or tubers). See the Common Weeds in Floriculture and Ornamental Nurseries table for a list of these and links to photographs and more information on them.

Common Weeds in Floriculture and Ornamental Nurseries.

COMMON NAME	SCIENTIFIC NAME‡
WINTER ANNUALS	
bittercress	*Cardamine* spp.
bluegrass, annual	*Poa annua*
burclover, California	*Medicago polymorpha*
chickweed, common	*Stellaria media*
cudweeds	*Gnaphalium* spp.
filarees	*Erodium* spp.
goosefoot, nettleleaf	*Chenopodium murale*
groundsel, common	*Senecio vulgaris*
lettuce, prickly	*Lactuca serriola*
mallow, little (cheeseweed)	*Malva parviflora*
mustard, wild	*Brassica* sp.
nettles	*Urtica* spp.
pearlwort	*Sagina* sp.
radish, wild	*Raphanus raphanistrum*
rocket, London	*Sisymbrium irio*
shepherd's-purse	*Capsella bursa-pastoris*
sowthistle, annual	*Sonchus oleraceus*
spurry, corn	*Spergula arvensis*

Continued on next page . . .

Common Weeds in Floriculture and Ornamental Nurseries, continued

COMMON NAME	SCIENTIFIC NAME‡
SUMMER ANNUALS	
barnyardgrass	*Echinochloa crus-galli*
buttercup, yellow	*Ranunculus* sp.
crabgrasses	*Digitaria* spp.
fleabane, hairy	*Conyza bonariensis*
henbit	*Lamium amplexicaule*
horseweed	*Conyza canadensis*
junglerice	*Echinochloa colona*
lambsquarters, common	*Chenopodium album*
nightshade, black	*Solanum nigrum*
nightshade, hairy	*Solanum physalifolium*
pigweed, prostrate	*Amaranthus blitoides*
pigweed, rough	*Amaranthus retroflexus*
pigweed, tumble	*Amaranthus albus*
puncturevine	*Tribulus terrestris*
purslane, common	*Portulaca oleracea*
sprangletops	*Leptochloa* spp.
spurges; prostrate, creeping, or spotted	*Euphorbia (=Chamaesyce)* spp.
willowherbs	*Epilobium* spp.
COMMON BIENNIALS AND PERENNIALS	
bermudagrass	*Cynodon dactylon*
bindweed, field	*Convolvulus arvensis*
johnsongrass	*Sorghum halepense*
kyllinga, green	*Kyllinga brevifolia*
nutsedge, purple	*Cyperus rotundus*
nutsedge, yellow	*Cyperus esculentus*
oxtongue, bristly (biennial)	*Picris echioides*
woodsorrel, creeping	*Oxalis corniculata*
MISCELLANEOUS	
liverwort	*Marchantia polymorpha*
mosses	Bryophytes (a division taxon)
‡ Scientific names are genus and specific epithet except where noted.	

Growing site and production practices largely determine which weeds are likely to become problems at a site. For example, weeds commonly associated with container nursery production include creeping woodsorrel, common groundsel, lesser-seeded bittercress, northern willowherb, and prostrate and spotted spurge. Sometimes annual bluegrass, liverwort, or pearlwort are a problem. In greenhouses, weeds that thrive in moist conditions often proliferate. These include liverwort, mosses, and pearlwort. In field sites, weed species vary greatly but the weed spectrum can be influenced by management practices in the field and by the environment. Because of these variations, each type of production situation is addressed separately in this guideline. After the section on general methods of weed management, there are special sections for weed management in

- container nurseries
- field-grown trees and shrubs
- field-grown flowers
- greenhouse-grown crops

GENERAL METHODS OF WEED MANAGEMENT (7/20)

Managing weeds in ornamental plant production, whether in field soil, greenhouses, or outdoor containers, can be difficult but is essential to successful production. Weeds not only compete with the crop for plant nutrients and sunlight but are also unsightly and do not meet clean nursery quality standards. In addition, ornamental plants infested with certain noxious weeds cannot be sold because of quarantine regulations. Because of the high value of ornamental crops and the limited number of herbicides available, growers often resort to costly hand-weeding. However, many of the strategies used in vegetable row crops or tree crops can be adapted for use in field-grown trees and cut flower production. For example, planting in rows allows the field to be more easily cultivated by hand or mechanically. The use of drip irrigation in tree or shrub production greatly reduces excessively wet areas, thus reducing the germination and growth of weeds.

Whether ornamentals are grown in containers, fields, or greenhouses, there are some control practices common to many methods of production that can reduce the impact of weeds on the crop as listed below in no particular order.

Prevention
The most important factor in overall weed control is to prevent weeds from developing seed and perpetuating the weed problem. Sources of weed introduction include weedy stock, weed seeds in the growing area or nearby, or plant propagules in manure, soil, uncomposted yardwaste, or other organic matter sources. Many growers cultivate or treat the margins of the property with herbicides to reduce the number of windborne or water-carried seeds that can move to the growing area. Screens on open-water inflow sources can be installed to keep out water-borne seeds. When using fine-mesh screens, increasing the surface area of the water intake and periodic debris removal may be needed to avoid clogging of the water flow.

Cultivation
Weed management systems for field-grown ornamentals start with mechanical cultivation. Begin this process by irrigating the field to induce weeds to germinate and then cultivate the new seedlings. Alternatively, the field can be sprayed with a postemergence herbicide after weed emergence so that the soil will not be disturbed by cultivation before planting. Each time cultivation occurs, new weed seeds can be brought close to the soil surface and germinate. This method reduces the soil seed bank so fewer weed seeds will be present to germinate when the crop is planted.

After planting (and crop emergence if a seeded crop), preemergence herbicides can be used before weed emergence or the field can be cultivated between rows after new weeds germinate or both. After harvest, cultivate again to kill emerged weeds so they do not seed and replenish the weed seed bank.

Cover Crops
Cover crops can be used between rows and at field edges to improve weed management and to allow for another crop to grow instead of weeds. See the Potential Cover Crops for Field-Grown Ornamentals for the desirability of species for cover crops. The cover crop selected will depend on soil type, environmental conditions, and the ornamental crop. The cover crop can be a living mulch that is repeatedly mowed to minimize competition, or it can be sprayed with herbicides and used as a nonliving mulch. Certain cover crops can be hard to suppress with herbicides, such as white or strawberry clovers. An annual cover crop can be established and allowed to senesce naturally or (where freezing temperatures occur) be killed back by exposure to frost.

Potential Cover Crops for Field-Grown Ornamentals.

DESIRABLE	INTERMEDIATE	LESS DESIRABLE
WINTER ANNUALS		
beans, bell or fava bromegrass, blando pea, Austrian winter field rye, cereal vetch, hairy or purple	clover, rose or crimson fescue, zorro brome, California oat (forage)	mustard,[1] wild or black ryegrass, annual
SUMMER ANNUALS		

beans, dry sorghum sudangrass sudangrass/sorghum hybrids		
PERENNIALS		
perennial ryegrass/hard fescue	orchardgrass, berber	bermudagrass
		clover, strawberry or white
[1] Mustards can be undesirable cover crops because they can be invasive weeds in wildlands.		

Mowing
Mowing is used to prevent rampant growth of the weeds, reduce the formation of seed, and reduce the spread of weed seed into cultivated areas. Properly timed mowing can also suppress some perennial weeds such as established johnsongrass. However, repeated mowing over a period of time (seasons or years) without any other means of weed control tends to favor the establishment of low-growing perennial grasses, which are very competitive for water and nutrients. Also, species that have flower heads below the level of the blade are not effectively controlled. If performed after seed set, mowing can spread weed seed and exacerbate weed problems.

Flaming
Flaming can be used before planting or on weeds between crop rows. To avoid injuring the crop, direct the flame at young weeds between the rows or use shields. Broadleaf weeds are controlled more effectively than grasses by flaming, and young weeds are better controlled than older ones. Because of the cost of fuel, the time required to pass over the beds, potential injury to workers, and fire hazard, flaming is not a widely used method of weed control for field-grown flowers or nurseries.

Hand-removal
Hand-hoeing or hand-pulling of weeds is always a part of crop management because cultivation does not remove all of the weeds. In some crops there may not be any other method of control. By removing the few remaining weeds in the crop, not only will there be less competition, but fewer weed seeds will be produced.

Mulches
Various kinds of bark, composted yardwaste, and other organic material can be used to help suppress annual weeds by covering the soil surface and preventing weed seed germination and establishment. Only 2 to 3 inches of fine organic mulch (finished yardwaste) may be required to totally eliminate light on the soil and suppress the growth of weeds. An advantage of the fine mulches is that after the crop is harvested, the mulch can be worked into the soil to improve drainage, soil structure, and water-holding capacity of the soil. A disadvantage of fine mulch is that weed seeds that fall on it will germinate and grow.

Coarse wood chips or bark may require 3 to 6 inches of material to eliminate light. Synthetic materials (geotextiles, landscape fabrics) made of polypropylene or polyester can also be used as mulches but because of cost, they generally are used only with perennial shrubs or trees or under containers. Because they last several years, they can be left on for the life of the tree or shrub, or they can be removed and reused. Dark plastic mulches can be used for weed control when using drip or furrow irrigation.

Soil Solarization
Heating soil to high temperatures can kill many weed seeds. Solarization is done by covering bare, moist soil with clear plastic during periods of high solar radiation and temperature. In California's interior valleys, this is generally during June to August. Before placing the plastic on the site to be treated, cultivate or closely mow any established plants and remove the clippings, then smooth the soil surface and irrigate the area well. Place clear polyethylene that is ultraviolet (UV) resistant over the area and extend it about 2 feet beyond the infested area on all sides and pull it tightly so it is close to the soil. The plastic must be left in place and maintained intact for 4 to 6 weeks for control of weeds. Many annual weeds can be controlled using this method. Weeds not well controlled include clovers, field bindweed, and purple and yellow nutsedge.

Media for containers or for use in greenhouses can be solarized using clear bags or flats or small, low mounds of soil covered with clear polyethylene. In greenhouses, beds can be solarized before planting. See *Soil Solarization: A Nonpesticidal Method for Controlling Diseases, Nematodes, and Weeds*, UC ANR

Publication 21377 and UC IPM *Pest Notes: Soil Solarization for Gardens and Landscapes*, UC ANR Publication 74145, for more details.

Transplants
Using transplants rather than direct-seeding a crop allows the crop to establish more quickly and be more competitive with weeds. Also, a transplant is generally more tolerant to soil-applied (preemergence) herbicides than are germinating crop seeds.

Herbicides
Herbicides are used in many ornamental production areas as an economical option to control weeds. By using herbicides before weeds emerge, weed competition with the ornamental crop can be reduced or eliminated, resulting in higher quality ornamental plants and less labor costs.

Herbicides are generally classified according to when they are used in relation to crop and weed growth stage. Preplant herbicides are applied before planting. These herbicides are used before the desirable plants are present because some can control both germinating seedlings and established plants. Preemergence herbicides kill weeds at the seed germination stage. These herbicides are applied before weeds emerge. Postemergence herbicides are applied after the weeds have emerged. Preemergence and postemergence herbicides may be applied before or after the crop is planted depending on the crop and the herbicide selected. See the section SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL to guide herbicide choice based on the weed species present.

Preplant herbicides
Herbicides that are applied before planting the crop may be fumigants, nonselective or selective postemergence herbicides, or preemergence herbicides, which are selective because they are generally safe for use around established plants. The fumigant herbicides, such as metam potassium* and metam sodium*, are often applied as an injection to cultivated soil. They are generally covered with a polyethylene tarp to seal in moisture and slow the escape of fumigant gas. Dazomet is a powder that is incorporated into the soil. All of these materials must be applied by licensed applicators. Nonselective postemergence herbicides can be used preplant as well. Certain preemergence herbicides can be applied and incorporated mechanically into soil before direct seeding or transplanting if the crop is tolerant to that herbicide. (*Requires a permit from the county agricultural commissioner for purchase or use.)

Preemergence herbicides
Preemergence herbicides must be applied before the weed seeds germinate. These herbicides comprise the largest number of herbicides available to ornamental growers because they are generally safest for the crop and the weed seedling stage is the easiest part of the plant cycle to interrupt. Examples of these herbicides are dimethphenamid-d, flumioxazin, indaziflam, isoxaben, napropamide, oryzalin, oxadiazon, oxyfluorfen, pendimethalin, prodiamine, and trifluralin. There are a number of preemergence herbicides sold as combinations such as dimethenamid-p/pendimethalin (Freehand), oryzalin/isoxaben (Snapshot), oxyfluorfen/oryzalin (Rout), and oxyfluorfen/pendimethalin (OH2).

Apply preemergence herbicides to the soil after cultivating or hand-weeding to remove emerged weeds. Follow the application with an irrigation or rain to move the herbicide in the top 1/2 inch of media or soil where the seeds are germinating. A second handweeding 7 to 10 days after an herbicide application may be needed to ensure elimination of previously germinated seedlings. However, read the label to learn if doing so will affect the chemical barrier. For example, oxadiazon and oxyfluorfen are taken up by the seedling as it emerges; disturbing the soil may create some gaps in the herbicide barrier.

Because of the varied germination periods of the weed species and the selectivity and sometimes limited persistence of the herbicides, it can be necessary to use different preemergence herbicides at different times of the year or repeat application of a particular herbicide to achieve the best control. For example, common groundsel and lesser-seeded bittercress can germinate at almost any time during the year, but their maximum germination in a field situation occurs in a cool, moist environment. Thus, a late summer herbicide treatment for control of winter annual seedlings is most desirable. For summer weeds such as crabgrass and purslane, apply herbicides in late winter. Keep in mind that where artificial conditions for germination can occur, such as in a container nursery where irrigation may occur daily, these weeds can germinate at any time. The length of time a preemergence herbicide stays active is also an important

consideration in application frequency and timing. For example, because of frequent irrigation herbicides may not control weeds for as long as stated on the label.

Postemergence herbicide
Postemergence herbicides are applied after weeds have emerged. Some are very selective and control only a narrow range of weed species. Examples of selective postemergence herbicides include clethodim, fluazifop-p-butyl, and sethoxydim. Fluazifop-p-butyl and sethoxydim control most annual grasses, except annual bluegrass and fine fescue. Clethodim will control annual bluegrass as well as other grasses. Products containing phenoxy herbicides, such as 2,4-D, will selectively control broadleaf weeds in monocots but will injure a broadleaf crop. There are no selective postemergence herbicides that can be used over a wide spectrum of ornamental species for broadleaf weed control. Nonselective herbicides are those containing diquat, glufosinate, glyphosate, pelargonic acid, and plant oils such as eugenol. Nonselective herbicides can be used around the field to keep weeds from seeding but must be kept away from the crop.

Apply postemergence contact herbicides when weeds are in the seedling stage, the stage when they are the most susceptible and require the least amount of herbicide for effective control. Translocated herbicides such as glyphosate and the grass selective herbicides can be effective on bigger weeds. In some field-grown flowers, shrubs, or trees, control of grasses with the postemergence herbicides clethodim, fluazifop-p-butyl, or sethoxydim can be very effective. Many postemergence herbicides need addition of an adjuvant (surfactant oil) for maximum control. Check the herbicide label for information about whether a surfactant should be added and which type of surfactant to use and the rate.

By using preemergence or postemergence herbicides or, where possible, mulches instead of cultivation or hand-weeding, the root system of desirable plants is not disturbed. Roots are not cut off with a hoe or crop plants pulled accidentally. And because new weed seeds are not brought to the soil surface, as they would be with cultivation, fewer weeds will germinate to start a new weed crop.

Application of Herbicides
Calibration of the equipment is essential for proper application regardless of whether the herbicide is sprayed or applied dry as granules. Granules and wettable powder formulations can cause severe wear to the application equipment, so the equipment will need to be calibrated more frequently.

Most liquid herbicides are applied at 20 to 60 gallons of solution per acre at pressures of 30 to 40 pounds per square inch (psi). Applying liquids with a single nozzle hand wand does not give as uniform distribution as multiple nozzles on a boom. Because the effectiveness of preemergence herbicide applications is highly dependent on even soil coverage, make applications as uniformly as possible. When applying to container plants be aware that the media surface may be blocked by plant foliage.

Where the crop makes it difficult for the herbicide to reach the media, a granular can be more effective. Granules are applied to dry foliage and if the foliage restricts the movement to the media surface, the foliage can be lightly brushed or shaken with a broomstick or similar tool to dislodge granules. Recalibration of the application equipment is important when changing herbicides as granule size and weight differ among herbicides.

SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL (7/20)

	PREEMERGENCE																
	DIH	DIM	D/P	FLM	IND	ISO	I/T	MCH	NAP	ORY	O/O	OXA	OXY	O/P	PEN	PRD	TRI
Mode of Action	14	15	15/3	14	29	21	21/3	15	15	3	3/14	14	14	14/3	3	3	3
ANNUAL WEEDS																	
barnyardgrass	C	C	C	C	C	N	C	C	C	C	C	C	P	C	C	C	C
bittercress, lesser-seeded	—	—	—	—	—	C	C	P	P	P	C	C	C	C	P	P	P
bluegrass, annual	—	C	C	—	C	N	C	C	C	C	C	C	P	C	C	C	C
burclover, California	—	—	—	—	C	C	C	N	N	N	C	N	C	C	N	N	N
chickweed, common	P	C	C	C	—	C	C	C	C	C	C	N	P	C	C	C	C
crabgrasses	P	C	C	P	C	N	C	C	C	C	C	C	N	C	C	C	C
cudweeds	C	—	—	—	C	C	C	N	P	N	C	C	C	C	N	N	N
filarees	—	—	—	C	C	C	C	N	C	P	C	C	C	C	N	N	N
fleabane	C	—	—	C	C	P	P	N	N	N	P	P	P	P	N	N	N
goosefoot, nettleleaf	C	—	C	—	C	C	C	P	C	C	C	C	C	C	C	C	C
groundsel, common	C	—	—	C	P	C	C	N	C	P	C	P	C	C	N	N	N
henbit	—	—	C	C	C	C	C	N	N	C	C	C	C	C	C	C	C
horseweed	C	—	—	C	C	P	P	N	P	N	P	P	P	P	N	N	N
junglerice	—	—	C	—	—	N	C	C	C	C	C	C	P	C	C	C	C
lambsquarters, common	C	C	C	C	C	C	C	P	C	C	C	C	C	C	C	C	C
lettuce, prickly	C	—	—	—	P	C	C	N	C	P	C	P	C	C	N	N	N
mallow, little (cheeseweed)	—	—	P	C	C	C	C	N	P	P	C	C	C	C	P	P	P
mustard	—	—	—	C	C	C	C	N	P	N	C	C	C	C	N	N	N
nettle, stinging	C	C	C	C	C	C	C	C	P	P	C	C	C	C	P	P	P
nightshade, black	C	P	P	C	C	C	C	C	N	N	C	C	C	C	N	N	N
nightshade, hairy	C	P	P	C	C	C	C	C	N	N	C	C	C	C	N	N	N
pearlwort	—	—	C	—	—	C	C	P	C	C	C	N	P	C	C	C	C
pigweeds	P	C	C	—	C	C	C	C	C	C	C	C	C	C	C	C	C
purslane, common	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C
radish, wild	—	—	—	—	C	C	C	N	N	N	C	C	C	C	N	N	N
rocket, London	—	—	—	—	C	C	C	N	C	N	C	C	C	C	N	N	N
shepherd's-purse	—	—	—	C	C	C	C	P	P	N	C	C	C	C	N	N	N
sowthistle, common	C	—	—	C	C	C	C	P	C	N	C	C	C	C	N	N	N
sprangletops	—	—	C	—	—	N	C	C	C	C	C	P	N	C	C	C	C
spurge, prostrate or spotted	C	—	C	—	C	C	C	N	N	C	C	C	C	C	C	C	C
spurry, corn	—	—	C	—	—	C	C	C	C	C	C	N	P	C	C	C	C
willowherbs	—	—	—	C	C	P	P	N	N	P	C	P	C	C	N	N	N
BIENNIAL WEEDS																	
oxtongue, bristly	—	—	—	—	—	N	N	N	N	N	N	N	N	N	N	N	N
PERENNIAL WEEDS																	
bermudagrass (plant)	N	—	—	—	N	N	N	N	N	N	N	N	N	N	N	N	N
bermudagrass (seedling)	C	—	C	—	—	N	C	C	C	C	C	P	N	N	C	C	C
bindweed, field (plant)	P	N	N	—	N	N	N	N	N	N	N	P	N	N	N	N	N
bindweed, field (seedling)	C	—	P	—	—	N	C	N	N	P	C	C	C	C	P	P	C
buttercup, yellow	—	P	P	—	—	N	N	N	N	N	N	N	N	N	N	N	N
johnsongrass (plant)	N	—	—	—	N	N	N	N	N	N	N	N	N	N	N	N	N
johnsongrass (seedling)	C	C	C	—	—	N	C	C	C	C	N	N	N	P	P	C	C
nutsedge, yellow	P	P	P	P	N	N	N	P	P	N	N	N	N	N	N	N	N
nutsedge, purple	—	—	—	N	N	N	N	P	N	N	N	N	N	N	N	N	N
woodsorrel, creeping (plant)	—	—	—	—	—	N	N	N	N	N	N	N	N	N	N	N	N

	DIH	DIM	D/P	FLM	IND	ISO	I/T	MCH	NAP	ORY	O/O	OXA	OXY	O/P	PEN	PRD	TRI
woodsorrel, creeping (seedling)	—	—	C	—	C	C	C	N	N	C	C	C	C	C	C	C	C
MISCELLANEOUS																	
liverwort	—	—	—	C	—	—	—	—	—	—	P	P	P	P	—	—	—

C = control P = partial control N = no control — = Information not available or not presented

DIH = dichlobenil (Casoron)
DIM = dimethenamid-P (Tower)
D/P = dimethenamid/pendimethalin
FLM = flumioxazin (Broadstar, Sureguard)
IND = indaziflam (Marengo G)
ISO = isoxaben (Gallery)
I/T = isoxaben/trifluralin
MCH = metolachlor (Pennant)
NAP = napropamide (Devrinol)
ORY = oryzalin (Surflan)
O/O = oryzalin/oxyfluorfen
OXA = oxadiazon (Ronstar)
OXY = oxyfluorfen (Goal)
O/P = oxyfluorfen/pendimethalin
PEN = pendimethalin (Pre-M, Pendulum)
PRD = prodiamine (Barricade)
TRI = trifluralin (Treflan)

Susceptibility of Weeds to Herbicide Control, continued

	POSTEMERGENCE							
	CLE	DIQ	FLU	GLU	GLY	PAR	PEL	SET
Mode of Action	1	22	1	10	9	22	26	1
ANNUAL WEEDS								
barnyardgrass	C	C	C	C	C	P	C	C
bittercress, lesser-seeded	N	P	N	C	C	—	P	N
bluegrass, annual	C	C	N	C	C	C	C	N
burclover, California	N	P	N	C	C	P	P	N
chickweed, common	N	C	N	C	C	C	C	N
crabgrasses	C	P	C	C	C	C	P	C
cudweeds	N	P	N	C	C	N	P	N
filarees	N	N	N	C	P	P	N	N
fleabane	N	N	N	C	C	P	N	N
goosefoot, nettleleaf	N	N	N	C	C	C	N	N
groundsel, common	N	N	N	C	C	C	N	N
henbit	N	N	N	C	C	C	N	N
horseweed	N	N	N	C	C	C	N	N
junglerice	C	P	C	C	C	P	P	C
lambsquarters, common	N	P	N	C	C	P	P	N
lettuce, prickly	N	N	N	C	C	P	N	N
mallow, little (cheeseweed)	N	N	N	P	P	N	N	N
mustard	N	P	N	C	C	C	P	N
nettle, stinging	N	P	N	C	C	P	P	N
nightshade, black	N	P	N	C	C	C	P	N
nightshade, hairy	N	P	N	C	C	C	P	N
pearlwort	N	N	N	C	C	—	N	N
pigweeds	N	P	N	C	C	C	P	N
purslane, common	N	C	N	C	C	N	C	N
radish, wild	N	C	N	C	C	P	C	N
rocket, London	N	N	N	C	C	C	N	N
shepherd's-purse	N	P	N	C	C	C	P	N
sowthistle, common	N	P	N	C	C	C	P	N
sprangletops	N	N	N	C	C	P	N	N
spurge, prostrate or spotted	N	C	N	C	C	C	C	N
spurry, corn	N	P	N	C	C	—	P	N
willowherbs	N	P	N	C	C	P	P	N
BIENNIAL WEEDS								
oxtongue, bristly	N	N	N	P	C	—	N	N
PERENNIAL WEEDS								
bermudagrass (plant)	C	N	P	P	C	P	N	P
bermudagrass (seedling)	C	C	C	C	C	C	C	C
bindweed, field (plant)	N	N	N	P	P	P	N	N
bindweed, field (seedling)	N	C	N	C	C	C	P	N

buttercup, yellow	N	N	N	P	C	—	N	N
johnsongrass (plant)	C	N	P	P	C	N	N	P
johnsongrass (seedling)	C	C	C	C	C	C	C	C
nutsedge, yellow	N	N	N	N	P	P	N	N
nutsedge, purple	N	N	N	N	P	P	N	N
woodsorrel, creeping (plant)	N	N	N	P	C	—	N	N
woodsorrel, creeping (seedling)	N	C	N	C	C	—	C	N
	CLE	DIQ	FLU	GLU	GLY	PAR	PEL	SET

C = control P = partial control N = no control — = Information not available or not presented

CLE = clethodim (Envoy)
DIQ = diquat (Reward)
FLU = fluazifop-p-butyl (Fusilade)
GLU = glufosinate (Finale)
GLY = glyphosate (Roundup Pro)
PAR = paraquat (Gramoxone)
PEL = pelargonic acid (Scythe)
SET = sethoxydim (Vantage)

Container Nurseries

INTEGRATED WEED MANAGEMENT FOR CONTAINER NURSERIES (7/20)

The growth and vigor of nursery stock can be reduced when weeds are allowed to grow in the container for any length of time. Slow-growing crops that do not cover the surface of the media in the container quickly are particularly vulnerable to weed infestations. Managing weeds in container nurseries involves eliminating weeds and their seed and preventing the introduction of new weed seeds into the nursery. Although growing medial is usually weed-free at planting, weed seeds can be blown in from other areas or may be brought in with the liner (transplant). Frequently, preemergence herbicides are applied to the surface of potting mix in containers of 1 gallon or larger to prevent the establishment of weed seeds. Mulches may also be applied after canning or after weeding. After container plants are established, preemergence herbicides are applied one or more times per year for weed management. Hand-pulling of weeds that have escaped the herbicide treatments is necessary to prevent them from setting seed and reestablishing a weed population.

Most weeds in a container nursery come from

- contaminated liners
- equipment
- irrigation water
- movement of soil
- plants growing between, in, or near pots
- potting mix, if it is stored uncovered where weed seed can blow in
- vehicles
- windborne seeds

Transplants produced in the nursery or purchased from others should be free of weeds and weed seed and moved into larger, weed-free containers. Use preemergence herbicides in and between the containers to reduce contamination or reinfestation, but take care so that herbicides are not carried off-site in water runoff.

The most effective way to manage weeds is to start with a clean area and to keep it clean by creating a weed-free, well-drained site for containers. Covering the nursery site with concrete, a geotextile (landscape fabric), or gravel helps control weeds under and between containers. Control perennial weeds before grading and installing irrigation equipment because they are nearly impossible to control after a nursery is established.

Soil Mixture

Although potting mix is usually weed-free, it can become contaminated with weed seed if stored uncovered where seeds can blow in from neighboring areas. Fumigate, solarize, or steam sterilize any seed-contaminated soil mix. Check the soil mix periodically for weed seeds by placing samples of soil mix in a flat or two. Keep the flats moist and check for weed germination for 1 to 2 weeks. If weeds grow, consider fumigation or solarization of the soil mix.

For fumigation to be most effective, the soil mixture needs to be uniformly wet for 3 to 4 days before fumigation treatment so that the weed seeds absorb water and begin to germinate. If the mix is too dry or too wet or there are large clods of soil, fumigation will not be uniform. Fumigation is most successful when the soil is placed on a concrete pad or in a container and the fumigant or steam is introduced at several locations in the mix.

There are two main methods to fumigate a soil mix:

1. *Steam fumigation*. The steam is usually mixed with air and injected into a loose soil mix to heat the mix to at least 140°F for 30 minutes. Length of time and temperature are critical if weed seeds are to be controlled. Cover the pile so that the entire pile, including the outer edges, reaches 140°F. A major problem of steam fumigation is that equipment, such as a boiler and blower, are required.

2. *Chemical fumigation*. Fumigation with pesticides such as dazomet (Basamid), metam potassium*, or metam sodium* is sometimes used as a preplant treatment in potting mixes. For recommended fumigants, see MANAGEMENT OF ROOT-KNOT AND OTHER SOIL-DWELLING NEMATODES. Dazomet is a dry formulation that is mixed into the potting mix before wetting the pile. The pile is then covered for about 2 weeks as the dazomet degrades into the active fumigant, methyl isothiocyanate. The cover is removed and the soil allowed to air for 2 weeks before using the mix for potting. Metam potassium and metam sodium are liquids that can be applied in water to the mix and then tarped for 2 weeks. Air out the soil for 2 weeks before planting the crop. Fumigants such as metam potassium and metam sodium are sources of volatile organic compounds (VOCs) but are minimally reactive with other air contaminants that form ozone. Fumigate only as a last resort when other management strategies have not been successful or are not available. (*Requires a permit from the county agricultural commissioner for purchase or use.)

Although less commonly used, soil solarization can also be used to control weeds in the potting mix before planting. See the discussion of soil solarization in GENERAL METHODS OF WEED MANAGEMENT at the beginning of the weeds section.

Monitoring Container Nurseries
See the Common Weeds in Container-Production Nurseries table for links to photographs and more information on these species. Because many of these weeds can germinate year-round in the nursery, check the containers regularly. Some weed species can flower and produce seed in only a month from the seedling stage, so monitoring followed by hand-weeding is needed at least monthly to remove any weeds that were missed by herbicide treatments or from the last hand-weeding. It is essential to monitor for winter annual weeds germinating in late summer and for summer annuals germinating in late winter.

Common Weeds in Container-Production Nurseries.

Common name	Scientific name
bittercress	*Cardamine* spp.
cudweed	*Gnaphalium stramineum*
groundsel, common	*Senecio vulgaris*
lettuce, prickly	*Lactuca serriola*
liverwort	*Marchantia polymorpha*
pearlwort, birdseye	*Sagina procumbens*
sowthistle, annual	*Sonchus oleraceus*
spurge, prostrate or spotted	*Chamaesyce maculata*
willowherbs	*Epilobium* spp.
woodsorrel, creeping	*Oxalis corniculata*

Identifying the weeds present in a given situation is an important factor in deciding which weed control strategies to employ. Use the *Weeds of California*, UC ANR Publication 3488, and the UC IPM *Weed Photo Gallery* to help identify weeds. University of California Cooperative Extension advisors or county agricultural commissioners, botanic gardens, or arboretum personnel can also help with weed identification. Once the weed is identified, the herbicide labels and tables of SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL will help you determine the best herbicide or combinations of herbicides to supplement a weed management program and provide optimum control of the weed species present.

Herbicides
Preemergence herbicides are used extensively in container-grown ornamentals, usually in conjunction with handweeding to control any weeds that escape the chemical treatment. The herbicides used depend on the weed species expected (see monitoring section), the time of year, the stage of the ornamental plants, and the tolerance of the ornamental plants to the herbicides. The weed species present at a particular site must be properly identified in order to select the effective herbicide. Apply the herbicide as soon as possible to achieve optimal weed control but keep in mind that some plants may be injured if applied before the soil has settled around the roots.

Herbicides used in container production will not harm the ornamental species listed on the label if care is taken to use them properly. A number of factors determine if the ornamental plant will be adversely affected. These include the

- **Degree of plant establishment**. Newly-planted plants are more sensitive because generally they have smaller root systems than established plants.
- **Dosage of the herbicide**. Higher dosages can cause crop injury; rates above the label are illegal. Use the lowest dose that will control the weeds targeted. Note that using too low of rate can promote the development of resistance to herbicide.
- **Formulation**. Granular formulations are generally safer with some products than the emulsifiable concentrate or wettable powder formulations. However, injury can result if the granules collect in the whorl of the plant.
- **Plant size**. The younger the crop plant the greater the sensitivity to herbicides, and therefore, the greater the likelihood of it being injured.
- **Rate of plant growth**. Actively growing plants often are more sensitive to injury from certain herbicides than dormant plants.
- **Soil texture and organic matter content**. These properties can affect an herbicide's tendency to leach into the root zone. Some herbicides can be more strongly adsorbed on soil particles than others. As clay and organic matter content increase, binding increases and usually there is less leaching.
- **Spray techniques**. The method of application will affect distribution of the herbicide on the target. For most herbicides, the height of the spray boom should be adjusted so that the top of the ornamental plant receives uniform spray distribution. This means that with normal spray booms equipped with fan type nozzles, the nozzles should be at least 20 to 24 inches above the top of the plants. Spray booms adjusted too low can cause plant injury with certain herbicides. Individual nozzles should be checked for proper flow rate and spray pattern.
- **Tank mixing of products**. Mixing in wetting agents (chemicals that reduce the surface tension of liquids) or another herbicide that has wetting agents in it with an herbicide that has postemergence activity can greatly increase the activity and perhaps also increase crop injury and reduce selectivity. Check the label and follow any instructions regarding adding adjuvants or tank-mixing products.
- **Temperature**. Temperature affects rates of chemical reactions in plants. Higher temperatures can greatly increase the speed of chemical reactions, which can result in greater injury to plants as well as to weeds. Higher temperatures may also increase herbicide absorption through leaves and roots.

Herbicide runoff can be a serious problem in some situations, so observe the following precautions to reduce runoff:

- Spot treat.
- Use herbicides with water solubility of less than 3.5 ppm as listed in the *Herbicide Handbook* and certain online guides (PDF).
- Use low-volume applications. Use only as much water as needed to move the herbicide into soil with the first irrigation following an application.

Container spacing can also affect herbicide loss when granular herbicides are applied. Tight spacing of containers can keep 50% more of the herbicide in the container rather than on the ground compared to containers that are spaced 8 inches apart. Additionally, herbicide loss can be reduced if drop spreaders are used rather than rotary spreaders. However, herbicide that falls on the ground is not totally lost because it helps control weeds between containers and thus contributes to the total weed management.

SPECIAL WEED PROBLEMS FOR CONTAINER NURSERIES (7/20)

BITTERCRESS (hairy bittercress, lesser-seeded bittercress, popweed)

Bittercress is a small winter annual that will germinate almost any time in container production. It grows upright when the seed stalk starts to form and is easy to hand-weed at that stage, but as a seedling it is very difficult to remove easily. It produces hundreds of seed per plant, and when the capsule matures it expels the seed some distance from the original plant. Remove this weed before it flowers to reduce seed production and new infestations. Herbicides that are effective against bittercress are those that contain isoxaben, oxadiazon, or oxyfluorfen. Sanitation is also important to reduce the spread of this weed. Because the seed of this weed adheres to soil on the outside of the pots, wash pots before reuse or moving them from an infested area. The seeds are also easily carried in irrigation water. Avoid overwatering or allowing water to runoff from an infested area to a clean one.

COMMON GROUNDSEL

Common groundsel is probably the most difficult weed to control in container nurseries in California. It is a hardy weed that grows rapidly and germinates anytime during the year in container nurseries, whereas in the field it usually germinates in fall and early winter. Preemergence herbicides suppress the rooting, making the weed easier to pull. Also, because the seedling is smaller after the use of a preemergence herbicide, competition with the desirable plant is not very significant. Remove this weed before it flowers because its seeds are easily spread by wind. Preemergence herbicide combinations containing dichlobenil, dimethenamid-P + pendimethalin, flumioxazin, isoxaben, napropamide, or oxyfluorfen have given good control.

CREEPING WOODSORREL (Oxalis)

Creeping woodsorrel is a perennial plant that grows in a prostrate manner and forms roots along its stems where nodes contact the soil. It is a prolific seed producer. When its seed pods mature, they burst open and forcefully expel seeds, which may land several feet from the plant. Because the seeds are rough, they adhere to clothing or the surfaces of machinery and are easily dispersed. The primary method of managing creeping woodsorrel is to hand-pull established plants before they set seed, being careful to remove as much of the creeping stolons as possible, and to control germinating seeds with mulch or the preemergence herbicides indaziflam, isoxaben, oryzalin, oxadiazon, oxyfluorfen, pendimethalin, prodiamine, or trifluralin.

CUDWEED

Cudweed is an annual that germinates in fall and grows through the winter and spring. It is a whitish, hairy plant that has small inconspicuous flower heads. The preemergence herbicides dichlobenil, indaziflam, isoxaben, and oxyfluorfen have been effective in controlling the seedlings of this weed as they germinate.

LIVERWORT

Liverworts are nonvascular, primitive plants that reproduce vegetatively and through spores. Their flat leaf-like structure is called a thallus and their root-like structure is a rhizoid. These plants can form dense colonies in ornamental containers resulting in crop damage and reduced marketability. Preemergence herbicides containing flumioxazin or oxyfluorfen provide limited control of this weed, but are not labeled for use in greenhouses. There are no selective postemergence herbicides available.

PEARLWORT

Pearlwort is a low-growing winter annual that roots on the stems and forms mosslike mats in the container. It reproduces by seed. If oxadiazon has been used repeatedly without rotation to other herbicides it becomes a dominant weed in the nursery. A preemergence application of isoxaben, napropamide, oryzalin, pendimethalin, prodiamine, or trifluralin will control pearlwort.

SPURGE

Creeping and prostrate (spotted) spurge are low-growing annuals that grow rapidly and quickly produce seed. They are more easily removed when older, but by then the seeds have usually been produced and fall off the plant into the container when the weed is removed. Mulching reduces establishment. The

preemergence herbicides dichlobenil, indaziflam, isoxaben, oryzalin, oxadiazon, oxyfluorfen, pendimethalin, prodiamine, and trifluralin will control spurge.

WILLOWHERB

There are at least two species of willowherb found in nursery containers, *Epilobium paniculatum* and *E. ciliatum*. Willowherb seeds profusely and the seed blows in the wind. Preemergence herbicides that have been effective in controlling germinating seeds include dimethenamid-P + pendimethalin, flumioxazin, oxadiazon, and oxyfluorfen.

HERBICIDE TREATMENT TABLE FOR CONTAINERS AND FIELD-GROWN TREES AND SHRUBS (7/20)

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. The following are listed alphabetically. When choosing a pesticide, consider information relating to resistance management, the pesticide's properties, and application timing. Tank mixes may be necessary to achieve desired control; see the table SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTOL for information on control of specific weeds. Always read the label of the product being used.

Note: Not all ornamentals will tolerate each herbicide. Check the label for species selectivity.

PREEMERGENCE HERBICIDES

A. DICHLOBENIL

(Casoron 4G)	See label	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14

COMMENTS: Not for container-grown ornamentals. Check label carefully for sensitive crops. A dormant season application of dichlobenil can control many seed-propagated, perennial, broadleaf weeds and provide residual control through early summer. Good for control of *Equisetum* and mugwort.

B. DIMETHENAMID-P

(Tower)	See label	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]:15

COMMENTS: Mix with isoxaben or pendimethalin to expand the weed spectrum controlled. Can be used over the top on well-rooted plants. Check label for sensitive crops and test on a small group of each crop before applying widely.

C. DITHIOPYR

(Dimension 2EW)	See label	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3

COMMENTS: For application to established container and field-grown, tolerant ornamentals as listed on the label.

D. FLUMIOXAZIN

(Broadstar, granular)	See label	12	NA
(Sureguard, sprayable)	See label	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14

COMMENTS: Avoid contact with foliage of young crop plants. Wash foliage as soon as possible after application. Can cause stem dieback or leaf burn on sensitive plants. Has some postemergence activity. Provides moderate liverwort control. Helps provide preemergence control of annual grasses, chickweed, hairy fleabane, horseweed, and other annual broadleaves. Test on a small number of plants before using widely.

E. INDAZIFLAM

(Marengo G)	See label	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 29

COMMENTS: Not for use on certain field-grown trees and shrubs; check label for permitted uses. Long residual. Irrigate immediately following application for best activity. Can be used on many ornamentals and also used around beds and greenhouses for long-term, preemergence, weed control.

F. ISOXABEN

(Gallery SC)	See label	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 21

COMMENTS: Excellent herbicide for broadleaf weed control. Does not control annual grasses and willowherb, therefore often it is mixed with oryzalin or trifluralin to control grasses. It is safe on a wide range of woody ornamentals.

G. METOLACHLOR

(Pennant Magnum)	See label	24	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 15

COMMENTS: Controls yellow nutsedge as well as some annual grasses, but to be effective it must be incorporated into the soil where nutsedge germinates and grows through the treated area. Check label for crop safety. This herbicide is one of the more soluble products (solubility 490 ppm) – make sure that it does not move with irrigation or rainwater.

H. NAPROPAMIDE
(Devrinol DF-XT) See label 24 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 15
COMMENTS: Needs mechanical incorporation (such as a power tiller, adequate irrigation, or 1 to 2 inches of rainfall within 2 to 3 days) for optimum results. The first irrigation seems to be critical for maximum activity. Safe on many woody plants but is weak in controlling some broadleaf weeds such as members of the aster and nightshade families, oxalis, and spurge. An excellent grass herbicide and can suppress common groundsel. Generally less efficacious but often safer than the combination herbicides, it is useful in herbaceous crops. Unless it is applied before rooted liners are established, injury is rare. If placed in the container around the newly planted liner before an irrigation settled the soil or if placed in the root zone, injury (stunting) may result. If the soil is moist and there is no rainfall or irrigation within 7 days following application, an appreciable amount of the herbicide is lost and weed control will be lessened.

I. ORYZALIN
(Surflan AS) See label See label NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3
COMMENTS: A relatively broad-spectrum preemergence herbicide that does not need mechanical incorporation. Controls germinating seeds of annual grasses and many broadleaf weeds and can be used safely around many herbaceous and woody ornamentals. Leaches slightly into the soil from rainfall or irrigation. Can cause girdling of certain gymnosperms at the soil line: young hemlocks or firs (*Abies* spp.) up to about 3 years of age are affected, but arborvitae, junipers, pines, and *Taxus* are more tolerant. Stems of Monterey pines may exhibit some swelling. Oryzalin is a strong root inhibitor but most broadleaf ornamentals are very tolerant to oryzalin if the herbicide is not in the root zone. Commonly used in combination with other herbicides to widen the weed spectrum controlled.

J. OXADIAZON
(Ronstar G) See label 12 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14
COMMENTS: Not for use in conifer nurseries or on certain weeds species; see label. A broad-spectrum preemergence shoot-girdling herbicide. In containers, granular oxadiazon plus napropamide is a good combination with a broad range of safety in woody plants. The wettable powder formulation should not be applied over young growth. Oxadiazon does not control weeds in the chickweed family but napropamide controls those. Has a relatively long residual, 12–16 weeks. Oxadiazon is not very effective on certain broadleaves including chickweed, horseweed, and pearlwort. Oxadiazon is very effective when applied in fall or spring. Oxadiazon does not leach readily in the soil, is not a root inhibitor, and thus is less likely to injure established species. Injury may occur if oxadiazon is applied to wet foliage, is not washed from the foliage, or the granules collect in leaf bases or crowns. If treated soil is cultivated, weed control effectiveness is reduced.

K. OXYFLUORFEN
(Goal 2XL) See label 24 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14
COMMENTS: For use only around conifers and selected deciduous trees grown in the field. Excellent in dormant or hardened conifers where groundsel, malva, mustards, or purslane are found. Controls these weeds in a few days and provides residual, broadleaf control. Oxyfluorfen cannot be safely sprayed over most deciduous plants. Safest to the conifers when applied as granules. Weak on common chickweed, grasses, and horseweed. Oxyfluorfen acts by girdling the stem of seedlings; thus in soil, oxyfluorfen is most effective with frequent irrigation. If treated soil is cultivated, weed control is reduced.

L. PENDIMETHALIN
(Pendulum 2G, Pendulum AquaCap) See label 24 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3
COMMENTS: Do not apply Pendulum AquaCap over the top of transplants; see label. Gives excellent grass control and controls many broadleaf weeds. Weed spectrum controlled is similar to that of oryzalin. Often combined with an additional herbicide to widen spectrum of weeds controlled. Controls oxalis and spotted spurge. An encapsulated formulation (AquaCap) has no odor and less persistent orange color. Though it is a root inhibitor, it is less injurious to roots than oryzalin or prodiamine.

M. PRODIAMINE
(Barricade) See label 12 NA
WSSA MODE-OF-ACTION GROUP NUMBER: 3.
COMMENTS: Stable on the soil surface. Does not provide as long of weed control as oryzalin at the maximum label rates for both. Has been less effective for groundsel and spurge suppression than some other dinitroaniline herbicides. Inhibits root growth. Low water solubility and does not move deeply in the soil.

N. TRIFLURALIN

(Lebanon Treflan) See label 12 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3
COMMENTS: In the same class of herbicides as oryzalin (dinitroanilines), but it is not as stable on the soil surface. Must be incorporated with cultivation or irrigation or covered with a mulch very soon after application. Inhibits root growth. Often mixed with other herbicides (benefin or isoxaben) to widen the weed spectrum controlled.

PREEMERGENCE COMBINATIONS
Note: ***For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum active ingredient (a.i.) on any label when tank mixing products that contain the same a.i.***

A. DIMETHENAMID-P/PENDIMETHALIN
(FreeHand 1.75G) See label 12 NA
WSSA MODE-OF-ACTION GROUP NUMBERS[1]: 15/3
COMMENTS: Controls many common nursery weeds such as eclipta, oxalis, spurges, and willowherbs. Can be applied very soon after potting. Provides preemergence control or suppression of yellow nutsedge.

B. ISOXABEN/TRIFLURALIN
(Snapshot 2.5 TG) See label 12 NA
WSSA MODE-OF-ACTION GROUP NUMBERS[1]: 21/3
COMMENTS: Gives broad-spectrum control of annual broadleaf and grass weeds. Apply only to soil where established weeds have been removed. If the soil has been freshly cultivated, apply only after the soil has settled, then follow with an irrigation.

C. ORYZALIN/OXYFLUORFEN
(Rout) See label 24 NA
WSSA MODE-OF-ACTION GROUP NUMBERS[1]: 3/14
COMMENTS: Provides excellent broad-spectrum control of annual broadleaf and grass weeds. Can be applied after a cultivation to reduce subsequent germination. Water in after application. If granules remain in plants at the base of the leaf or in whorls, burn will occur. Residual control is 3–4 months.

D. OXYFLUORFEN/PENDIMETHALIN
(OH2) See label 24 NA
WSSA MODE-OF-ACTION GROUP NUMBERS[1]: 14/3
COMMENTS: Provides excellent broad-spectrum control of annual broadleaf and grass weeds. Should be watered-in immediately after application. Slightly less root pruning than the oryzalin/oxyfluorfen formulation (Rout). Residual control is about 3 months.

E. OXYFLUORFEN
(Goal 2XL) See label 24 NA
. . . PLUS . . .
OXADIAZON
(Ronstar Flo) See label 12 NA
WSSA MODE-OF-ACTION GROUP NUMBERS[1]: 14/14
COMMENTS: Not currently registered in California for use on annual bluegrass, annual sedge, bristly oxtongue, cheeseweed, fiddleneck, fireweed, shepherd's-purse, sow thistle, ripgut bromegrass, and wild oats. Gives broad-spectrum control of grasses and broadleaf weeds. Soil should be thoroughly settled after cultivation and rainfall or irrigation because the products form a surface barrier that controls seedlings as they germinate and grow through the herbicides. Cultivation after treatment destroys the control.

F. PRODIAMINE/OXYFLUORFEN
(Biathlon) See label See label NA
WSSA MODE-OF-ACTION GROUP NUMBERS[1]: 3/14
COMMENTS: See the comments above on these herbicides individually.

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)
Selective (broadleaves)			
A. OXYFLUORFEN			
(Goal 2XL)	See label	24	NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14			
COMMENTS: For use only around conifers and selected deciduous trees grown in the field. Postemergence applications of oxyfluorfen will control certain annual broadleaf weeds. Effective only on certain young seedling weeds, especially little mallow. Perennial broadleaf weeds will be burned but not controlled. Activity is enhanced if a surfactant or crop oil is added. Spruces and true firs are injured by oxyfluorfen during their early flush but after about 5 weeks of new growth, they are tolerant. Dormant applications do not cause injury.			
Selective (grasses)			
A. CLETHODIM			
(Envoy Plus)	See label	24	NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1			
COMMENTS: Controls most annual grasses, including annual bluegrass.			
B. FLUAZIFOP-P-BUTYL			
(Fusilade II)	See label	12	NA
(Ornamec Over-The-Top)	See label	4	See COMMENTS
WSSA MODE-OF-ACTION GROUP NUMBER[1]: NC			
COMMENTS: Do not apply to ornamentals that may be harvested for food within 1 year after application. Kills most annual and perennial grasses; however, it will not control annual bluegrass or hard fescue. Most effective on young, actively growing grasses and less effective on mature grasses. Has injured certain azalea cultivars, especially at high rates, causing spotting and necrosis on leaves. Certain junipers also are sensitive to fluazifop-p-butyl; consult the label carefully.			
Nonselective			
A. CAPRYLIC ACID/CAPRIC ACID			
(Suppress)	See label	24	NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: NC			
COMMENTS: Works best on newly emerged weeds. Do not apply through any type of irrigation system.			
B. CITRIC ACID/CLOVE OIL			
(BurnOut)	See label	0	NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: NC			
COMMENTS: Do not directly spray or allow to drift to desirable plants.			
C. CLOVE OIL			
(Matratec)	See label	0	NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: NC			
COMMENTS: For use in and around greenhouses. Do not directly spray or allow to drift to desirable plants.			
D. DIQUAT			
(Reward)	See label	24	NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 22			
COMMENTS: Not for use in ornamental seed crops in California. Labeled for use *around* container-grown ornamentals. Kills annual weeds, but only burns off the top of perennials. Contact activity only; affects only green tissue. Good for weed control in winter.			
E. FATTY ACIDS/AMINE SALTS			
(Finalsan Herbicidal Soap)	See label	24	NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: NC			
COMMENTS: For *around* field-grown ornamentals. Do not directly spray or allow to drift to desirable plants.			
F. GLUFOSINATE			
(Finale)	See label	12	NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 10			
COMMENTS: For use as a directed spray *around* container-grown ornamentals and established field-grown ornamentals. Do not apply directly to or allow to drift to desirable green tissue or thin or			

uncalloused bark. Contact herbicide with a limited amount of systemic activity; kills annual weeds, but only burns off the tops of perennials.

G. GLYPHOSATE
(Roundup Pro) See label 4 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 9
COMMENTS: Labeled for use *around* container-grown ornamentals and established woody ornamentals. A systemic herbicide that translocates to the roots and growing point of plants and kills the entire plant. Effective on both annual and perennial weeds. Contact with leaves of the ornamentals will result in injury to the plant. Glyphosate activity is increased in low water volumes. For example, greater activity is obtained at 20 gal/acre than at 50 gal/acre. This herbicide can be used alone or combined with a preemergence herbicide.

H. PARAQUAT*
(Gramoxone SL 2.0) See label 24 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 22
COMMENTS: For use as a directed *around* established field-grown ornamental trees. Do not apply directly to or allow to drift to desirable green tissue or bark. Kills annual weeds, but only burns tops off perennials. Controls young annual weeds with contact activity only and affects only green tissue.

I. PELARGONIC ACID
(Scythe) See label 12 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 26
COMMENTS: Labeled for use *around* container-grown ornamentals. Works by contact activity only (does not move in plants) and affects only green tissue. Good control of young annual weeds, but only burns off the top of perennials. Must be applied at high rates in high volumes of water. Very rapid activity.

1 Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode-of-action numbers are useful in planning mixtures or rotations of herbicides with different modes of action. For more information, see http://www.hrac-global.com.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

* Permit required from county agricultural commissioner for purchase or use.

NA Not applicable.

Field-Grown Trees and Shrubs

INTEGRATED WEED MANAGEMENT FOR FIELD-GROWN TREES AND SHRUBS (7/20)

Field-grown trees and shrubs are generally grown in rows to facilitate planting, weeding by hand or mechanical cultivation, and cultural operations such as grafting and pruning. Most weeds are controlled in established plantings by cultivation and application of preemergence herbicides, but perennial weeds need to be controlled before the crop is planted.

Crop Rotation
Sometimes the field is fumigated before planting. During the growing season, cultivation, herbicides, or other control methods are used. After the crop is harvested (either bareroot in winter or potted in spring), the field is planted to a cereal crop in fall (barley, oats, or wheat) and harvested the following spring. Herbicides can be used in the cereal crop that will reduce weed problems in the next crop of trees and shrubs.

Solarization
Soil solarization is a valuable tool to clean up a site before a fall planting (see "Solarization" under GENERAL METHODS OF WEED MANAGMENT.

Cover Crops
Cover crops, especially winter annuals such as barley, oat, wheat, or combinations of these with rose clover, may be planted between tree rows in early fall. Cover crops reduce erosion and help maintain soil organic matter when the cover is worked into the soil in the spring. Mow the cover crop and work it into the soil before it seeds to reduce competition with the marketed crop.

Mulches
To reduce weeds in field rows, cuttings can be planted through holes in paper mulch. After planting, organic mulches (e.g., bark chips) can be applied around the plants and between the rows. Organic mulch must be deep enough to shade out all weed seedlings as they germinate. Keep organic mulch back some from basal stems of the crop to avoid promoting crown decay. Geotextile can be placed along the sides of newly planted stock. The geotextile materials must be placed close to the plant to reduce the number weeds will grow around the base of the plant. It is often beneficial to combine geotextile and organic mulches to achieve good coverage and reduce ultraviolet degradation of the geotextile.

SPECIAL WEED PROBLEMS FOR FIELD-GROWN TREES AND SHRUBS (7/20)

LITTLE MALLOW (Cheeseweed)

Cheeseweed is a winter annual or biennial that forms hard seed that can remain dormant for long periods of time. It generally germinates in fall after rainfall or an irrigation, but it may germinate any time during winter and spring. The germinating seed is controlled by most preemergence herbicides, especially oxadiazon and oxyfluorfen. Flumioxazin, indaziflam, and isoxaben are also effective. Oxyfluorfen is also effective applied postemergence to the young plant. Glyphosate is not very effective against this weed.

YELLOW NUTSEDGE

Yellow nutsedge, sometimes call nutgrass, is a perennial sedge that is often confused with a grass. Fumigation before planting is usually effective in controlling this weed. Repeat applications of glyphosate (before the five-leaf stage when new tubers are formed) will reduce populations over time. Bentazon (Broadloom T&O) may be used around some tree species. If the area is left fallow, halosulfuron can be used and then the crop can be planted the next season. Most preemergence herbicides do not control nutsedge, but metolachlor (Pennant) will suppress sprouting of the tubers. Soil solarization will reduce yellow nutsedge but will not eradicate it.

HERBICIDE TREATMENT TABLE FOR CONTAINERS AND FIELD-GROWN TREES AND SHRUBS (7/20)

See table in the previous section.

Field-Grown Flowers

INTEGRATED WEED MANAGEMENT FOR FIELD-GROWN FLOWERS (7/20)

Most weeds are controlled in field-grown flower crops with cultivation, hand-hoeing, preplant fumigation, and herbicides where there is crop safety. Crops are planted in rows to make cultivation easier and to reduce crop damage from the cultivators. The crops may be direct seeded, but are often transplanted as bulbs or plugs; transplants are more tolerant to handling and herbicides than direct-seeded crops. After establishment, the crops can be cultivated two or three times before the crop canopy closes and the crop begins to compete with the weeds. Some handweeding is usually required to remove all of the weeds.

Crop rotation is beneficial to reduce weeds in the crop. When the same crop is grown year after year, the population of weed species that escape normal cultural practices increases. Good rotation crops are barley, oats, or wheat in winter and corn or sudangrass in summer.

Mulch
Unless the crop is sprinkler irrigated, a dust mulch often is created that keeps the soil surface dry and reduces the germination and establishment of annual weeds. Organic mulches used around transplants can reduce weeds if the light cannot reach the soil. Fine mulches (composted yardwaste) applied 1-1/2 to 2 inches deep before the weed seeds germinate or when weeds are still in the seedling stage will control most of the weeds. If the mulch is coarse, 3 to 6 inches may be required to completely eliminate light from the soil, but unlike fine mulch, they do not allow weed seed germination in the mulch. Bulbs such as Dutch iris may be good candidates for mulching for weed control. They have a large food reserve to push through the mulch and may have better growth after mulching. With some crop species, having a fine mulch right around the base of the plant may result in disease damage to plants. Mulches should not be used if they contain weed seed or plant propagules (e.g., bulbs, rhizomes, or tubers).

Soil Solarization
Solarization effectively controls many weed species before planting. Solarization must be done during periods of high solar radiation and temperature. Before placing the plastic on the site to be treated, closely mow any established plants, remove the clippings, and then water the area well. Place clear polyethylene that is ultraviolet (UV) resistant over the area, extend it about 2 feet beyond the infested area on all sides, and pull it tightly close to the soil. The plastic must be left in place and maintained intact for 4 to 6 weeks for control of weeds. Many annual weeds can be controlled using this method. Weeds not well controlled include field bindweed, purple and yellow nutsedge, and sweet clover. In areas where solar radiation and temperatures are low and marginal for solarization, purslane is not controlled well.

Flaming
Shielded propane burners effectively control young weeds between rows without disturbing the soil and bringing weed seeds to the soil surface as cultivation would do. Flaming controls broadleaf weeds better than grasses.

Herbicides
Most crops have one or more selective preemergence herbicides available for use. See the table TREATMENT FOR FIELD-GROWN FLOWERS for selective herbicides that are registered on flower crops. Postemergence herbicides (fluazifop-p-butyl, sethoxydim) can be used to control some grasses in broadleaved crops. These are applied after the weeds emerge but while they are still small (1–3 inches in height). If weeds are larger than 3 inches, more herbicide will be required and some weeds may not be controlled. Broadleaf herbicides are generally not safe enough to use over flower crops. Even some selective grass herbicides may injure the crop if treated during the flowering stage. Control weeds when they are small and before they flower and set seed. If a few weeds remain, hand weed them.

Herbicides can be used before the crop is planted. The broad-spectrum fumigants dazomet, metam potassium*, and metam sodium* can be used on prepared beds to control weeds and other soilborne pests. Depending on which fumigant is used, crops can be planted within days or in 2 to 4 weeks to allow time for the fumigant to dissipate. (* Permit required from county agricultural commissioner.)

Another method before planting is called a "stale seedbed" treatment. Beds are prepared for planting and irrigated to germinate weeds. After most of the weeds have germinated, a postemergence herbicide like diquat or glyphosate is applied to kill the weeds. Because no cultivation is done before planting, no new weed seeds are brought to the surface. This "irrigate, germinate, eliminate" approach may be repeated two or more times before planting the crop to reduce the seed populations in the soil.

Preemergence herbicides also can be applied after seeding or transplanting a crop but before the weeds emerge. These herbicides generally must be incorporated mechanically along the planted row or leached slightly into the soil by rainfall or 1/2 inch irrigation after application. See specific comments on the herbicides in the table TREATMENT FOR FIELD-GROWN FLOWERS.

After the annual flower crop has been harvested, clean up any weeds before they set seed. This can be done most effectively by cultivating. If the field is not needed until the next season, it may be beneficial to plant a cover crop to reduce weeds, keep the soil from eroding, reduce dust, and maintain organic matter in the soil.

HERBICIDE TREATMENT TABLE FOR FIELD-GROWN FLOWERS (7/20)

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. The following are listed alphabetically. When choosing a pesticide, consider information relating to environmental impact, resistance management, the pesticide's properties, and application timing. Tank mixes may be necessary to achieve desired control; see the table SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTROL for information on specific weed control. Always read the label of the product being used.

PREEMERGENCE HERBICIDES

A. ISOXABEN
(Gallery 75DF) — See label — 12 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 21
COMMENTS: Excellent herbicide for broadleaf weed control. Major weakness is annual grass control. Therefore, it is often mixed with oryzalin or trifluralin. Some broadleaf weed species can be controlled for up to 18 months with the labeled rates. Isoxaben does not effectively control Malvaceae (mallows). Some herbaceous ornamentals such as *Digitalis*, snapdragon, and *Veronica* may be killed by postplant, preemergence applications of isoxaben.

B. NAPROPAMIDE
(Devrinol DF-TX Ornamental) — See label — 24 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 15
COMMENTS: Works best if mechanically incorporated or followed by rainfall or a sprinkler irrigation of 1/2 inch within 7 days after application. The first irrigation seems to be critical for maximum activity. It is an excellent grass herbicide and can suppress common groundsel. Generally less efficacious but often safer than the combination herbicides. Is safer if applied after transplanting. If the soil is moist and there is no rainfall or irrigation within 7 days following application, an appreciable amount of the herbicide is lost and weed control will be lessened.

C. ORYZALIN
(Surflan AS Specialty) — See label — 24 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3
COMMENTS: A relatively broad-spectrum preemergence herbicide. Can be applied up to 21 days prior to rainfall or before irrigation that is needed to move it into seed zone. Needs 1/2 inch of irrigation or rain to move it to appropriate depth. Controls annual grasses and many broadleaf weeds and can be used safely on some crops after transplanting. Leaches slightly into the soil with irrigation or rainfall. A strong root inhibitor. Many broadleaf ornamentals are tolerant to oryzalin if the herbicide is not in the root zone. Even when applied at rates of 4 lb a.i./acre, sometimes weeds in the aster family (common groundsel, fleabane, prickly lettuce, sowthistle), mustard family (bittercress), and legume family (burclover) are not completely controlled. For most labeled weeds, control usually is effective for 2–3 months. Oryzalin can control spotted oxalis and spurge from seed for about 4 months. Tolerance is marginal on some crops; thus, use low rates until familiar with the herbicide and crop combination.

D. OXADIAZON
(Ronstar G) — See label — 12 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 14
COMMENTS: A broad-spectrum preemergence herbicide that is used during the growing season from spring until fall. It is moved off crop foliage and into the soil by a sprinkler irrigation following application. Oxadiazon is a shoot-girdling herbicide. The granular formulation is safer than the wettable powder. It is weak on all of the chickweed family and on certain broadleaves including chickweed, horseweed, and pearlwort. Has a relatively long residual, 12–16 weeks, but if cultivated control will be lost. It is very effective when applied in fall or spring. Does not leach readily in the soil, is not a root inhibitor, and thus is less likely to injure established species. Injury may occur if applied to wet foliage, if it is not washed from the foliage, or if the granules collect in leaf bases or crowns.

E. PENDIMETHALIN
(Pendulum 2G) — See label — 24 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3
COMMENTS: Gives excellent grass control and will control many broadleaf weeds. Controls a broad-spectrum of broadleaf and grass weeds that is similar to what oryzalin controls. It is often combined with an additional herbicide to widen the spectrum of weeds controlled. Though it is a root inhibitor, it is less injurious to roots than oryzalin or prodiamine.

F. PRODIAMINE
(Barricade) See label 12 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3
COMMENTS: Prodiamine is stable on the soil surface. It also has been less effective for spurge and groundsel suppression than some other dinitroaniline herbicides. Inhibits root growth.

G. TRIFLURALIN
(Lebanon Treflan) See label 12 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3
COMMENTS: In the same class of herbicides as oryzalin (dinitroanilines), but it is not as stable on the soil surface and must be incorporated with cultivation or irrigation. At low rates trifluralin has been used as a preplant incorporated herbicide for some direct-seeded crops but is safer for use before transplanting.

PREEMERGENCE COMBINATIONS
Note: For tank mixes, observe all directions for use on all labels, and employ the most restrictive limits and precautions. Never exceed the maximum active ingredient (a.i.) on any label when tank mixing products that contain the same a.i.

A. ORYZALIN/OXYFLUORFEN
(Rout) See label 24 NA
WSSA MODE-OF-ACTION GROUP NUMBERS[1]: 3/14
COMMENTS: Limited registrations for field-grown flowers. Woody plants are more tolerant than herbaceous plants. Provides excellent broad-spectrum control of annual broadleaf and grass weeds. If granules remain in plants at the base of the leaf or in whorls, burn will occur. Residual control is 3–4 months.

POSTEMERGENCE HERBICIDES
Nonselective

A. DIQUAT
(Reward) See label 24 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 22
COMMENTS: Labeled for use as a preplant treatment and directed postemergence use in field grown ornamentals. Kills annuals weeds, but only burns off the top of perennials. Controls young annual weeds with contact activity only; affects only green tissue.

B. GLYPHOSATE
(Roundup Pro) See label 4 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 9
COMMENTS: Labeled for use before planting. A systemic herbicide that translocates to the roots and growing point of the plants and kills the entire plant. Effective on both annual and perennial weeds. Contact with leaves of the ornamentals will result in injury to the plant. Glyphosate activity is increased in low water volumes. For example, greater activity is obtained at 20 gal/acre than at 50 gal/acre. Can be used alone or combined with a preemergence herbicide. Often takes 7 or more days after application for complete control. Avoid drift.

C. PARAQUAT*
(Gramoxone SL 2.0) See label 24 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 22
COMMENTS: For harvest aid and desiccation applications, preplant or preemergence (broadcast or banded), and postemergence directed spray. Controls young annual weeds with contact activity only; affects only green tissue.

D. PELARGONIC ACID
(Scythe) See label 12 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 26
COMMENTS: Labeled for use preplant. Controls young annual weeds by contact activity only; affects only green tissue. Must be applied at high rates in high volumes of water. Kills annual weeds, but only burns off the top of perennials. Does not move in plant. Very rapid activity (minutes in high sunlight).

Selective (grasses)

A. CLETHODIM
(Envoy Plus) See label 24 NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1
COMMENTS: Controls most annual grasses, including annual bluegrass. Safe to use over most broadleaf ornamentals.

B. FLUAZIFOP-P-BUTYL
(Fusilade II) See label 12 NA

	(Ornamec)	See label	4	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1
COMMENTS: Postemergence contact selective herbicide for use in field grown ornamentals. Kills most annual and perennial grasses, however it will not control annual bluegrass or hard fescue. It is most effective on young actively growing grasses and less effective on mature grasses. Ornamec Over-The-Top not for use on certain ornamental species in California; see label.

C. SETHOXYDIM

(Poast)	See label	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 1
COMMENTS: Controls most annual grasses, except annual bluegrass or hard fescue. Most effective on young, actively growing grasses. A nonphytotoxic oil or nonionic surfactant must be added for best control.

* Permit required from county agricultural commissioner for purchase or use.

1 Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode-of-action numbers are useful in planning mixtures or rotations of herbicides with different modes of action. For more information, see http://www.hracglobal.com.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

NA Not applicable.

Greenhouse-Grown Crops

INTEGRATED WEED MANAGEMENT INSIDE GREENHOUSES (7/20)

It is difficult to control weeds in greenhouses because the types of plants grown are generally sensitive to herbicides and weeds are often hard to reach with an herbicide application. Only one preemergence herbicide is registered for use in greenhouses (indaziflam) and that is for beneath benches and greenhouse floors only. Only a few weed species are common problems in greenhouses. They are all closely associated with high moisture and nutrients and spread rapidly if they are allowed to become established.

The most common weeds in and around greenhouses include annual bluegrass, common chickweed, creeping woodsorrel, lesser-seeded bittercress, liverwort, moss, and pearlwort. Others that may be present include cheeseweed, cudweed, fireweed, prostrate and spotted spurge, sowthistle, and willowherb. Controlling these weeds will also help reduce the reservoir of insects and plant pathogens that are often associated with weeds.

Reducing standing water or high moisture around the interior perimeter of the greenhouse will help control these weeds as they often become established there and can spread from those habitats.

Cultural Control
Sanitation is the best method for weed control. Weeds may be brought into the greenhouse in potting mix or with cuttings, bulbs, or other plant material or on dirty pots and tools. If weeds do get in, they should never be allowed to flower and seed. This is especially true of bittercress and creeping woodsorrel (oxalis). Maintain trash cans in the greenhouse for weeds that are pulled during maintenance, so they can be readily removed before flowering. Hand-weed frequently (daily or weekly) so no weeds go to seed. If the floors are concrete, regularly wash or sweep away soil that drops to the floor so that weeds will not establish or seed. When crops are rotated, clean weeds out of the greenhouse and clean benches, tubing, and walls to remove seeds that may be sticking to them. Irrigate with water that is free of fungal spores and weed seeds.

If using raised or self-contained beds, pasteurize the soil before planting by either steaming or solarizing. Solarization is described in GENERAL METHODS OF WEED MANAGEMENT and steam fumigation in CONTAINER NURSERIES.

Herbicides
Only Marengo (indaziflam) is currently available for preemergence use in greenhouses and **only under benches or on the floor, not in the container**. Many of the other preemergence herbicides are quite volatile at greenhouse temperatures and can move or accumulate or both in greenhouses to levels toxic to crop plants. Even though some herbicides may be labeled for use in a crop, **the label must specifically state that it can be used in greenhouses to be legal and safe.**

On the greenhouse floor and under the benches a postemergence herbicide can be used to reduce weed populations and to keep the weeds from flowering and seeding. Provide good drainage and level the gravel or soil under the benches to reduce water collecting in low areas. Wet areas increase the chance of liverwort and moss infestations. Air movement at the floor level will help dry off the floor and will also reduce the chance of infestations of weeds favored by wet areas. After a crop has been harvested, remove any weeds to keep them from seeding so new seeds will not be added to the seedbank in soil.

SPECIAL WEED PROBLEMS INSIDE GREENHOUSES (7/20)

LIVERWORT AND MOSSES

Liverwort and mosses can be found in many greenhouses where plants are highly irrigated and fertilized. Their presence is exacerbated when there is high nitrogen in the upper soil surface, such as by top-dressing. These types of plants reproduce by spores and vegetatively and are easily spread throughout a greenhouse. They can compete with the crop for nutrients and water and can also create a barrier on the potting media surface that restricts water movement into the container resulting in poor irrigation efficiency and increased runoff. Decreasing the amount of water applied and avoiding top-dressing, as well as inspecting plants before they come into the greenhouse, can reduce the presence and impact of liverwort and mosses.

HERBICIDE TREATMENT TABLE FOR INSIDE GREENHOUSES (7/20)

Common name (Example trade name)	Amount to use	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. The following are listed alphabetically. When choosing a pesticide, consider information relating to environmental impact, resistance management, the pesticide's properties, and application timing. Tank mixes may be necessary to achieve desired control; see the table SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTOL for information on specific weed control. Always read the label of the product being used.

PREEMERGENCE HERBICIDES

A. Indaziflam

(Marengo)	7.5-15.5 fl oz/acre	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 29
COMMENTS: Very long residual. For use under benches and greenhouse floors only. Do not exceed 18.5 fl oz in a 12 month period.

POSTEMERGENCE HERBICIDES

A. DIQUAT

(Reward)	Spot application: 1–2 qt plus 8–16 oz nonionic surfactant/100 gal water Broadcast: 1–2 pt plus 16–32 oz nonionic surfactant/100 gal water	24	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 22
COMMENTS: Apply in 15–40 gal water/acre. Do not allow contact of spray or drift to desirable foliage.

B. GLUFOSINATE

(Finale)	Spot application: 1.5 fl oz/1 gal water Broadcast application: 3 qt when weeds less than 6 inches tall *or* 4 qt when weeds are 6 inches or taller	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 10
COMMENTS: Apply as directed spray under benches or on floors of the greenhouse or around the periphery of the greenhouse. Do not have air circulation fans running. Apply using large droplets and low pressure to avoid drift or contact with green leaves or stems of crop. Do not use in greenhouses with edible crops.

C. GLYPHOSATE

(Roundup Pro)	Spot application: 0.66–1.33 oz product/1 gal water Broadcast application: (annuals) 2 qt–1 gal/100 gal water (perennials) up to 2 gal/100 gal water	4	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 9
COMMENTS: Apply to young weeds under benches along walkways or along the edge of the greenhouses. Use low pressure and large droplets to reduce chance of drift of spray on to leaves of the crop. Do not apply to any runoff water. Turn off air circulation fans during application. Desirable vegetation should not be present during application.

D. PELARGONIC ACID

(Scythe)	See label	12	NA

WSSA MODE-OF-ACTION GROUP NUMBER[1]: 26
COMMENTS: Apply to young weeds under benches, along walkways, or along the edge of greenhouses.

[1] Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode-of-action numbers are useful in planning mixtures or rotations of herbicides with different modes of action. For more information, see http://www.hracglobal.com.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

NA Not applicable.

INTEGRATED WEED MANAGEMENT OUTSIDE GREENHOUSES (7/20)

Control weeds outside the greenhouse to help prevent movement of their seeds into the greenhouse. Weed control in the area around the greenhouse will also reduce the chances that insects and plant pathogens that may live and reproduce on weeds will move into the greenhouse. If insects such as aphids, leafhoppers, lygus bugs, thrips, or whiteflies are abundant on the weeds outside the greenhouse, it may be desirable to control them before the weeds are removed or these insects may move into the greenhouse when the weed host dies.

Weeds outside the greenhouse can be controlled by cultivation or mowing where feasible and with herbicides. Take care when applying herbicide so that it does not move into the greenhouse by drift or runoff. Preemergence herbicides can be used if the soil slopes away from the greenhouse so no soil or water that may contain an herbicide gets into the greenhouse. Vents in the greenhouse and fans should be closed or shut off while herbicide applications are being made so that the herbicide will not be drawn into the greenhouse. Also, volatile herbicides (e.g., oxyfluorfen) should not be used around the outside of a greenhouse.

HERBICIDE TREATMENT TABLE FOR OUTSIDE GREENHOUSES (7/20)

Common name (Example trade name)	Amount per Acre	REI‡ (hours)	PHI‡ (days)

Not all registered pesticides are listed. The following are listed alphabetically. When choosing a pesticide, consider information relating to environmental impact, resistance management, the pesticide's properties, and application timing. Tank mixes may be necessary to achieve desired control; see the table SUSCEPTIBILITY OF WEEDS TO HERBICIDE CONTOL for information on specific weed control. Always read the label of the product being used.

PREEMERGENCE HERBICIDES

A. ISOXABEN
(Gallery 75 DF) — 0.9975 lb — 12 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 21
COMMENTS: Apply preemergence or combine with a postemergence herbicide if young weeds are established. May be combined with other preemergence herbicides to control additional broadleaf weeds.

B. ORYZALIN
(Surflan AS) — 2–4 qt — 24 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3
COMMENTS: Combine with a postemergence herbicide if young weeds are present. May be combined with other preemergence herbicides to control a broader spectrum of grasses and broadleaf weeds.

C. PENDIMETHALIN
(Pendulum 3.3 EC) — 2–3.96 lb a.i. — 24 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3
COMMENTS: Apply preemergence. May be combined with a postemergence herbicide if young weeds are present. May be combined with other preemergence herbicides to control grasses and certain broadleaf weeds.

D. PRODIAMINE
(Barricade) — 0.65–1.495 lb — 12 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 3
COMMENTS: Apply preemergence. May be combined with a postemergence herbicide if young weeds are present. May be combined with other preemergence herbicides to control grasses and certain broadleaf weeds.

POSTEMERGENCE HERBICIDES

A. DIQUAT
(Reward) — 1–2 pt plus 16–32 oz nonionic surfactant/100 gal water — 24 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 22
COMMENTS: Apply 15–40 gal/acre or enough to wet young weeds. Apply when weeds are young for improved control.

B. GLUFOSINATE
(Finale) — Spot application: 1.5 fl oz/1 gal water
Broadcast application: 3 qt when weeds are less than 6 inches tall *or* 5 qt when weeds are 6 inches or taller. — 12 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 10
COMMENTS: Apply as directed spray under benches or on floors of the greenhouse or around the periphery of the greenhouse. Do not have air circulation fans running. Apply using large droplets and low pressure to avoid drift or contact with green leaves or stems. Do not use in greenhouses with edible crops.

C. GLYPHOSATE
(Roundup Pro) — Annuals: 2 qt–1 gal/100gal water
or 0.66–1.33 oz/gal water
Perennials: see comments — 4 — NA
WSSA MODE-OF-ACTION GROUP NUMBER[1]: 9
COMMENTS: Apply lower rates to young weeds. Apply to perennials when in flower stage and the soil moisture is sufficient to maintain active growth of the weeds.

[1] Group numbers are assigned by the Weed Science Society of America (WSSA) according to different modes of action. Although weeds may exhibit multiple resistance across many groups, mode-of-action numbers are useful in planning mixtures or rotations of herbicides with different modes of action. For more information, see http://www.hracglobal.com.

‡ Restricted entry interval (REI) is the number of hours (unless otherwise noted) from treatment until the treated area can be safely entered without protective clothing. Preharvest interval (PHI) is the number of days from treatment to harvest. In some cases, the REI exceeds the PHI. The longer of two intervals is the minimum time that must elapse before harvest.

NA Not applicable.

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PRECAUTIONS FOR USING PESTICIDES

Pesticides are poisonous and must be used with caution. READ THE LABEL BEFORE OPENING A PESTICIDE CONTAINER. Follow all label precautions and directions, including requirements for protective equipment. Apply pesticides only on the crops or in the situations listed on the label. Apply pesticides at the rates specified on the label or at lower rates if suggested in this publication. In California, all agricultural uses of pesticides must be reported. Contact your county agricultural commissioner for further details. Laws, regulations, and information concerning pesticides change frequently. This publication reflects legal restrictions current on the date next to each pest's name.

Legal Responsibility. The user is legally responsible for any damage due to misuse of pesticides. Responsibility extends to effects caused by drift, runoff, or residues.

Transportation. Do not ship or carry pesticides together with food or feed in a way that allows contamination of the edible items. Never transport pesticides in a closed passenger vehicle or in a closed cab.

Storage. Keep pesticides in original containers until used. Store them in a locked cabinet, building, or fenced area where they are not accessible to children, unauthorized persons, pets, or livestock. DO NOT store pesticides with foods, feed, fertilizers, or other materials that may become contaminated by the pesticides.

Container Disposal. Dispose of empty containers carefully. Never reuse them. Make sure empty containers are not accessible to children or animals. Never dispose of containers where they may contaminate water supplies or natural waterways. Consult your county agricultural commissioner for correct procedures for handling and disposal of large quantities of empty containers.

Protection of Nonpest Animals and Plants. Many pesticides are toxic to useful or desirable animals, including honey bees, natural enemies, fish, domestic animals, and birds. Crops and other plants may also be damaged by misapplied pesticides. Take precautions to protect nonpest species from direct exposure to pesticides and from contamination due to drift, runoff, or residues. Certain rodenticides may pose a special hazard to animals that eat poisoned rodents.

Posting Treated Fields. For some materials, *restricted entry intervals* are established to protect field workers. Keep workers out of the field for the required time after application and, when required by regulations, post the treated areas with signs indicating the safe re-entry date. Check with your county agricultural commissioner for latest restricted entry interval.

Preharvest intervals. Some materials or rates cannot be used in certain crops within a specified time before harvest. Follow pesticide label instructions and allow the required time between application and harvest.

Permit Requirements. Many pesticides require a permit from the county agricultural commissioner before possession or use. When such materials are recommended, they are marked with an asterisk (*) in the treatment tables or chemical sections of this publication.

Processed Crops. Some processors will not accept a crop treated with certain chemicals. If your crop is going to a processor, be sure to check with the processor before applying a pesticide.

Crop Injury. Certain chemicals may cause injury to crops (phytotoxicity) under certain conditions. Always consult the label for limitations. Before applying any pesticide, take into account the stage of plant development, the soil type and condition, the temperature, moisture, and wind. Injury may also result from the use of incompatible materials.

Personal Safety. Follow label directions carefully. Avoid splashing, spilling, leaks, spray drift, and contamination of clothing. NEVER eat, smoke, drink, or chew while using pesticides. Provide for emergency medical care IN ADVANCE as required by regulation.

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