



# University of California UCNFA News



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## Management of Downy and Powdery Mildews: Three New Diseases Hit California

by Deborah M. Mathews

### Introduction and Overview

Although the names sound similar and they both produce fuzzy growth on leaves, the pathogens that cause the diseases known as downy mildew and powdery mildew are quite distinct. Powdery mildews have a long history in California and are easily one of the top diseases growers have to deal with. Rose, verbena and crepe myrtle all are common hosts. Downy mildews are equally common; however, over the last few years three devastating diseases caused by downy mildew pathogens have been found in the United States and have recently made their way to California. Impatiens, coleus and basil are all being affected by different organisms but the result is the same: loss of the crop.

Downy mildews **are not fungi**; they are in a different taxonomic group or kingdom which contains the water molds, the same group that *Phytophthora* and *Pythium* species are in. The downy mildews produce lavender, brownish, gray or white spores on the lower surfaces of leaves (fig. 1). Angular yellow spots develop on the upper surfaces, which may become brown and result in defoliation and plant death in severe infections. These pathogens prefer cooler temperatures (45 to 70°F) and humidity above 85%; spore production and infection depend on the presence of free water.

In contrast, powdery mildew is caused by several true fungi and their white-to-gray mycelium and spores are primarily found in round spots on the upper surfaces of leaves (fig. 2), but many can also be found on the lower surfaces and other plant

### Editor's Note

This issue focuses on plant diseases and disease management. Deborah Mathews' feature article and her "Disease Focus" column, as well as the regional reports from farm advisors, highlight some plant diseases that are new to California, including downy mildews of impatiens, coleus and basil; boxwood blight; citrus greening; and Phormium anthracnose. Identification and management of other diseases and disorders is also described in our regional reports and feature article, as well as in Don Merhaut's "Get Cultured." In addition to our featured topic on diseases, Richard Evans's "Science to the Grower" and Jim Bethke's "Insect Hot Topics" provide important information on weed and insect pests.

♦ Steve Tjosvold and Julie Newman

## MANAGEMENT OF POWDERY MILDEWS: continued from page 1



**Fig. 1.** Lavender sporulation of downy mildew (*Peronospora* spp.) on lower surface of leaf. Photo by Dennis H. Hall, courtesy of UC Statewide IPM Program.



**Fig. 2.** Powdery mildew on upper surface of periwinkle leaf. Photo by Deborah Mathews.

parts. Symptoms are unsightly and can cause distortion, but rarely death. Powdery mildews prefer moderate temperatures (68 to 86°F) and relative humidity of 95%, but do not require free water to reproduce.

An accurate diagnosis is critical for successful management of downy and powdery mildew diseases. However, keep in mind that both types of pathogens can occur at the same time on the same host, making diagnosis more difficult. This article will help you in the identification of these diseases and the implementation of a management program to minimize their effect.

### New Downy Mildew Diseases

**Basil.** On basil, downy mildew is caused by *Peronospora belbahrii* (fig. 3), a quarantined pathogen in California, meaning that all plants must be destroyed when the pathogen is detected. In 2011 *P. belbahrii* was found by the California Department of Food and Agriculture (CDFA) at several large retail locations in multiple counties and was traced to seed lots, at least some of which were imported from Italy. Since 2009 there have been several detections of this disease in California, primarily in San Diego and the Central Coast regions, due to their permissive climates.

In early infections this downy mildew disease can be mistaken for a nutritional deficiency since mild yellowing of the leaves is the first symptom to appear and because the spores are only visible on the lower surfaces of the leaves; it can go unnoticed until it has already become established and it is too late for control. In addition to being seed-borne, the spores can be dispersed in the air, spreading rapidly in the field and the greenhouse. Chemical controls are somewhat limited for edible varieties, but check labels for permitted uses. Other control strategies are addressed in the management section below.

**Coleus.** In coleus, a new form of downy mildew has been appearing since 2006 that is difficult to control. It causes the typical sporulation on the undersides of leaves, but brown and black splotches of tissue appear on the upper sides; the leaves curl, defoliating readily (fig 4) and seedlings are stunted. All cultivars tested seem to be susceptible; little natural resistance is available, although disease severity does vary with the cultivar and some are only



**Fig. 3.** Downy mildew on field-grown basil (A) and dark lesions on upper surfaces of greenhouse-grown plant (B) caused by *Peronospora belbahrii*. Photos by Margery Daughtrey, Cornell University (A) and Cheryl Blomquist, CDFA (B).



### MANAGEMENT OF POWDERY MILDEWS: continued from page 2

mildly affected. The pathogen is in the genus *Peronospora* but experts have not settled on a species designation — it is similar in many ways to *P. belbahrii*, but different in others.

Scouting and managing this disease is difficult because it has the ability to remain somewhat dormant and invisible to the eye until the environment is just right; however, once conditions are conducive, symptoms can develop virtually overnight. It is recommended that coleus plants are not kept in the greenhouse between crop cycles due to the pathogen's ability to harbor symptomless infections when the environment isn't optimum for disease development. This pathogen is not seed-borne, but seedlings are very susceptible to spores coming from other infected plants, so seed-grown plants should be kept separately from mature plants or vegetatively propagated stocks.

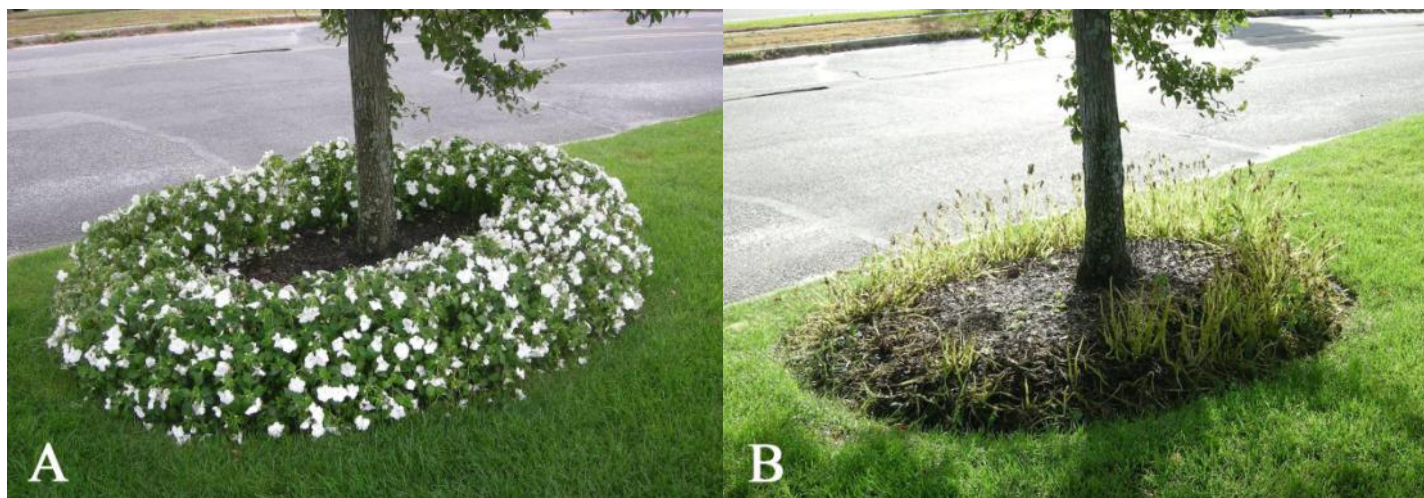
**Impatiens.** Impatiens (*Impatiens walleriana*) in greenhouses has been



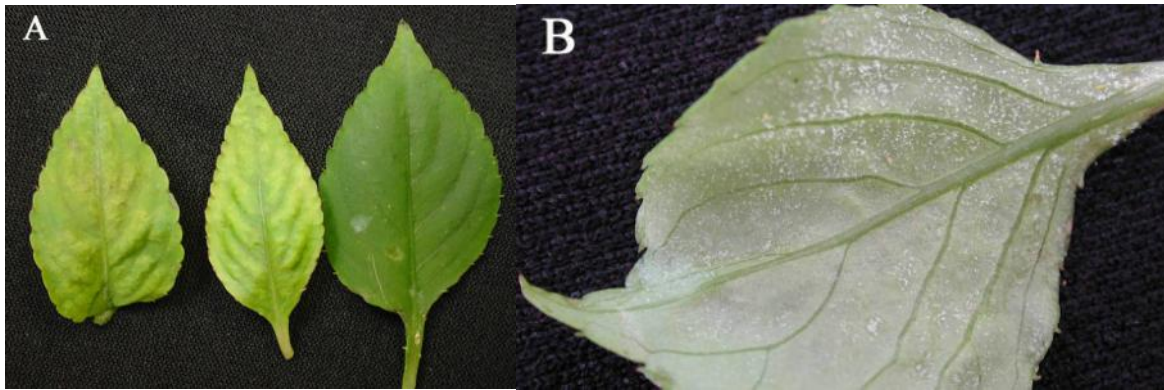
**Fig. 4.** Downy mildew of coleus causing dark spots on the upper surface of leaves (A) and curling with sporulation on the undersides of the leaf (B). Photos by Margery Daughtrey, Cornell University

known to get downy mildew for years, but has only recently been severely affected in the landscape by *Plasmopara obduscens*. New Guinea impatiens is not affected by this disease, nor are other common bedding plants. On the east coast and across the United States last fall, major plantings of *I. walleriana* were destroyed by downy mildew. It was also found last year in the central and southern coastal regions of California.

This disease develops rapidly. Fig. 5 shows a planting of apparently healthy impatiens around a street tree (A), only to be decimated 5 weeks later (B). The pathogen, *P. obduscens*, is different from the downy mildew pathogens that attack basil and coleus since it not only produces airborne spores, but also swimming zoospores and oospores, which are long-term survival structures that can overwinter in the soil from infected leaf and flower debris. The production of oospores means that plant material should not be composted to avoid carryover of the disease.



**Fig. 5.** Devastation of impatiens in a landscape planting as downy mildew was first detected (A) and after 5 weeks (B). Photos by Margery Daughtrey, Cornell University.

**MANAGEMENT OF POWDERY****MILDEWS:** continued from page 3

**Fig. 6. Early symptoms ofimpatiens downy mildew. A) stunting, yellowing of leaves; healthy leaf on right and B) sporulation on underside ofimpatiens leaf. Photos by Margery Daughtrey, Cornell University.**

For impatiens grown in greenhouses, care should be taken to remove any landscape plantings of impatiens on the property so that if they become infected, spores will not migrate into the greenhouse facility. The disease is not seed-borne, but seedlings are quite susceptible to spores from other locations, especially the cotyledons. The first signs of disease are yellowing of a small number of leaves and stunting, followed by white sporulation on the undersides of leaves, and leaf and flower drop (fig. 6). Early detection is especially critical for this disease since once sporulation starts, chemical control has been shown to be ineffective.

**Management and Control**

You can see that although these diseases may seem similar in name and appearance at first glance, they each have unique differences that make their identification and management separate endeavors. However, both powdery and downy mildews have similar cultural and sanitation strategies to prevent their introduction and reduce their reproduction and spread:

- Use good quality plant and seed material with a history of low disease incidence, selecting varieties with genetic resistance to each disease. Inspect new arrivals and reject or quarantine if in doubt.
- Scout routinely (at least weekly) to identify and remove diseased plants before epidemics can result. For downy mildew, turn leaves over to check for sporulation on the undersides of leaves.

- Reduce humidity by increasing plant spacing and air flow; avoid overhead watering, but if used, apply early in the day to allow for drying of leaves by the afternoon.
- Do not hold plants between crop cycles; remove plant debris and clean benches before new plants are brought in.

Powdery and downy mildews also have similar responses to biological agents used as protectants such as *Bacillus subtilis* (e.g., Serenade, Cease) and *Trichoderma* (e.g., PlantShield). Chemical control measures for these two diseases, however, are quite different and must be considered separately. All of these pathogens are very prone to the development of resistance to most chemicals so proper rotation of the modes of action is critical to maintaining effective control. Chemical applications should be considered preventative since once these diseases get started, curative action can rarely be achieved. As with all chemicals, check the label for use on specific crops and locations.

**Chemicals for powdery mildew.** Contact fungicides work well as preventatives and for early, mild infections, notably potassium bicarbonate compounds and horticultural and neem oils. Phytotoxicity can be a problem with some plants, however, so care should be used before broad scale application. Systemic fungicides include triflumizole (e.g., Terraguard), myclobutanil (e.g., Eagle), the strobilurin group (e.g., Compass O, Insignia, Heritage), which is very prone to inducing resistance in pathogens, and thiophanates (e.g., Cleary's 3336, OHP 6672).

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*Chemicals for downy mildew.* Contact protectants such as mancozeb (e.g., Protect) and copper, alternated or mixed with systemics like mefenoxam (e.g., Subdue MAXX) applied as a drench at the beginning of the season and sprays of dimethomorph (e.g., Stature DM), phosphonates (Aliette), and strobilurins (e.g., Fenstop, Compass O, Insignia, Heritage), have shown good control. Effectiveness of any given chemical depends on the particular downy mildew pathogen present; what works well for one may give minimal control for others. Tank mixes of more than one of these agents in a rotation can be useful.

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**References and Further Reading***Basil downy mildew*

Wyenandt CA, Simon JE, McGrath MT, and Ward DL. 2010. Susceptibility of basil cultivars and breeding lines to downy mildew (*Peronospora belbahrii*). HortScience 45(9): 1416-1419.

<http://vegetablemdonline.ppath.cornell.edu/NewsArticles/BasilDowny.html>

*Impatiens downy mildew*

[http://www.e-gro.org/pdf/Bulletin\\_1-8\\_Impatiens\\_Downy\\_Mildew.pdf](http://www.e-gro.org/pdf/Bulletin_1-8_Impatiens_Downy_Mildew.pdf)

[http://go.ncsu.edu/impatiens\\_downy\\_mildew\\_webinar](http://go.ncsu.edu/impatiens_downy_mildew_webinar) (a 60-minute webinar by Dr. Colleen Warfield of Ball Hort; log in at website as a “guest” to play video).

*Coleus downy mildew*

<http://www.gpnmag.com/downy-mildew-coleus>



# SCIENCE TO THE GROWER: Are liverworts lost in the ozone?

by Richard Evans

The liverwort is unloved. It has the ugliest common name of any plant. Devoid of leaves, stems, or even a vascular system, it barely qualifies as a plant at all. It's considered primitive. It multiplies prolifically. Each archegoniophore, the structure that supports sexually-produced spores, releases up to 7 million spores, which remain viable for over a year (O'Hanlon 1926). (By the way, I'm glad I'm not O'Hanlon, who had to count 7 million liverwort spores.) Liverwort also reproduces asexually: cup-like structures generate a multitude of asexually-produced gemmae, each gemma giving rise to a new plant. Fragments of liverworts also produce new plants.

One liverwort species, *Marchantia polymorpha*, can wreak havoc in nurseries. A mat of liverworts on the surface of a potting substrate impedes water and nutrient entry, leaving the crop plant hungry and thirsty. In addition, liverworts can harbor pests and diseases, including fungus gnats, *Fusarium* and *Pythium*.

Control of liverworts in a nursery is difficult. Hand weeding, in addition to being tedious and expensive, may not be effective unless the top inch or so of substrate is removed. The registered chemicals for postemergent treatment have a spotty record of success against liverwort, depending on conditions during and after treatment. Quinoclamine, an algicide that has performed well in trials, as well as in extensive studies by a graduate student at Auburn University (Newby 2006; Newby and others 2006), will not be registered for use in the United States for human safety reasons.

Two scientists at the University of Guelph recently reported that use of ozone-treated irrigation water may reduce liverwort growth as a side benefit (Graham and Dixon 2012). Based on their previous investigations, which included assessment of ozone-related phytotoxicity in horticultural crops (Graham and others 2009), Graham and Dixon supposed that some of liverwort's primitive characteristics would make it particularly sensitive to ozone. To test their ideas, they grew liverworts on rockwool and subjected it to a range of aqueous ozone concentrations and exposure times. They found that liverwort growth and development were controlled well by applying ozone-treated water five times per week. Although Graham and Dixon didn't simultaneously treat a nursery crop, their previous work showed that the ozone concentrations and exposure times used in this study did not damage select woody nursery plants (Graham and others 2009).

Ozone treatment of irrigation water has its hazards and complications. Most operators use a batch treatment system, in which treated water is stored to allow ozone breakdown before use on crops. Graham and Dixon argue that carefully managed direct application of aqueous ozone in nurseries could provide the ancillary benefit of liverwort control, in addition to the pathogen control that is at the heart of ozone water treatment.

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- Graham T, Dixon MA. 2012. Liverwort control: An ancillary role for ozone-based irrigation water treatment systems? *HortScience* 47: 361-367.
- Graham T, Zhang P, Zheng Y, Dixon MA. 2009. Phytotoxicity of aqueous ozone on five container-grown nursery species. *HortScience* 44: 774-780.
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- Newby A, Altland JE, Gilliam CH, Wehtje G. 2006. Postemergence liverwort control in container-grown nursery crops. *Journal of Environmental Horticulture* 24: 230-236.
- O'Hanlon ME. 1926. Germination of spores and early stages in development of gametophyte of *Marchantia polymorpha*. *Botanical Gazette* 82: 215-222.

# GET CULTURED: When disease symptoms are caused by poor nutritional or cultural practices

by Donald J. Merhaut

It can be difficult to distinguish plant biotic diseases caused by pathogens or insects from various abiotic disorders caused by mismanagement of cultural practices, poor nutrition, or some environmental issue. In the following article, we will help you determine the difference between biotic and abiotic disorders and discuss some of the more common abiotic disorders so that you can properly correct these issues or prevent these problems from happening.

One of the primary differences between biotic and abiotic disorders is that **abiotic disorders are often expressed as a pattern on the plant or in the production bed, unlike biotic disorders which are not.** For example, the deficiency symptom of a specific nutrient is typically expressed on all of the oldest or youngest leaves, depending on the nutrient in question. Usually, if there is a nutrient deficiency, all plants in the production bed will also express the same symptoms. On the other hand, the infestation of aphids will begin on one part of the plant, spreading from the point of initial infestation to other parts of the plant and to plants in proximity of the infected plant in a production bed.

To determine the cause of plant disorders, always take into consideration six factors: (1) *Media* – temperature, hydrophobic/hydrophilic properties, pH, aeration, water holding capacity; (2) *Fertilizers* – amount, type and concentration of nutrients, formulation (liquid, granular, or polymer-coated fertilizers), application methods; (3) *Cultural Practices* – pruning, weed control, staking, greenhouse vs. field production practices, practices involving newly planted liners vs. mature, retail-ready plants, container type and color, use of growth regulators, etc.; (4) *Irrigation Practices* – type (overhead, drip, hydroponic, ebb and flow, hand-watering), scheduling, duration; (5) *Weather and Environmental Conditions* – humidity, wind, light conditions, air temperature, and pollution; (6) *Plant Type* – rooted liners, seedlings, different genera, species and cultivars.

Below is a list of some of the more common abiotic disorders, their symptoms and causes.

**Uniform stunting of healthy plants in entire production bed.** Lack of fertilizer can lead to this type of abiotic disorder symptom. Another cause can be mismanaged cultural practices such as too little or too much water (if no fertilizer is in irrigation water), compacted, poorly aerated media (causing poor root growth), or improper application of growth regulators. This abiotic disorder can also be caused by unsuitable weather or greenhouse environmental conditions for plant growth.

**Entire plant is chlorotic and all plants are chlorotic and stunted in the production bed.** This can be caused by insufficient fertilizer or compacted or poorly aerated soil which is limiting root growth and function. However, if symptoms are not uniform for the entire production bed, a root pathogen is possible.

**Non-uniform plant growth in a production bed.** Sometimes some plants are stunted, some appear normal, and yet others are vigorous. This may be caused by improper blending of fertilizers into the media, so that some plants have insufficient fertilizer, while other plants have enough, and some plants have a lot or too much fertilizer. These symptoms may also be caused by improper application of growth regulators.

**Uniform yellowing of oldest leaves on all plants in the production bed.** This is usually caused by a deficiency of a specific nutrient in the fertilizer program. The nutrient would be one of the mobile elements such as nitrogen, magnesium (fig. 1), potassium, and sometimes immobile elements such as sulfur or molybdenum. With sulfur and molybdenum deficiency symptoms, yellowing may also occur throughout the plant canopy, not just the newest or oldest leaves. The crop manager should check the fertilizer program for an adequate complement of the mobile nutrients mentioned and/or take a tissue sample for nutrient analysis.

**Uniform yellowing of newest growth on all plants in the production bed.** These symptoms are usually indicative of a deficiency of one or more of the immobile plant

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**Figure 1. Magnesium deficiency symptoms in mums appear as a uniform interveinal chlorosis of oldest leaves. Magnesium deficiencies may be caused by lack of magnesium in the fertilizer program or high concentrations of ammonium and potassium relative to magnesium concentrations in the fertilizer regime.**

essential nutrients: calcium, iron, manganese, copper, boron, zinc, sulfur, molybdenum. Media pH also may be a problem since many micronutrients are precipitated as soil pH increases above 6.0 (molybdenum is the exception).

**Uniform yellowing and deformation of newest growth on entire plant and all plants in the production bed.** These symptoms are usually associated with particular immobile micronutrients such as manganese, copper, boron and zinc. Also, when these symptoms are not uniformly expressed in the entire production bed at the same time, insect or pathogen attack of the new growth is feasible.

**Uniform reddening of oldest leaves and stems.** This is a common phosphorus deficiency symptom and may be associated with phosphorus unavailability to growing roots due to improper fertilizer placement or lack of sufficient phosphorus in the fertilizer. Symptoms may also be caused by cold soils or me-

dia, which would limit adequate root growth to take up phosphorus.

**Non-uniform symptoms in a production bed.** Sometimes, abiotic disorders appear to be random in a production bed. For example, a leaking irrigation emitter may cause excessive watering and leaching of nutrients from containers in proximity of the faulty emitter. In this case, plants may become chlorotic only in this area. Low spots in production beds may cause root dieback in waterlogged containers, which may eventually lead to disease. Proper construction of production beds, taking into consideration slope, drainage, and surfaces such as gravel (fig. 2), will allow for necessary drainage after irrigation or rain events.

Dust, wind, and rodents can also cause random abiotic symptoms. Dust that accumulates on foliage of containers near roads (fig 3) may cause necrosis or other damage to foliage. In some areas, field mice and other rodents may chew the bark off of plants at ground level; total girdling will cause wilting followed by whole plant death. Where plants are on individual drippers, rodents and small mammals will chew off dripper tubes to get to the water, especially in areas where water is scarce, which can lead to



**Figure 2. Properly constructed production beds. Soil was compacted to prevent leaching of fertilizers and pesticides into the ground; several inches of gravel were placed on top of the compacted soil to provide drainage of irrigation and rain water away from containers and to minimize the spread of weeds and pathogens in the bed.**



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**Figure 3. Dust blowing up from dirt roads and landing on production beds downwind. Dust on roads can be minimized by gravel or paving, or by spraying roads with water.**

In conclusion, as part of an integrated pest management (IPM) program, it is imperative to keep good records on all aspects of production: weather, fertilizer programs, irrigation programs, pesticide spray programs, management of pests including rodents and other animals in problem areas. Proper record keeping will help minimize the likelihood of abiotic disorders repeating themselves and will also minimize or prevent the introduction of pests and diseases that often attack already weakened or poorly grown plants. Additionally, it is important to begin a nursery operation with a properly designed and constructed production area, including roads, drains, and production beds. Finally, for commonly grown crops, a nutrient analysis of tissue is recommended. When possible, healthy tissue should be compared to unhealthy tissue.

random abiotic disorder symptoms. When it is windy, some plant species blow over; when the foliage hits the ground, it can be predisposed to diseases from the soil. Tall plants, which may easily fall over, should be tied or staked in place in some way.

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## DISEASE FOCUS: Boxwood blight — a new threat to California

by Deborah M. Mathews

A new disease of boxwoods (*Buxus* spp.) was first detected in Connecticut last fall and has since been found in nine eastern states and Oregon, as well as British Columbia and Ontario in Canada. It has been common in Europe and New Zealand for two decades. It has not yet been detected in California, but our industries should become informed on what to look for to ensure early detection and management.

The disease is caused by the fungus *Cylindrocladium pseudonaviculatum* (= *C. buxicola*, *Calonectria pseudonaviculata*). Symptoms include brown leaf spots with dark edges, black cankers on stems, and severe defoliation and dieback (figs. 1-3). Fungal fruiting bodies called sporodochia, which are composed of many sticky spores, are found on the undersides of leaves and on black stem lesions and can be seen with a hand lens. The disease can develop rapidly, within a week, especially in warm, humid environments with a temperature optimum of 77°F, although it is capable of survival in a wide temperature range of 41 to 86°F. Some plants are able to remain symptomless for a few weeks when the amount of inoculum is low and suboptimum weather conditions exist. The disease can occur on all

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**Fig. 1. Boxwood blight getting started; note defoliated leaves in bottom of pot. Photo by Kelly Ivors, North Carolina State University.**



**Fig. 2. Multiple boxwood plants showing severe blight and defoliation. Photo by Kelly Ivors, North Carolina State University.**



**Fig. 3. Close up of dark stem lesions caused by *Cylindrocladium buxicola*, causal agent of boxwood blight. Photo by Mike Munster, North Carolina State University.**

boxwood species, however varieties of *B. sempervirens* seem to be the most susceptible. *C. buxicola* has been shown to also infect *Sarcococca* spp. (fragrant sweet box) and *Pachysandra terminalis* (Japanese spurge), both members of the Buxacea, in the laboratory; other species are being tested for susceptibility. The fungus does not require a wound for entry and can penetrate plants directly or through stomates, but does require high humidity or free water to be present for infection. Overhead watering and tightly spaced plants encourage spread of the disease. The sticky spores can be carried by water and on anything coming into contact with them like tools, equipment, shipping containers, shoes/clothing, etc. Hardened masses of mycelium can survive for years on leaf debris in the soil.

Care must be taken in diagnosing this disease because other pathogens can cause symptoms similar to boxwood blight including *Volutella*, *Phytophthora nicotianae*, *Pratylenchus* root lesion nematodes, and cold injury. Multiple infections by one or more of these with the boxwood blight pathogen further complicates accurate diagnosis. Fungicides cannot control the disease once it starts, but may be useful for preventing or reducing sporulation and spread; research is in progress to assess the most effective chemicals.

The basic management tools include: Know the signs and symptoms of boxwood blight and scout your plants regularly; Inspect plants before unloading and reject problem plants immediately; Limit entry of new plant material and keep isolated from existing plants for 30 to 60 days. If this disease is suspected at your location you should immediately notify your County Agricultural Commissioner, UC Cooperative Extension office or the California Department of Food and Agriculture (CDFA) so that an accurate diagnosis can be made and mitigation steps started.

More information can be found at: <http://boxwoodblight.org>, hosted by the American Nursery and Landscape Association (ANLA). A 45-minute video seminar is available for viewing at this website and multiple articles with information and current best management practices can be found in the "Additional Resources" section.

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## INSECT HOT TOPICS: New scale insect in Hawaii

by James A. Bethke

Invasive insects commonly expand their host range following establishment in new habitats. Here's another example. *Fiorinia phantasma* Cockerell & Robinson (Hemiptera: Diaspididae), an armored scale insect, was originally described from collections from the undersides of *Neolitsea* sp. (Lauraceae) leaves in the Philippines. It invaded Oahu, Hawaii in December 2004, infesting the undersides of wax leaf privet, *Ligustrum japonicum* (Oleaceae). It was collected again in Hawaii on November 2008 on *Pittosporum tobira*, and in September 2011, it was reported as a serious pest on areca palms in the landscape in Maui. Since 2008, this insect has been observed on numerous hosts including those listed in Table 1.

*Fiorinia phantasma* are mussel shaped, similar to the oyster scale. Mature female scales shrink in size, becoming encased within their second instar shed skin. They commonly have distinct red horizontal stripes running across their width (fig.1). However, some vary and have indistinct or pale red dashes, a full red covering, or a full pale yellow to clear covering. When the hard scale is turned over, female insects are yellow with relatively large eggs (1/5 of their body size). Male and female scale can be found intermingled on the undersides of leaves (fig.1), but when populations reach high densities, crawlers begin to colonize the topsides of foliage.

Damage caused by *F. phantasma* is recognizable by the yellow blotches on the upper leaf surfaces of host plants (fig.2). As the scale population increases, intense feeding damage to the leaf causes leaf drop on some plants.

A variety of predators and a parasite have been observed feeding and parasitizing *F. phantasma* in Hawaii. Predators include *Telsimia nitida* (Coccinellidae), *Cybocephalus nipponicus* (Cybocephalidae), *Chrysoperla comanche* (Chrysopidae), and *Aleurodothrips fasciapennis* (Phlaeothripidae). A single species of *Aphytis* sp. (Aphelinidae) emerged from parasitized scales at a rate of about 10%.

Hawaii markets ornamental plant products to California brokers, ornamental plant producers and retail outlets, and a common palm that moves to California is the areca palm, *Chrysalidocarpus lutescens*. If you are importing these palms from Hawaii, you should be careful to isolate incoming shipments until they are assured to be free of this pest.

For more information about *Fiorinia phantasma*, see the following web sites:

[http://scholarspace.manoa.hawaii.edu/bitstream/handle/10125/21682/43\\_59-61.pdf?sequence=1](http://scholarspace.manoa.hawaii.edu/bitstream/handle/10125/21682/43_59-61.pdf?sequence=1)

[http://www.sel.barc.usda.gov/catalogs/diaspidi/Fioriniaphantasma.htm#Fioriniaph%20antasma\\_distrib](http://www.sel.barc.usda.gov/catalogs/diaspidi/Fioriniaphantasma.htm#Fioriniaph%20antasma_distrib)

<http://scholarspace.manoa.hawaii.edu/handle/10125/21682>

<http://hawaii.gov/hdoaladmin-rules/pi/ppc/npa-1/Fiorinia%20phantasma%20NPA.pdf>

[http://www.wpdn.org/webfm\\_send/233](http://www.wpdn.org/webfm_send/233)

Photos are provided by Dr. Arnold Hara, Department of Plant and Environmental Protection Sciences, Beaumont Research Center, University of Hawaii.

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**INSECT HOT TOPICS:** continued  
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**Table 1. Documented host plants of *Fiorinia phantasma* Cockerell & Robinson.**

<i>Chrysalidocarpus lutescens</i>	Arecaceae	golden cane palm or areca palm or butterfly palm
<i>Cocos nucifera</i>	Arecaceae	coconut palm
<i>Hyophorbe lagenicaulis</i>	Arecaceae	bottle palm
<i>Veitchia merrillii</i>	Arecaceae	Christmas palm or Manila palm or Adonidia
<i>Wodyetia bifurcata</i>	Arecaceae	Foxtail palm
<i>Calophyllum inophyllum</i>	Clusiaceae	Ponnaakam or Punna or Ponne
<i>Cassia</i> sp.	Fabaceae	Cassia
<i>Heliconia caribaea</i>	Heliconiaceae	Heliconia or lobster claw
<i>Ficus benjamina</i>	Moraceae	weeping fig or Benjamin's fig or Ficus tree
<i>Myoporum sandwicense</i>	Myoporaceae	<i>Naio</i> or bastard sandalwood or false sandalwood
<i>Noronhia emarginata</i>	Oleaceae	Madagascar olive
<i>Pandanus tectorius</i>	Pandanaceae	thatch screwpine or Hala or Bacua or Vacquois
<i>Murraya paniculata</i>	Rutaceae	orange jessamine
<i>Ravenala madagascariensis</i>	Strelitziaceae	traveller's tree or traveller's palm
<i>Neolitsea</i> sp.	Lauraceae	
<i>Machilus</i> sp.	Lauraceae	



**Fig. 1. Female (striped) and male (white) *Fiorinia phantasma* on the undersides of areca palm. Photo by Dr. Arnold Hara.**



**Fig. 2. Damage on the upper surface of areca palms. Photo by Dr. Arnold Hara.**

## UC Cooperative Extension San Benito and Santa Clara Counties

### REGIONAL REPORT: Regulatory Updates

by Maria de la Fuente, PhD

#### European Grapevine Moth Update (EGVM)

**E** GVM was first detected in the United States in the Napa Valley in October 2009. The pest (*Lobesia botrana*) is found in Southern Europe, North Africa, Anatolia, the Caucasus and Chile where it causes serious damage in grapes. Trapping and quarantines have therefore been established in a number of counties in California. Although the literature indicates that some ornamentals may be hosts, so far only flowers of olive trees adjacent to vineyards have been found to be infested by EGVM in California. However, it still is feared that ornamentals may harbor the pest and move it with shipments on infested hosts even if EGVM may not be a particularly damaging pest on ornamentals. Since it is not clear how important nursery hosts are to the movement of EGVM, for now regulatory authorities are emphasizing the control of the most obvious path of movement — on grape plants and fruit. Nursery growers that produce fruit trees, grapes and other known hosts of EGVM should be monitoring for this pest.

The EGVM Technical Working Group (TWG) convened in Sacramento to meet and discuss the year's program activities and to make recommendations for the program's continued progress in 2012. The TWG is composed of scientists from around the world who have experience with controlling EGVM in their home countries; their role is to make recommendations to the California Department of Food and Agriculture (CDFA) and the United States Department of Agriculture - Animal and Plant Health Inspection Service (USDA-APHIS) on how to best go about the eradication efforts here in California.

The TWG's recommendations have been reviewed by the USDA and CDFA and those that were adopted include lifting the quarantine regulation from the counties of Fresno, Mendocino, Merced and San Joaquin effective March 8, 2012 and reducing the quarantine areas throughout the State from 5 miles surrounding detections to 3 miles from detections. *Rubus* spp. (blackberries, raspberries) have been removed from the EGVM host list.

The counties of Santa Clara, Santa Cruz and Nevada will be deregulated after the 2012 season if: (1) No further EGVM detections are made; (2) EGVM trapping is conducted at 25 traps per square mile throughout the 2012 season; (3) EGVM trapping within 500 meters of detections made in 2010 and 2011 is conducted at 100 traps per



Adult female European grapevine moth (EGVM) *Lobesia botrana* (left) and larvae (right). Earlier stages of EGVM larvae are tan to yellow-brown (top). Later stages become dark colored (bottom). Photos by J. K. Clark, Courtesy of UC IPM.

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square mile for at least two generations prior to deregulation; (4) Treatment for EGVM control are made during the first and second generations of 2012 (May/June and July/August) in all vineyards within 500 meters of detections; (5) No mating disruption is used during 2012.

The Santa Clara County EGVM detection program has deployed traps in vineyards throughout the county as well as within the three-mile quarantine area. The traps will be serviced every two weeks through mid-October 2012. In 2012, growers will apply treatments to grapes growing within a 500-meter radius from EGVM detections. Non-commercial grape growers within this treatment area will again have the choice of having treatment of *Bacillus thuringiensis* (Bt) or flowers/fruit removal by CDFA staff. Commercial grape growers within the treatment area will conduct first and second generation EGVM control treatments, just as in 2011. Degree-day modeling will determine when treatments will be made. The University of California created a degree-day website for EGVM infested areas. The site has not been updated for the 2012 season, but can be viewed and bookmarked for future use at the UC Cooperative Extension Sonoma county's web site <http://cesonoma.ucdavis.edu/files/84650.pdf>.

The Santa Clara County quarantine boundaries have been substantially reduced in 2012, freeing several growers from commodity shipping restrictions. These growers are being contacted by their District Biologist and informed of the modified restrictions.

For additional information on EGVM, view the University of California's IPM guideline at: <http://www.ipm.ucdavis.edu/EXOTIC/eurograpevinemoth.html>. An article on the potential impact of this pest for nursery growers was published in Steve Tjosvold's Regional Report for the winter 2011 edition of *UCNFA News*: [http://ucanr.org/sites/UCNFAnews/Regional\\_Report\\_Santa\\_Cruz\\_Monterey\\_Cos/](http://ucanr.org/sites/UCNFAnews/Regional_Report_Santa_Cruz_Monterey_Cos/).

Maps of the quarantine and related information may be found online at:  
[http://www.cdca.ca.gov/phpps/PE/InteriorExclusion/egvm\\_quarantine.html](http://www.cdca.ca.gov/phpps/PE/InteriorExclusion/egvm_quarantine.html)  
[http://www.aphis.usda.gov/plant\\_health/plant\\_pest\\_info/eg\\_moth/index.shtml](http://www.aphis.usda.gov/plant_health/plant_pest_info/eg_moth/index.shtml)

**Methyl Bromide Alternatives and Fumigation Regulations Update**

*Methyl iodide update.* In March, Arysta LifeScience Corporation announced the immediate suspension of product sales for all formulations of the fumigant MIDAS® in the United States. Methyl iodide (iodomethane) had been considered as a potential replacement for methyl bromide, whose use is being phased-out due to its ozone-depleting properties.

The decision to suspend sales was made as part of an internal review of the fumigant and based on its economic viability in the U.S. marketplace. Arysta LifeScience will continue to support the use of iodomethane outside of the United States where it remains economically viable.

*Metam sodium and metam potassium buffer zone mitigation measures.* The pre-plant soil fumigants, metam sodium and metam potassium are important tools for successful and viable production of nursery crops in Santa Clara County. The application of these materials in California can be accomplished through a variety of methods – shank injection, spray blade, rotary tiller, sprinkler, drench and drip. In Santa Clara County, all applications are now made through drip lines buried within prepared beds.

The County of Santa Clara – Division of Agriculture has been working with the Department of Pesticide Regulation in a review of scientific studies to determine whether mitigation measures could be developed for Santa Clara County to lessen the buffer zone requirements for drip applications of the methyl isothiocyanate (MITC)-generating fumigants. The mitigations were developed with input from end-users to ensure the measures incorporated viable field practices.



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The mitigation measures require that drip tape must be buried under at least 6 inches of soil and that water must be run through the drip lines for 1 to 2 hours immediately following the completion of the application. A second post-application of water must be applied through the drip lines or sprinklers the evening of the application, beginning one hour before sunset and running from 1 to 3 hours. Each post-application water treatment must apply a total of 0.2 to 0.4 acre inches of water. These mitigation measures have been finalized for use in Santa Clara County, and are now being included as part of the conditions of use for metam sodium and metam potassium restricted material permits.

**Pesticide Illness Surveillance Program**

Agricultural commissioners investigate pesticide illnesses that occur in their jurisdictions, whether or not they involve agriculture. The investigators attempt to locate and interview all people with knowledge of the exposure events, collect samples when useful, and review relevant records. When appropriate, they request authorization from the affected people to obtain relevant portions of their medical records to include with the investigative reports.

The Department of Pesticide Regulation (DPR) provides instructions, training and technical support for the investigators. The instructions include directions for when and how to collect samples of foliage, clothing, or surface residues to document unintended exposure or contamination of persons and/or the environment. As part of the technical support, DPR contracts with a California Department of Food and Agriculture Center of Analytical Chemistry (CAC) to analyze the samples.

When investigations are complete, CAC send reports to DPR describing their findings. These reports describe the circumstances that may have led to pesticide exposure and the consequences to the exposed individuals. In their role as enforcement agents, CAC also determine whether pesticide users complied with safety requirements. In 2009, there were 1,329 reported cases of pesticide exposure. Of those cases, 308 were related to agricultural use. In Santa Clara County, there were 44 reported pesticide illness or injury incidents, with two of those cases related to the agricultural use of pesticides. The compilation of reports and statistics on pesticide illness investigations in California for 2009 is available for viewing at <http://www.cdpr.ca.gov/docs/whs/2009pisp.htm>.

**Annual Well Inventory**

A report summarizing well sampling results collected by DPR and the California Department of Public Health in 2011 was released in February. It includes an analysis of the results to determine probable sources of detected pesticides and actions taken to prevent migration of pesticides to ground water. In Santa Clara County, more than 1 500 well samples were tested for 44 different pesticides. No pesticides were detected in these samples. The report can be viewed at [www.cdpr.ca.gov/docs/emon/grndwtr/wellinv/wirmain.htm](http://www.cdpr.ca.gov/docs/emon/grndwtr/wellinv/wirmain.htm)

**Phytosanitary Certificate and Issuance Tracking System.**

On March 1, 2012, the County of Santa Clara – Division of Agriculture adopted the Phytosanitary Certificate and Issuance Tracking (PCIT) software system to electronically generate and process export certificates for local shippers. The system was created by the USDA-APHIS and has been in use in locations across the country since 2005.

Originally, PCIT was developed to issue Federal phytosanitary export certificates. It can now also be used to issue State phytosanitary certificates and has been modified to allow local governments to collect certification fees electronically. PCIT offers many timesaving functions to our shippers and also reduces the cost of each certificate issued by \$6.00. APHIS is making several improvements to PCIT in the coming months. PCIT will begin automatically transferring phytosanitary certificates to foreign countries receiving U.S. exports, reducing previous delays associated with paper-

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work verification. In addition, APHIS is expanding the availability of user-printed phytosanitary certificates, eliminating the need for users to pay for shipped documents.

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**REGIONAL REPORT: New anthracnose disease on New Zealand flax**

**by Steve Tjosvold**

New Zealand flax and its hybrid cultivars are very important to the ornamental nursery industry locally, in California and the world, as they are becoming a popular component in many new landscapes. An important anthracnose disease was recently found on New Zealand flax (*Phormium*) in a California Central Coast nursery. The detection of the causal agent, *Colletotrichum phormii*, on nursery stock was the first time this fungus was found in North America. All symptomatic plants were destroyed by regulatory officials. Foliar symptoms consisted of dark brown lesions with the central portions discolored. These lesions eventually coalesced to form large irregular necrotic areas. In older lesions, black acervuli (spore-containing structures) formed resembling “blackheads.”

Anthracnose is a general group of fungal diseases that cause dark, sunken lesions on leaves, stems, flowers, and fruits. These fungi infect many deciduous and evergreen trees and shrubs and can infect fruits, vegetables and turfgrass. Examples include *Colletotrichum*, *Coniothyrium*, *Diplodia*, *Discula*, *Gloeosporium*, *Glomerella*, *Gnomonia*, *Macrophoma*, *Marssonina*, *Phoma*, *Phyllosticta* and *Phyllostictina*.

There is no study with *C. phormii* that has determined the complete range of potential hosts. It, like other closely related *Colletotrichum* species, appears to be attacking host plants within the family of Agavaceae. *C. phormii* attacks *Phormium* and possibly *Dracaena*. *C. agave* only infects *Agave*, and *C. dracaenophilum* is only found on *Dracaena* (Farr et.al 2006). Given this information, it would be prudent to concentrate monitoring efforts first on *Phormium*, then on *Dracaena*, and finally on other genera in the family Agavaceae.

Little is known about the biology of *C. phormii*. In general, anthracnose fungi need water in order to disseminate and infect, and they don't spread in dry conditions. Some *Colletotrichum* species can attack seeds and roots and many survive in plant residue and soil. *C. phormii* is known to be among the slowest growing of the *Colletotrichum* species that

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attack Agavaceae. However, locally, nearly all plants of the same cultivar that were found with the disease were found to be symptomatic. Assume that it spreads by splashing rain or sprinklers. Assume that it survives on living plants, plant debris, and maybe seed.

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**Anthrachnose caused by *Colletotrichum phormii* on *Phormium* hybrid detected for the first time in North America. Photo credit John Kovarik.**

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## UC Cooperative Extension Ventura and Santa Barbara Counties

### REGIONAL REPORT: Black foot disease

by Julie Newman

**B**lack foot disease has caused significant economic damage in California grape vineyards since the 1990s. Young vines are most susceptible. Plant symptoms are black, sunken root lesions, necrotic root crowns and black vascular streaking. Leaves appear scorched or water stressed and may be chlorotic. Vines are often stunted and may be killed.

Black foot disease in grapes in California is caused by various species of *Cylindrocarpon*. The primary source of inoculum is infected soil, but nursery plants are also a potential infection source. In a 2007 survey of 165 non-symptomatic rooted grapevine cuttings selected randomly from various nurseries in California throughout the year, 26% tested positive for *Cylindrocarpon* in PCR assays.

*Cylindrocarpon* is a common soil-borne fungus that causes root rots and rots of underground storage structures such as bulbs. These fungi are often associated with other pathogens and have a wide host range, including various agricultural crops such as fruit trees (e.g., apple, peach, plum) and strawberries (fig. 1), in



Fig. 1. Black root rot damage on the strawberry plant on the right caused by *Pythium* and *Cylindrocarpon* spp. Photo by Paul Reeser.

addition to grapes. Many ornamental species are *Cylindrocarpon* hosts, including boxwood (fig. 2) — not to be confused with *Cylindrocladium* that causes boxwood blight — and other woody shrubs such as azalea (fig. 3). Various trees (e.g., pine, douglas fir, deodar cedar, magnolia) and flowering plants (e.g., African violet, cyclamen, Easter lily, oriental lily) are hosts. In California, there are three common *Cylindrocarpon* species: *C. destructans*, *C. liriodendri* and *C. macrodidymum*. Of 192 California Department of Food and Agriculture state records of *Cylindrocarpon* found on 124 host species since 2007, over 74% were found in Santa Barbara County and 10% were found on nursery stock.

*Cylindrocarpon* is spread in the nursery in contaminated potting media or soil. Potting media should be heat pasteurized or solarized; methyl bromide is an effective soil treatment but is being phased out. Equipment and reused containers can also spread the disease and should be thoroughly washed to remove clinging debris, soil or potting mix particles, and plant material. Heat treatment is effective in killing the plant pathogens that adhere to containers or that are in the debris. Where steam is not available,



Fig. 2. These Japanese boxwood (*Buxus microphylla japonica*) nursery plants are infected with *Cylindrocarpon* sp. Symptoms shown include poor growth, low vigor, yellow foliage and defoliation. Photo by Heather Scheck, Santa Barbara County Agricultural Commissioner.

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**Fig. 3. Healthy azalea roots (left) compared to roots infected with *Cylindrocarpon destructans*. Damage symptoms shown include low root volume and dark discoloration. Not shown are the above-ground symptoms which include stunted and weak growth. Photo courtesy of the California Department of Food and Agriculture.**

solarization may be effective. Hot water dips have been shown to be effective in reducing *Cylindrocarpon* inoculum on containers and in infected nursery stock. DMI fungicides (e.g., triadimefon, propiconazole, myclobutanil) and thiophanate-methyl are effective fungicides for managing disease problems (be sure to check labels for registration and use requirements). Biocontrol studies using mycorrhizal fungi resulted in good control of black foot disease in grapes.

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**FIELD OBSERVATIONS: Watch out for invasive pests and diseases!****Lesser Snow Scale**

One of the most important steps in avoiding invasive pests in the nursery is to isolate and carefully inspect all incoming shipments of plant material. All infested plant material should be treated or disposed of before introducing into the production area. One A-rated pest that is sometimes found in incoming shipments — especially in shipments from Hawaii and Florida — is the lesser snow scale (*Pinnaspis strachani*). This armored scale is extremely common in the southern and eastern areas of the United States. It is occasionally found in Southern California nurseries and was recently detected in a nursery in Ventura County.

Lesser snow scale (fig. 1) has a wide host range of over 150 plant hosts, including palms, foliage, hibiscus and orchids. It is a potential threat to agriculture because it is also a host of crops such as citrus and blueberries; it has been found on avocados coming into California from Mexico. The adult female is 2 to 3 mm long with a pear-shaped white cover. The immature male scale cover is white and elongated with three longitudinal ridges.

**Light Brown Apple Moth (LBAM)**

Two male moths were recently detected in a Santa Barbara County nursery in Goleta inside the Santa Barbara County quarantine area. There is also a quarantine area in Santa Maria where three male moths were found earlier this year near production nurseries. Previously, detection of LBAM in Santa Barbara County nurseries was limited to Carpinteria.

**Q-Rated Pathogens**

Impatiens downy mildew (*Plasmopara obducens*) and basil downy mildew (*Peronospora bellbahrii*) have been detected in multiple production nurseries in Santa Barbara County, according to Heather Scheck, Plant Pathologist for the Santa Barbara Agricultural Commissioner's Office. Basil downy mildew was also found in Ventura County. Both are Q rated (quarantine

significance). Details about these diseases are provided in Dr. Deborah Mathew's feature article on mildews.

Heather Scheck also reports the first finding in a Santa Barbara County landscape of gladiolus rust (fig. 2). This Q-rated pathogen was recently detected in Carpinteria near a nursery that grows gladiolus. A survey of the area is planned.

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**Fig. 1. Lesser snow scale, adult female (left) immature males (right). Photo courtesy of Natalia von Ellenrieder, California Department of Food and Agriculture.**



**Fig. 2. Gladiolus rust, *Uromyces transversalis*, was recently found in a Carpinteria garden. Photo by Heather Scheck, Santa Barbara County Agricultural Commissioner.**





## REGIONAL REPORT: Citrus greening in California

by Jim Bethke

**H**uanglongbing (HLB), or citrus greening, has finally made its way into California. To date, a single tree and a single Asian citrus psyllid (ACP) have tested positive for the disease, and the anticipated regulations for citrus production and retail nurseries are now in effect. Some of these regulations are still under review by the California HLB Task Force Science and Technology Advisory Committee, but every nursery that carries citrus should take note because subsequent spread is likely. At present, about 4800 trees at 18 facilities (production and retail) are on indefinite hold.

The California Department of Food and Agriculture declared a state interior quarantine (#3439 HLB Disease) as of April 12, 2012, and the declaration includes information on the disease, the area quarantined, the regulated articles, and movement restrictions. An approximate five-mile circle has been drawn around the infested tree, and action is being taken within the circle. No plants in the Rutaceae family can move out of quarantine. All Rutaceae plants within 800 meters of the infested tree have been tested for HLB, and so far all have tested negative. In addition to the surveys for HLB, all Rutaceae plants within 800 meters have been treated in adherence to quarantine protocol.

The present HLB infection likely occurred through the movement of infected tissues from Asia that were grafted onto a backyard tree in Hacienda Heights, which has since been removed and destroyed. A full investigation is in progress, and other trees associated with the infected tree have been identified. So far, they have tested negative for HLB. If the historic pattern of movement of HLB by infected psyllids remains consistent, then HLB from the tip of Baja or central Mexico will eventually establish in San Diego County and other parts of California.

In anticipation of an HLB find, the CDFA has been preparing further restrictions on citrus nursery stock

and its production. In short, to protect the citrus production industry, all citrus must now be produced in protected culture. Screenhouses must be constructed under specified construction standards that include a 100-foot buffer from any Rutaceae plants, as well as screens that exclude ACP, air curtains or positive airflow, and self-closing doors. The facility must be maintained pest free, with detection trapping and records that demonstrate the facility is free of psyllids. The facility must be inspected for breaches, and trapping or suction monitoring for ACP must occur regularly. Source citrus must originate from APHIS-approved State certified clean stock, and all citrus within the facility must be treated at least 30 days and no later than 90 days prior to shipment.

Unfortunately, a recent scientific paper demonstrates that edible fig (*Ficus carica*) is an ACP host. How this will affect the genus *Ficus* is still not clear, but edible fig will most likely be added to the list of regulated articles, further complicating the situation for the nursery industry. The HLB Task Force Science and Technology Committee is reviewing the literature and will soon make recommendations concerning this issue to the CDFA.

See below for important information from some of the pertinent web sites:

CDFA Plant Quarantine Manual: #3439 HLB Disease:

<http://pi.cdfa.ca.gov/pqm/manual/pdf/423.pdf>  
(includes map of the quarantined areas of Los Angeles and Orange counties).

United States Department of Agriculture Animal and Plant Health Inspection Service (APHIS) Plant Protection and Quarantine: Interstate movement of citrus and other Rutaceous plants for planting from

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areas quarantined for citrus canker, citrus greening, or Asian citrus psyllid:

[http://www.aphis.usda.gov/plant\\_health/plant\\_pest\\_info/citrus/downloads/interstate-mvmnet-protocol.pdf](http://www.aphis.usda.gov/plant_health/plant_pest_info/citrus/downloads/interstate-mvmnet-protocol.pdf)

**FIELD OBSERVATIONS**

Was it a bug, a mite, a disease? The orchid buds (fig. 1) were aborting; plants were dying. It was thought that these symptoms must have had some biological cause. Of course the first action is to drench it with a fungicide, but to no effect. No insects were present. Several species of mites, however, were observed feeding on the pollen in open flowers and in the potting media, so the damage must have been caused by mites, right? Should they be sprayed with a miticide? Nope.

Not all damage is caused by an organism. The plants in this situation were being well watered and fertigated on a daily basis until they were moved to a different facility and watered every ten days with city water. The roots had been sitting in media with an EC of 1.6, which is known to be detrimental to orchid roots in sphagnum, and visible salt deposits were observed on pot surfaces (fig. 2). The recommended EC is between 0.6 and 1.0 and the scientific recommendations for an EC of  $>1.5$  is to leach immediately. If it is  $>1.0$ , the recommendation is to back off the fertilizer concentrations until the EC is back to the recommended levels. These are common conditions for orchids, but different plants have different needs, and different potting media will react differently with differing ECs. You should know what EC levels are tolerated by your plants, and do your best to modify the water and fertigation so that salt levels remain safe.



**Fig. 1. Orchid buds showing signs of wilting and eventual abortion.**



**Fig. 2. White crusty deposits indicate water evaporation and salt deposits on the media surface.**

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# CAMPUS RESEARCH UPDATE: Is western flower thrips a single species?

by Mark C. Hoddle

Western flower thrips (WFT), *Frankliniella occidentalis* (fig. 1), is native to the western United States and is a notorious global pest of horticultural and agricultural crops. Much effort has been invested in studying the biology, ecology and management of WFT. Often results from different studies are not consistent and can vary greatly. Recent work by Rugman-Jones et al. at the University of California, Riverside used molecular analyses to investigate the genetic structure of populations of WFT throughout California, and from different countries, or by using appropriate gene sequences for WFT on GenBank. Results revealed that WFT is comprised of two morphologically indistinguishable species that co-occur in California, sometimes being collected simultaneously on the same host plant (e.g., commercially grown plums and peaches). These two species have invaded New Zealand and China, and it is possible that they co-exist in other countries but have not been detected. This study has significant implications for vector transmission studies, biology, behavior and ecology research, and assessing the efficacy of natural enemies and insecticides. A simple molecular technique has been developed to reliably separate these two cryptic species.



**Fig. 1. Close-up view of an adult western flower thrips.**  
Photo by Jack Kelly Clark, UCANR.

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*Mark S. Hoddle is Cooperative Extension Specialist, Department of Entomology, UC Riverside*

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# New publications from Agriculture and Natural Resources

*compiled by Steve Tjosvold*

## Maintaining Microirrigation Systems

This handy publication discusses the maintenance issues of microirrigation systems that can be used on tree crops, row crops, and trees and vines. Chapters include an overview of maintenance needs, monitoring and water assessment, causes and prevention of clogging, flushing and safety concerns. Also includes methods of preventing root intrusion, soil ingestion, bacterial growth, and backflow contamination. One of a series of water management handbooks prepared by the UC Irrigation Program; it is not eligible for discounts. \$16.00

For eBook download instructions, please visit  
<http://anrcs.ucdavis.edu/?faq=525&col=7>.

Authors: Larry Schwankl, Blaine Hanson, Terry Prichard

ANR Publication # 21641

ISBN 978-1-60107-778-3

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## Sprinkle Irrigation of Row and Field Crops

This manual provides practical information on the design, management, and maintenance of the sprinkle irrigation methods commonly used in California for irrigating field and row crops, with a focus on hand-move, wheel line, and portable solid-set systems. Inside you'll find discussion of management considerations such as when to irrigate, how much water to apply, and how to monitor soil moisture. You'll also find an overview of uniformity and efficiency, sprinkle lateral design considerations, calculating pressure losses along laterals, factors affecting uniformity, effect of pressure spacing, and wind on catch can uniformity, as well as evaluating and improving sprinkle irrigation systems. A chapter on energy considerations covers pump

selection, factors that affect pumping plant performance, pump performance tests, variable speed drives for pumping plants, and measures to consider to reduce energy use. Handy tables clearly illustrate key concepts to help you with decision making and trouble-shooting. Contains 46 illustrations and 28 tables, as well as 8 appendices of selected cover-crop coefficient relationships. \$25.00

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