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Inside

Pesticide Use on the Decline in California Cut Flower Production: The Untold Story

by Michael Parrella, Christine Casey, Andrew Melicharek, Machiko Murdock and Daniel Klittich

Excessive use of pesticides in the production of floricultural crops has been an issue for decades. While certainly not true when focusing on most individual growing operations, the industry as a whole is defined by its bad actors and the result is that the entire industry has a negative association with pesticide use. This seems to come to the fore and makes good press around Valentine's Day (Valentine, 2013). Much of the focus on excess use of pesticides in cut flowers has been in South America (Stewart, 2007) and this has led to some harsh criticism of the industry (Donohue, 2008). However, there has been concern in California as well, where approximately 80% of the cut flowers in the United States are produced (Lallanilla, 2013). The negative aspects usually focus on the health and safety of farm workers, and historically the floriculture industry does not have a good track record. For example, 2003 data from the California Department of Pesticide Regulation (CA DPR) indicate that almost 30% of all the incidents involving farm workers and pesticide residue exposure in California occurred in ornamental crops, and this ranked second among all agricultural crops produced in the state. Of course this information is close to 10 years old, so what is the situation today? In order to address this question accurately, pesticide use in greenhouse cut flowers needs to be examined in comparison to overall pesticide use in California agriculture. In addition, the changing size of the floriculture industry over the past decade also needs to be considered.

Editor's Note

The focus of this newsletter issue is on IPM programs to address the increasing numbers of pests that impact ornamental crops and curtail the escalating use of pesticides to control them. The two feature articles report progress in reducing pesticide use (written by Michael Parrella) and developing IPM programs for weeds, mollusks and vertebrates (written by Cheryl Wilen). Our regular columns — "Science to the Grower," "Disease Focus," "Insect Hot Topics" — describe various IPM issues (thrips management and fertilizers, pathogen management in recycled water, and monitoring for Ligurian leafhopper, respectively). The use of hot water treatments in IPM programs and the management of Bagrada bug and light brown apple moth are discussed in the three Regional Reports.

♦ **Julie Newman and Steve Tjosvold**

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Trends in Pesticide Use In California

In 1990, California became the first state to require full reporting of agricultural pesticide use. Growers were required to turn in monthly Pesticide Use Reporting forms to their County Agricultural Commissioner. The result has been a massive database (compiled and maintained by the CA DPR). This allowed a comprehensive look/analysis of overall pesticide use in the state and these data can be examined by commodity, by pesticide, by county, etc. Of course there have been changes over the more than 20 years that these data have been collected. During the early years of data collection, ornamental production was not broken down into subcategories, so it was not possible to separate pesticide use in greenhouse cut flowers, for example, from pesticide use in field-grown nursery stock. This made an analysis of pesticide use in ornamental production more difficult. However, this has changed and by 2001 the categories were more clearly defined. Therefore a comprehensive look at pesticide use in greenhouse cut flower production really has to start in 2001.

From 2006 to 2009, overall pesticide use in California dropped and the state was very proud of this decline. However, CA DPR reported that from 2009 to 2010, pesticide use increased by 9.5 % (15 million pounds active ingredient), and in 2010, California used more than 173 million pounds of pesticide active ingredient. How did the cut flower industry contribute to these pesticide figures? Despite an increase in pesticide use across all of California crops in 2010, pesticide use in greenhouse cut flowers continued to decline (fig. 1). For some, this decline in pesticide use was not fast enough, but it is still positive and the cut flower industry needs to be recognized for this. In 2001, cut flowers ranked 49th among all agricultural commodities in terms of total pesticide use. By 2010, this rank had dropped to 82nd. (The farther down on this list you are as a commodity, the better.)

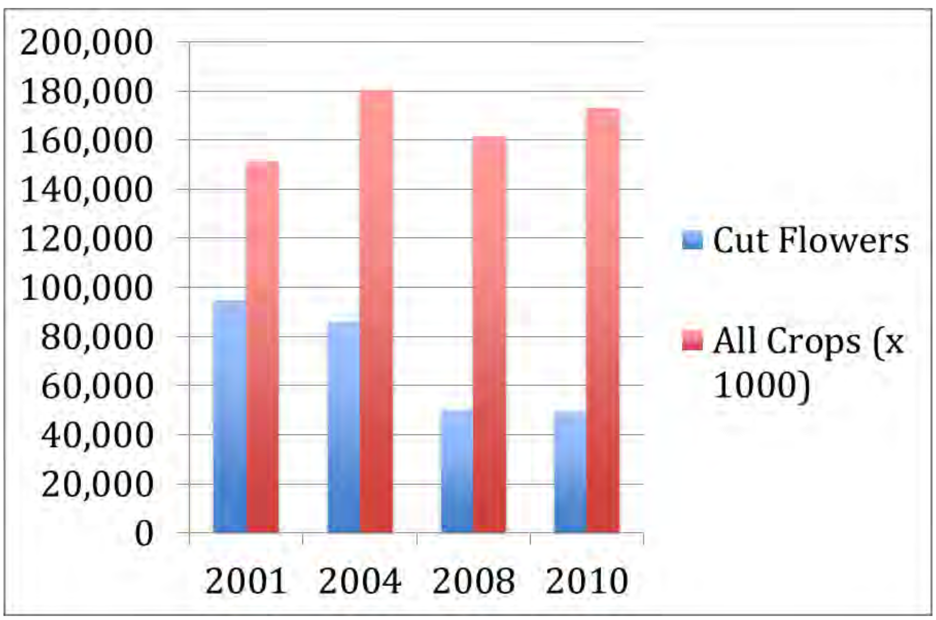

Fig. 1. Pounds of pesticide applied in California on all crops (red bars) and on cut greenhouse cut flowers (blue bars) from 2001-2010. The amounts applied to all crops must be multiplied by 1000.

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There has been a decline in cut flower acreage from 2006 to 2010: As one looks at the cut flower statistics in California, in 2006 the total value was $318 million and in 2010, this had dropped to $286 million. However this reduction does not explain the dramatic 50% reduction in pesticide use that occurred from 2001 to 2010. In fact the data from these dates are remarkably similar. In 2001, 48,469 pesticide applications were made to 86,800 acres and in 2010, 45,894 applications were made to 81,695 acres. It is important to note that along with a reduction in pesticide use has come a reduction in the number of reported incidents related to field worker exposure to pesticides. CA DPR reported that for greenhouse cut flowers in 2009, this dropped to 2% of the total number of cases in California agriculture.

A simple reduction in pesticide use does not tell the full story. Altering the type of pesticides used may be even more important. As noted above, CA DPR recorded an increase in pesticide use in 2010, but much of that use was attributed to the increased use of sulfur for control of powdery mildew in crops such as grapes. Inorganic sulfur, although not benign environmentally, is approved for organic production, and the increased use of such a pesticide takes some of the sting out of a negative scenario where pesticide use is increasing statewide. Likewise, the mix of pesticides used by floriculture producers is changing. It is slanting away from the use of traditional, broad-spectrum materials such as organophosphates and carbonates towards inorganic products like soaps and oils, botanicals, insect pathogens, insect growth regulators and the use of biological control agents.

Statistics on pesticide use can often be confounded by the activity of the pesticide itself. For example, older chlorinated hydrocarbon insecticides (like DDT) were applied at rates of 4 pounds active ingredient per acre, while the pyrethroid insecticides (like permethrin) are applied at 0.1 pounds active ingredient per acre. Therefore, simply switching from DDT to permethrin would achieve the goal of using less pesticide active ingredient per acre, when in fact you are making the equivalent (and in many cases more) pesticide applications per acre. The reverse also can be true. Application rates of sulfur are often many times that of conventional powdery mildew materials (something that is generally true for "safer" insecticides), so switching to sulfur (often viewed as positive because of its organic certification) will increase the total amount of pesticide applied per acre. The bottom line is that when you switch from one pesticide to another you need to take into consideration the activity and application rates in order to really determine whether there has been a reduction in active ingredient per acre in addition to the number of applications per acre.

Reasons Underlying the Change

Over the past ten years, there have been some profound changes that have led to the reduction in pesticide use and the types of pesticides applied in cut flowers in the state. These include: (1) the advent of 3rd party certification organizations that ultimately lead to pesticide reduction and a wiser choice of pesticides; (2) the greater use of screening in many greenhouses in the state; (3) the ever-increasing rules and regulations focusing on groundwater and farm worker health and safety; (4) the greater acceptance of thresholds, where some insects can be tolerated on a crop before a pesticide is applied; (5) greater use of monitoring with light traps, pheromone traps and yellow/blue sticky cards; (6) increased frequency of spot spraying to control early pest infestations without treating the entire greenhouse; (7) the advent of effective "reduced risk" materials that can replace traditional chemistry; (8) a new generation of growers who have grown up under the concept of going green; (9) a consuming public with a greater acceptance of organic production and with an increasing negative perspective of pesticides; and (10) the widespread use of biological control agents — the three Ps: insect pathogens, parasites and predators.

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The Role of Research and Extension

For many years there has been considerable research funded in California by national organizations (American Floral Endowment, Fred C. Gloeckner Foundation, Joseph H. Hill Memorial Foundation, to name a few), state commodity organizations (e.g., California Cut Flower Commission) and state agencies (e.g., CA DPR and the California Department of Food and Agriculture). In addition, the USDA ARS Floriculture and Nursery Research Initiative has provided continued funding to UC Davis and UC Riverside (as well as other universities nationwide). The ultimate goal of some of these research projects is to produce healthy plants while using less pesticide.

As noted earlier, pesticide use declined in cut flower production in California by almost 50% from 2001 to 2010. However, from 2008 to 2010, there was only a slight decline (50,105 pounds to 49,250 pounds, respectively). In 2009 there was actually a slight increase up to 51,000 pounds — this suggests a trend where things have leveled off. Have we bottomed out in terms of reducing pesticide use? Is the law of diminishing returns playing a role here? The challenge will be to keep this total pesticide use declining in addition to altering the types of pesticides used. We think the industry is poised for this challenge and look forward to what the next 10 years will bring.

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Progress in Managing Weeds, Mollusks and Vertebrates

by Cheryl Wilen

Insects, mites, pathogens — these plant pests often get first billing when talking about advances in research and implementation of integrated pest management (IPM). However, agricultural systems, including ornamental plant production, are beset with many other classes of pests including weeds, mollusks (snails and slugs) and vertebrate animals. These pests probably are not as prominent on a grower's radar as arthropods or pathogens because they may not be causing direct damage to crops. Nevertheless, unless managed appropriately, they will affect the grower's bottom line.

Weed Management

Weed management consistently ranks as one of the highest pest management expenses in ornamental crop production. This may be due to the variety of crops grown at a single operation and the paucity of herbicides that can be used on more than a few species. Additionally, only a small number of herbicides are available to control emerged weeds; therefore cultivation and hand weeding are frequently employed. One advance in the management of weeds is the use of mulches for container production. Mulches can be used when herbicides are unavailable to reduce the cost of hand labor or as a supplement to chemical control. While application is more labor intensive than herbicides, research conducted by myself and others have shown that the length of time that mulches are effective in controlling weeds is equal to many herbicides and may even be longer. However, the size of the chips must be matched to the container size: chips should not be larger than ½ inch for 1-gallon containers, but slightly larger chips can be used in 5-gallon and larger containers.

In field production, the most important weed management problem facing the industry has been the phase out of methyl bromide. Research to address this issue is still underway and there has been some progress. Solarization, steam, and soil additives such as mustard seed meal are being tested and implemented as fumigant alternatives for both field and greenhouse-grown crops.

Soil heating through solarization is an effective method for managing some weeds and soil-dwelling plant pathogens including nematodes. Photo by Jack Kelly Clark, courtesy of UC IPM.

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Additionally, a number of new herbicides, including those with novel modes of action, have been introduced or will soon be available for nursery crops, such as dimethenamid-P (active ingredient in Freehand, Tower) and indaziflam (a.i. in Specticle, Marengo). Also on the horizon, but still being tested, are bioherbicides containing iron HEDTA — which selectively control some broadleaf weeds — and a new product derived from bacteria that is a non-selective preemergent herbicide (Marrone Bio Innovations).

Mollusk Management

Snails and slugs often cause direct damage to nursery crops but more importantly can limit where a grower can ship. Mollusks and their eggs in container media may not be detected until the shipment arrives at the final destination. When found, the result can be crop destruction, return, or — in a worst case scenario — restriction of shipment to other states and similar restrictions imposed on other growers through quarantine regulations. In California and other states, we have been studying how newly registered materials such as ferric sodium EDTA can be used in snail control as well as looking at natural products, including essential plant oils as repellants. A system of preventative methods combined with inspection, monitoring and appropriate timing of controls will be the most effective IPM program for mollusks, as with many pests.

Vertebrate Management

Rabbits, birds and deer are the vertebrate pests that seem to most affect nursery and cut flower operations. Rabbits will eat bulbs and plant leaves and chew on irrigation tubing, deer tend to browse and birds pull up newly sprouted plants in the field. Due to fish and game and other wildlife regulations, growers are often limited to preventative measures such as fencing for rabbits and deer or crop covers for birds. Repellents vary in their

European brown snail eggs are laid in soil or potting media in groups of about 5 to 50. Eggs are bright white initially and become darker brown as the embryo develops. Photo by Jack Kelly Clark, courtesy of UC IPM.

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effectiveness and research is continuing to find repellents that work for a longer period of time and have more predicable activity. One group supporting this work is the Vertebrate Pest Control Research Advisory Committee of the California Department of Food and Agriculture; current and past project reports are archived at their website: http://www.vpcrac.org/.

UC IPM Resources

The University of California Statewide IPM Program maintains a web-based Pest Management Guideline (PMG) for floriculture and nursery production systems (http://www.ipm.ucdavis.edu/PMG/selectnewpest.floriculture.html) to be used in concert with the book *Integrated Pest Management for Floriculture and Nurseries* (UC ANR Publication 3402). These resources can be very helpful to growers trying to manage weeds, mollusks and vertebrates as well as arthropods and pathogens. As new products reach the market and new IPM components are developed, they will be included in the PMG.

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Rabbits can indirectly damage the crop by chewing on irrigation tubing (*left*). Covering tubing with duct tape or sliding flat drip lines (*right*) over the line will deter chewing. Dropping tubing from a raised line to keep tubing off the ground will also reduce damage to the tubing. Photos by Tracy Ellis.

Cottontail rabbits will browse many plants species in a nursery. Three-foot tall fencing will exclude cottontail rabbits. Photo by Tracy Ellis, courtesy of UC IPM.

SCIENCE TO THE GROWER: One thrips, two thrips, fed thrips, dead thrips

by Richard Evans

Western flower thrips (*Frankliniella occidentalis*), a widespread pest of many ornamental crops, is hard to control because both juveniles and adults live within flowers and buds, rarely loitering in the open where they would be vulnerable to chemical sprays. Not that insecticides are all that effective anyway. This insect has become resistant to almost everything except Lunchables, and nobody has come up with a suitable spreader-sticker for applying Lunchables to ornamental crops.

Speaking of Lunchables, one pest management approach worth considering is to feed plants in a way that makes them less appetizing to pests. For instance, several years ago researchers at Texas A&M (Chau and Heinz, 2006) examined the effect of liquid feed concentration on western flower thrips abundance on potted chrysanthemums. Plants received a 15-16-17 fertilizer at rates ranging from 75 to 750 ppm nitrogen. The number of thrips was highest on plants fertilized with 280 to 375 ppm N. Mums fertilized at a rate of 188 ppm N had about half the number of thrips found on mums fertilized at 375 ppm N, yet were the same height and produced a similar number of flowers. Unfortunately the authors didn't report plant dry weight or leaf elemental composition, both good measures of fertilizer effects on growth.

The same research group (Chow and others, 2012) recently investigated the effect of liquid feed concentration on western flower thrips abundance and the ability of a natural enemy (*Amblyseius swirskii*) to suppress the thrips population on greenhouse cut roses. Roses received a 15-5-15 fertilizer at a rate of either 50 or 150 ppm nitrogen. Plants in the 50 ppm treatment had 30% fewer thrips than those in the 150 ppm group. Fertilizer rate did not affect the population of the natural enemy, and the combination of low fertilizer rate and exposure to the natural enemy was a double whammy for thrips, reducing their population to about 25% of what it was in the well-fed roses that weren't protected by *Amblyseius*. In fact, the low fertilizer treatment alone was as effective at controlling thrips as the natural enemy alone. By the way, reducing the fertilizer rate lowered nutrient levels in the rose leaves, but not enough to affect yields or quality. However, I suspect that a longer experiment would show that 50 ppm N is too low to sustain high productivity in roses. Other research has shown that greenhouse cut roses require between 75 to 100 ppm N for high yields.

Suppressing insect pest populations by manipulating crop fertilizer additions is an old idea, but one that deserves more recognition and application. This may be particularly true for ornamental crops, which typically receive far more fertilizer than they require. Come to think of it, I wonder if eating Lunchables would cut down my mosquito bites.

Richard Evans is Cooperative Extension Environmental Horticulturist, Department of Plant Sciences, UC Davis.

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DISEASE FOCUS: Do you know what might be lurking in your irrigation water?

by Deborah M. Mathews

Recycling irrigation water is becoming more common in nurseries and greenhouse operations due to a desire to be "green," financial considerations, and legal requirements from local government agencies or water districts. While it looks good on paper to save water for all of these reasons, one aspect that is commonly overlooked is the risk of plant pathogen build up and transmission within your operation. Fungi, bacteria, viruses and nematodes are all readily transmitted in water. This article will make you aware of some of the problems and management strategies for dealing with this issue.

The Culprits

Fungi and oomycetes are the biggest threats to plants in irrigation water. Major fungal players here are *Rhizoctonia, Botrytis, Fusarium oxysporum, Colletotrichum, Cylindrocladium* and *Sclerotinia,* with the oomycetes *Phytophthora* and *Pythium* presenting a particular threat due to their production of swimming zoospores. Bacteria found in water include species of *Erwinia, Pseudomonas* and *Xanthomonas.*

You are probably aware that plant viruses are transmitted by multiple methods including mechanical means (touching by hands, tools, plant to plant contact, contaminated surfaces, etc), and insects, but you may not be aware that they can also be transmitted through water via root contact. At least 10 plant viruses have been reported to be transmissible through irrigation water including *Tobacco mosaic virus* (TMV), *Cucumber mosaic virus* (CMV) and *Tomato spotted wilt virus* (TSWV) (1, 2, 3).

Multiple plant pathogenic nematode species are found in recycled water as well as in water from natural ponds, lakes or canals. These include root-knot (*Meloidogyne* spp.), dagger, ring and lesion nematodes.

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Management Options

Disinfection of contaminated water can be achieved by many methods. They include physical treatments — such as heat, UV light and filtration — and chemical treatments like chlorine and ozone. Each has its benefits and hazards.

Heat treatment for broad-spectrum pathogen control requires reaching a temperature of 140°F (60°C) for a minimum of 2 minutes, although many viruses require 185 to 194°F (85 to 90°C) for 3 minutes. This strategy is simple to perform, but the energy use required to achieve these temperatures can be expensive, the water must be cooled prior to use and beneficial microbes can indiscriminately be eliminated as well.

UV Irradiation using short wavelengths between 200 to 280 nm, with an optimum of 254 nm, causes the genetic material (DNA and RNA) of the pathogen to degrade, rendering them harmless. Doses ranging from 100 to 250 mJ/cm^2 are effective in removing virtually all pathogens. Water must be relatively clear for UV treatment to be effective so filtration prior to treatment is usually required.

Filtration to physically remove pathogens can be done with membranes with a defined pore size, with most fungi, bacteria and nematodes being removed with 0.1 mm pores, but not viruses. This greatly reduces flow rates, however, and filters must be regularly replaced which can be expensive. Filtration using sand beds (slow-sand filtration, SSF) has been shown to be efficient at removing almost all pathogen types, not only through physical exclusion of larger propagules, but mainly through biological inactivation via a microbial layer of microorganisms that forms on the sand. My laboratory is currently working on exclusion of viruses using SSF in collaboration with Dr. Loren Oki of UC Davis who has shown effective elimination of *Phytophthora* using SSF.

Chlorine is the most common chemical control method, although there are numerous other methods for decontaminating water. Chlorine is usually applied using liquid bleach (sodium hypochlorite). It is very effective in killing all pathogens, but levels must be constantly monitored to maintain effectiveness; chlorine is dependent on pH, can negatively react with nitrogen compounds and can be phytotoxic.

Ozone is another common chemical control method that disrupts membranes and proteins of pathogens and is very effective against all pathogen types. However ozone is sensitive to pH and organic matter in the water. It must be generated onsite and surplus amounts must be inactivated with carbon filters, adding to the cost.

Integrated pathogen management. The most effective water management strategies for pathogen removal incorporate two or more of the above methods. Prefiltration, followed by UV light treatment or a chemical method combination, is the most common.

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INSECT HOT TOPICS: Ligurian Leafhopper

by James A. Bethke

Insect cast skins can be used to indicate the presence of a pest. For instance, it is pretty common for the cast skins of aphids to be observed before you actually find any live aphids. Aphids can be cryptic and sometimes on the undersides of the leaves, so it is common to see cast skins sticking to honeydew on the upper surface of the leaf below the infested leaf.

I'll bet that if you had a shipment of plants rejected at the receivers for cast skins, you would be surprised. However, it occurred back in 2009 and again early this year. The Florida Division of Plant Industry (DPI) found cast skins on topiary rosemary plants from California at a discount store in 2008. They suspected that the insect was the Ligurian leafhopper, *Eupteryx decemnotata* Rey, a pest leafhopper from Europe. Back then tracebacks determined that there were populations of the Ligurian leafhopper in Napa County in Northern California and in Riverside County in Southern California, indicating that the pest was widespread in the state. This year, again, cast skins were found on topiary rosemary, but this time it was traced back to San Diego County. The San Diego County Agricultural Entomologist was able to identify the source of the infestation and help mitigate the problem.

The Ligurian leafhopper is named for its endemic range in the Ligurian Sea area of Europe, adjacent to northwest Italy. Unfortunately, it has rapidly expanded its range. Researchers attribute this spread to extensive trade and transport of catnip plants, which had become popular ornamental plants in Europe. In the mid 1990s it had spread to Portugal, Switzerland, Austria, Slovenia, Greece and much of Germany. In the late spring of 2011, huge populations of Ligurian leafhopper were found causing economic damage to sage and rosemary plants in southern England. The infestation was traced back to an importation of herb plants from Italy. Large numbers of adults were also found on sticky traps at a commercial nursery in southern England.

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Ligurian leafhoppers are small (less than 3 mm long, 0.12 inches) and have colorful wing patterns (fig. 1). They possess five pairs of conspicuous spots on the head, which separates this species from close relatives. The sage leafhopper (mint leafhopper), *Eupteryx melissae* Curtis, is widespread in the northern United States. It has a similar wing pattern, but has fewer spots on the head.

Fig. 1. Ligurian leafhopper. Photo by G. Arakelian, Senior Biologist, Los Angeles County, Department of Agricultural Commissioner/ Weights and Measures.

Leafhoppers typically lay their eggs in stems and petioles, so they are nearly impossible to detect. This is the principle reason for the concern about the presence of so many cast skins observed in shipments from California. As with most leafhoppers, following egg hatch, leafhoppers will pass through five nymphal instars and leave cast skins just like an aphid. Cast skins of later instars look much like an infestation of live adults (fig. 2). Nymphs do not possess wings but can hop away from danger as their name suggests. If the leafhopper possesses wings, it is a full adult leafhopper.

Fig. 2. Apple leafhopper cast skins on the underside of an apple leaf. Photo by Jack Kelly Clark, courtesy of UC IPM.

Many pest leafhopper species can be detected using yellow sticky cards because flying adults are attracted to the yellow color. Leafhoppers are most commonly observed on the undersides of leaves, but they can be found on all parts of the plant, especially when in high numbers. Another method of detection is the beat and sheet method. Striking foliage or stems with your hand or stick will dislodge the leafhoppers onto a sheet or flat surface.

Ligurian leafhoppers and the sage leafhoppers are known to be pests of many popular herbs in the mint family (Lamiaceae) such as rosemary, sage, marjoram, catnip, mint and oregano. Obviously, with the ever-increasing interest in herb production, especially greenhouse herb production, there is concern about pests that may be difficult to control using organic pesticides.

Leafhoppers have piercing-sucking mouthparts and

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Fig. 3. Ligurian leafhopper damage on rosemary. Photo by G. Arakelian, Senior Biologist, Los Angeles County, Department of Agricultural Commissioner/ Weights and Measures.

can cause damage to plants by destroying chlorophyll, removing plant fluids and by introducing toxins into the plant with their saliva. Ligurian leafhopper damage can be quite severe, and is similar to other leafhoppers (fig. 3). They cause severe stippling when high populations are present, which can lead to leaf distortion and stunting. Major damage to cultivated crops has been observed in Europe.

Do not just assume that your plants are leafhopper-free. Use appropriate monitoring methods to detect pest infestations and remain vigilant, especially if you are shipping plants out of state.

For more information about the Ligurian leafhopper, see the following web sites:

http://www.freshfromflorida.com/pi/pest-alerts/eupteryx-decemnotata.html

http://acwm.lacounty.gov/pdf/Ligurleafhop.pdf

www.tsusinvasives.org/database/sage-**leafhopper**.html

www.cabdirect.org/abstracts/20073053763.html

http://wwwuser.gwdg.de/~hnickel/eup_decemnotata.pdf

http://www.fera.defra.gov.uk/plants/publications/documents/plantClinicNews/junJul11Issue.pdf

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REGIONAL REPORT: LBAM field data available for Monterey Bay Area growers

by Steve Tjosvold

The light brown apple moth (LBAM) (*Epiphyus postvittanai*), native to Australia, was first detected in the continental United States in Berkeley, California in March 2007. This tortricid leafroller moth (fig. 1) is classified as a high risk pest by regulatory agencies because of its potential to damage a wide range of plant species, its current limited distribution in the world, and its potential to harm agricultural commerce in California and the United States. In general, however, it has not been particularly destructive in areas where it has been found in the landscape or native vegetation in the Monterey Bay Area. There is evidence of a relatively high parasitism rate by native parasitoids, which may be keeping LBAM in check. Losses by the ornamental and berry crops industries are mostly related to the result of regulatory closures and associated losses of perishable berries or nursery stock sales. There have been significant increases in production costs associated with the management of LBAM for affected growers. Insecticide use has greatly increased as growers attempt to eradicate the pest, and more personnel are employed to effectively scout for the pest.

We have been conducting research in Santa Cruz and Monterey counties to aid in LBAM detection and management since 2007. Among other research projects, we are evaluating the importance of LBAM in areas around the perimeter of nursery and berry fields because we suspect that LBAM may be migrating from natural vegetation and weeds into these production areas.

Scouting methods. Beginning in October 2011, we have monitored the perimeters of eight local nurseries and berry fields in Santa Cruz County and north Monterey counties where LBAM has been previously found. At each scouting location, a pre-defined area is scouted for approximately the same amount of time.

Two types of attractant traps are used to monitor adult (moth) population dynamics: LBAM pheromone-baited Jackson traps that attract and catch male LBAM moths (fig. 2) and bucket traps, baited with a moth attractant (terpinyl acetate and brown sugar solution), that attract and trap both male and female moths (fig. 3). The same numbers of traps are used at each location and trapped LBAM moths are counted.

Fig. 1. Light brown apple moth female adult and egg mass. Photo by S. Tjosvold.

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Fig. 2. Trapping on nursery perimeter. Scout checks Jackson trap containing a pheromone bait that specifically attracts and traps male LBAM moths. Photo by S. Tjosvold.

Fig. 3. Bucket trap containing attractant bait containing terpinyl acetate (a "fruity" food additive) and brown sugar solution that attracts and traps male and female LBAM moths. Photo by S. Tjosvold.

In addition, the perimeter weeds and natural vegetation are identified and are systematically scouted for leaf distortions, folding and other shelters that might be caused by LBAM larvae. If a larva is found in these shelters and has characteristics consistent with LBAM, it is removed along with some of the host vegetation and reared in a laboratory setting until a moth emerges. Specific features found on emerged moths are used to confirm identification of an LBAM larva and its association with a specific host plant.

Since the plant host dynamics change through the seasons, the "available hosts" are identified at each location. These would be the host plants that are not only present but also in a growing condition that would be expected to be suitable for colonization by LBAM. For example, winter annuals could be present in the winter through summer period, but would not be considered available when they first emerge in the winter (because they are too small) or later as the summer approaches (when they begin to die). Similarly, perennials such as the native California live oak could always be present in the scouted area, but they are considered available only when they have newly developed foliage that would be suitable for colonization.

How the data will be used. The trap data will be used to determine if there are patterns of moth emergence, and when emergence peaks this could identify periods of high risk of moth migration into production fields. With increased migration

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risk, scouting in the production areas could be intensified to detect young larval stages, which are easier to control with insecticides. Selective and biorational insecticides with *Bacillus thuringiensis* should only be used to target small larvae, and could be used effectively at this time. Other commonly used insecticides for LBAM, such as spinosad (Conserve) and methoxyfenozide (Intrepid), are also best used when larvae are small.

The plant host data will be used to help determine the relative importance of perimeter hosts in supporting LBAM and any particular seasons associated with that risk. With this information, high-risk weed hosts could be targeted for control and scouting in perimeters might be intensified to detect larvae during periods of host availability.

Recently we launched a web page that contains the current trap data, updated every two weeks. The eight monitored production sites are grouped into five generalized regions in Santa Cruz County and north Monterey County. For 2011 and 2012, this data shows a relatively synchronized peak moth emergence in early November in all monitored areas. The perimeter host data is not on the web page yet. However, for the 16-month period that data has been collected, the greatest numbers of larvae have been found on Coyote Bush (*Baccharis pilularis*), French broom (*Genista monspessulana*), Dovefoot geranium (*Geranium molle),* Buckhorn plantain (*Plantago lanceolata*) and wild radish (*Raphanus raphanistrum*). There are 26 different host species that have been identified so far. The website contains information on using the data for forecasting LBAM population development. For example, using a biofix date and degree-day information, growers could reasonably predict the presence of adult emergence, egg laying and subsequent life stages in the field. These terms and explanations are on the web page. Forecasting is still being evaluated for its usefulness. The website can be accessed through the UC Cooperative Extension Santa Cruz homepage: http://cesantacruz.ucanr.edu/. For questions, please contact me.

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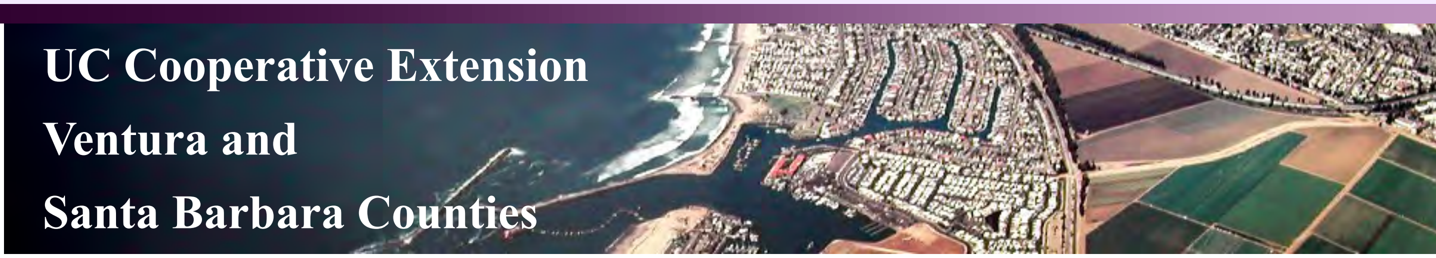

REGIONAL REPORT: Management of the Bagrada bug in nurseries

by Julie Newman

Damage caused by the Bagrada bug resulted in devastating crop losses for Ventura County growers last fall. This plant-feeding stink bug infests wild mustard weeds in the late winter to early spring. Pest populations rapidly increase in the weeds when seasonal temperatures rise. Record numbers of this pest have invaded newly planted cole crops after the weeds dry out in late summer. Additionally, the Bagrada bug has become a major problem in Ventura County nurseries where bedding plants, plugs, and transplants are produced—attacking young vegetable and ornamental plants in the mustard family Brassicaceae (Cruciferae).

The Bagrada bug, also called painted bug (*Bagrada hilaris*), was first found in the United States in Los Angeles County in 2008. By 2011, the pest had disseminated throughout Southern California including Ventura County. Last September, the pest moved northward to Santa Barbara and San Luis Obispo counties.

Weeds that serve as hosts include cruciferous weeds (e.g., various wild mustards, shepherd's purse, London rocket and pepperweed), as well as weeds in other plant families (e.g., lambsquarters, purple nutsedge, *Euphorbia* spp, perennial sowthistle, field bindweed). Globally, the Bagrada bug is a serious pest of cruciferous crops such as cabbage, cauliflower and broccoli. In nurseries, mustard family plants such as alyssum, stock, candytuft, rockcress and wallflower can be infested. Although mustard family plants are the primary hosts, the Bagrada bug also causes feeding damage on cultivated plants in other plant families. When preferred hosts are unavailable, the bug will attack plants that are not reproductive hosts and may or may not cause feeding damage. For example, large numbers of Bagrada bugs have been found in Ventura County on strawberry crops, although feeding damage has not been reported.

The Bagrada bug currently has a B rating by CDFA. Strict monitoring of outbound plants is required to prevent pest spread through the movement of plant material. Since the Bagrada bug can be found incidentally on a broad range of plant species, extensive crop monitoring for this pest in nurseries is necessary.

Identification and Biology

Adults are black with orange and white markings; the shield-shaped body is about ¼-inch (5-7 mm) long and about half as wide at the broadest part (fig. 1A). Eggs are barrel shaped and initially white but eventually turn orange. Females lay eggs in the soil beneath host plants, but may also oviposit on leaves or on hairy stems of non-host plants. Additionally, eggs are often laid on plant protective coverings such as mesh screens. Depending on temperature, a female bug can lay up to 150 eggs within two to three weeks that can hatch in four days. The nymph passes through five instars (fig. 1B). Newly emerged nymphs of all stages are orange-red but legs, head and thorax darken quickly. Older nymphs develop wingpads prior to becoming adults.

In Southern California there are multiple generations each year and populations generally peak late in summer and fall. Usually all life stages are present together on plants. Development is favored by warmer temperatures; the adults tend to fly when temperatures are above 85°F.

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Fig. 1. (A) Adult Bagrada bugs are black with orange and white markings and are commonly found mating, positioned end-to-end. Note that the female (*left*) is longer than the male (*right*). Photo by John Palumbo, University of Arizona, courtesy of UC IPM. (B) Bagrada bug nymph resembles an adult ladybird beetle, with similar bright coloration. Photo by Mike Lewis, courtesy of the Center for Invasive Species Research, UC Riverside.

Plant Damage

Adults and nymphs of the Bagrada bug feed on leaves, stems, flowers and seeds. They insert their needle-like mouth parts into young leaves and suck out sap, resulting in starburst-shaped lesions (fig. 2). Leaves eventually have large stippled areas and may wilt and die. Ultimately damage results in "scorched" leaves, stunting, blind terminals, and forked or multiple heads on cauliflower, broccoli and cabbage. Bagrada bugs are particularly damaging to small plants and may kill seedlings.

Fig. 2. (A) Typical fresh feeding damage appears light green with starburst lesions and then bleaches with age, giving leaves a "scorched" appearance when feeding is heavy. Photo by John Palumbo, University of Arizona, courtesy of USDA-NIFA Regional IPM Centers; (B) Multiple stages of Bagrada bug adults and nymphs (not shown) have caused large white stippled areas on alyssum. Photo by G. Arakelian, Los Angeles County Agriculture Commissioner.

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Management

Monitoring. Early detection is important because populations can build up quickly. All plants should be regularly inspected, especially incoming and out-going plant shipments and all host crops/weeds. More frequent monitoring may be necessary when temperatures rise above 75°F. When temperatures are low or extremely hot, these bugs may hide on the undersides of leaves, around stem bases, or in moist soil cracks and crevices. Bagrada bugs may not be readily observed until damage has begun. Look carefully for fresh feeding damage (light green starburst lesions), which may be easier to spot than the insects themselves. A good time to inspect is right after irrigating when pests hiding in the space between the potting mix and the sides of the container may be flushed out and more easily detected. When the bugs are common, they may be monitored by beating or by shaking plants over a tray or a sheet of paper.

Cultural control. Remove weed hosts in and near production areas. Bagrada bug adults, eggs and nymphs in the soil or container media can be controlled by steam or chemical treatment before planting. When bugs are abundant, isolate crucifers in a separate area in the nursery. Removal of crop residue after harvest can reduce carry-over between crops.

Mechanical control. Picking the bugs off plants by hand is only feasible if pest populations are very low. When infestations are heavy, it may be possible to vacuum the bugs. Using wild hosts as trap crops should be conducted carefully because the trap crop could also serve as a source of infestation for nursery plants. Growers with access to greenhouses can protect cruciferous bedding plants and vegetable plugs by producing them inside. Using a double-door system in greenhouses can help to exclude the bugs, and screened vents prevent entry of flying adults. As an alternative to greenhouses, screened tunnels or floating row cover fabric can provide plant protection. The mesh of the screening material must be fine enough to exclude the Bagrada bug nymphs and should be elevated so that it does not touch the plants because the bugs can feed through these coverings. The edges of protective covers must also be buried to prevent the bugs from crawling underneath to the plants.

Chemical control. There is little information on chemical control of the Bagrada bug in nurseries. Generally, stink bugs are difficult to manage with insecticides, and repeat applications are often necessary. Research on managing this pest on cole crops suggest that synthetic pyrethroids, neonicotinoids and organophosphate compounds may be effective in minimizing the damage, although the adult bugs may fly away before they are contacted only to return later. There are no effective chemical options for organic production although insecticidal soap and horticultural oils, including neem oil and paraffinic oil, may provide some control against the nymphs. Check the pesticide label to make sure the product is registered for use on nursery crops. Rotating chemicals with different modes of action is important to minimize potential resistance problems.

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More Information

See Jim Bethke's "Field Observations" in this newsletter. Additionaly, a detailed handout on the Bagrada bug was prepared for the UCNFA "BMP Programs for California Nurseries" meeting held in Ventura on March 20. The handout contains a list of registered pesticides, compiled by Jim Bethke, along with a list of references. If you would like a copy, please visit my website at http://ceventura.ucanr.edu/Environmental_Horticulture/Nursery/.

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REGIONAL REPORT: Hot Water Treatments to Control Pests

by James A. Bethke

Hot Water Use in Hawaii

Although I only know one local grower that uses hot water to control major pests prior to shipping their product, Hawaii frequently uses the technique. You may be aware that cut flowers and foliage from Hawaii are dipped in hot water baths, but did you know that potted nursery stock can also be disinfested by hot water treatments? This has been achieved in commercial nurseries by retrofitting the cargo area of trailers into large shower stalls where the hot water treatments are applied. Dr. Arnold Hara, professor of entomology in the Department of Plant and Environmental Protection Sciences at the University of Hawaii in Manoa, helped develop effective hot water bath and hot water shower treatments against pests of quarantine significance on cut flowers and foliage, propagative material and potted plants. He has demonstrated that selected insects, invertebrates and vertebrates (Coqui frog) can be controlled with hot water and not harm plant material. Dr. Hara and his colleagues believe that quarantine hot water

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treatments can be adjusted to any specific risk level, including zero tolerance. The information below summarizes some of their work, but more details — including temperature and duration required to kill specific pest species, and photos of the bath and shower systems used in Hawaii — can be found in Dr. Hara's presentation at the 2011 American Society of Horticultural Science (ASHS) meeting posted on his website at: http://www.ctahr.hawaii.edu/haraa/ASHSSystemsApproach092711Hara_rev%20%28NXPowerLite%20pptx%29.pdf .

Hot water bath. Dr. Hara has tested the hot water bath method on a number of plant species and found that immersion at 120.3°F for 1 to 10 minutes gave effective control of several species of insects, including aphids, scale, mealybugs and mites on nursery cuttings. Although the root mealybug is very difficult to control or eliminate, hot water dips are as effective as insecticides against this pest. Experiments showed that submerging potted rhapis palms in water held at 120°F until the internal root ball temperature reached 115°F was 100% effective in killing root mealybugs.

Hot water shower. Dr. Hara and his colleagues created a small hot water shower unit and a larger hot water trailer for commercial application (fig. 1) and demonstrated that water sprayed at 113°F for 5 minutes eliminates the coqui frog, an invasive pest in Hawaii. Heat damage to plants was reduced or eliminated by following the hot water shower with 1 to 2 minutes of cool water. Orchids and bromeliads were the only plants tested that were sensitive to the treatment. More information can be found at www.ctahr.hawaii.edu/coqui/documents/PosterAHaraFICCF.pdf .

Another serious pest successfully treated with sprays of hot water is the magnolia white scale. Potted plants treated at 120°F water for 5, 5, and 6 minutes resulted in 100% mortality of adults, nymphs and crawlers, respectively.

Fig. 1. Dr. Arnold Hara standing next to a potted nursery trailer that was recently used to disinfest Christmas trees (imported from Oregon) of slugs using a hot water shower treatment. Photo courtesy of A. Hara, University of Hawaii.

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Plant safety. Additional research on the plant safety of various temperatures demonstrated that most potted plants tested tolerated 113 to 120°F water for 5-, 10-, or 15-minute durations, with a few exceptions where new leaves and flowers were less heat tolerant. Tolerance of specific potted plant species to hot water treatments can be found in Dr. Hara's ASHS presentation, as well as thermal tolerance of species used as propagative material, cut flowers and foliage, and landscape plants.

What About California?

My goal is to find out how this technology can be used in California through a multi-state research effort with Dr. Hara and Dr. Lance Osborne (University of Florida). We are seeking federal funding to construct hot water treatment containers to demonstrate efficacy, reduction in pesticide use and shipment of clean ornamental stock between our respective states. Our hope is that with a combined effort we can study the heat tolerances of a great many plants and pests. With an effective matrix, we will be able to tell growers how long to treat selected plants to provide 100% mortality of the pests without damaging the plants. We are working in concert with the USDA (Cindy McKenzie, USDA ARS Florida), who can help establish protocols and phytosanitary requirements, and with IR4 (Cristi Palmer, IR4 Rutgers), who is providing assistance with testing biological pesticides that can be applied during shipping. Look for more information in the future.

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FIELD OBSERVATIONS: Bagrada bug exclusion is best option for organics

The Bagrada bug, *Bagrada hilaris* (Burnmerister), has become a serious pest on selected crops in nurseries. The primary plant hosts are plants in the Brassicaceae (Cruciferae) family, which includes important foods like cabbage, kale, turnip, cauliflower, mustard, broccoli and radish. They especially like the invasive wild mustard (shortpod or black). In nurseries, however, they prefer ornamental kale, alyssum and stock, and they prefer organically grown crucifers. Field-grown ornamental crucifers — especially stock — are also showing significant damage from this pest.

Growers are reporting that the Bagrada bug can be killed relatively easily with insecticides, but contact or coverage is difficult and some portion of the population always survives. Therefore, consistent applications are necessary. Chemical control options are few, however, due to the restrictions on labels. Remember, the products used have to be registered for nurseries and/or greenhouses. It also has to be registered for food crops if it is a vegetable headed for the garden. Options are especially limited for organic food crops grown in the nursery or greenhouse: One grower observes good kill using insecticidal soap, but the bugs just keep coming, and they have to consistently reapply.

Since there are few chemical control solutions for organic vegetables produced in the nursery, some growers have committed to protecting their plants behind insect exclusion screening. The Bagrada bug adult is large relative to whiteflies, but hatchlings are small. A screen that would exclude whiteflies would probably work very well.

If you want more information about Bagrada bugs, visit the following web site: http://cisr.ucr.edu/bagrada_bug.html. Also see Julie Newman's "Regional Report" in this newsletter and the handout she mentions which has a list of resources.

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Campus Research Updates

Compiled by Deborah Matthews

The red palm weevil invasion in Laguna Beach

by Mark S. Hoddle

In September 2008, inspection of a dead Canary Islands palm in Laguna Beach, Orange County, California, revealed the presence of a large weevil that was identified by USDA taxonomists as the red palm weevil (RPW), *Rhynchophorus ferrugineus*, a destructive pest of coconuts native to southern Asia. This insect has been classified by the Food and Agriculture Organization as the world's most destructive palm pest — it has caused immense devastation to Canary Islands palms around the Mediterranean and to date palms in the Middle East and northern Africa. RPW has been moved internationally by the trade in live palm trees used for landscaping. In Egypt, it has been estimated that more than one million date palms have been killed by this pest.

Coloration in *Rhyncophorus ferrugineus* is extremely variable and has historically led to the erroneous classification of color-defined polymorphs (variants) as distinct species. The color morph for this global invader is orange with red spots, and the closest population of this color morph to the United States is in the Caribbean on the islands of Aruba and Curacao (it was introduced via live palm imports from Egypt for landscaping around hotels). Consequently, the first incursion into North America was expected to be Florida. The first detection of RPW in Laguna Beach in California was surprising, not only because of the location but also because it was a different color morph. This color morph, black with a red stripe (fig. 1), was previously known as *R. vulneratus*, and was synonomized with *R. ferrugineus* by Canadian researchers in 2004.

Fig. 1. Red palm weevil found in Laguna Beach, California. Photo courtesy of J. Kabashima, UC Cooperative Extension, Orange County.

DNA work at UC Riverside has revealed that these two weevils are indeed separate species. *R. vulneratus* was found in Laguna and it likely originated from Indonesia, possibly from the island of Bali. The mode of introduction of this weevil into Laguna Beach is undetermined. Palm imports into the United States have been banned to prevent the accidental introduction of RPW. One introduction hypothesis is that *R. vulneratus* was introduced for food: the larvae in parts of southeast Asia are considered a delicacy (http://cisr.ucr.edu/blog/invasive-species/entomophagy-collecting-and-eating-red-palm-weevil-larvae-from-nipa-palms-in-sumatra-indonesia/). Pheromone traps have failed to detect adult weevils for more than one year now and it is possible that focused pesticide applications to infested palms may have eliminated incipient populations in Laguna Beach. More information can be found at http://cisr.ucr.edu/red_palm_weevil.html and on the associated blog: http://cisr.ucr.edu/blog/. Also, Jim Bethke published an article on palm weevils in his regional report for the *UCNFA News* fall 2011 edition, available at http://ucanr.edu/sites/UCNFAnews/newsletters/Download_UCNFA_News_as_PDF40180.pdf.

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

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Managing Asian Citrus Psyllid Infestations in Nurseries

by Matt Daugherty

The Asian citrus psyllid (*Diaphorina citri*, fig. 1) has emerged as a major threat to California citrus, in large part due to its role as a vector of Huanglongbing disease. To ensure that nursery stock is not contributing to spread of the vector and disease (fig. 2), rules are in place that limit the movement and mandate treatment with insecticides of all psyllid host plants at nurseries. Nonetheless, well over 200 *D. citri* infestations have occurred at Southern California retail nurseries and garden centers, which has led to plants being put on hold or destroyed. Ongoing research by UC Riverside and Cooperative Extension personnel is investigating factors that undermine control of *D. citri* in nurseries. Prior studies have shown that systemic insecticide is maintained at effective concentrations for three months or more. Yet, preliminary results suggest that nursery stock commonly remains onsite for well over three months post treatment — more than a year in some cases. Future efforts will concentrate on working with nurseries to develop best management practices that encourage, among other things, the timely turnover of nursery stock.

Matt Daugherty is Assistant Extension Specialist, Department of Entomology, UC Riverside

Fig. 1. Asian citrus psyllid adults feeding on young citrus flush. Photo by Michael Rogers, University of Florida.

Fig. 2. Citrus and related plants in the family Rutaceae may host psyllids and Huanglongbing. Photo by Adam Zeilinger, UC Riverside.

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New publications from Agriculture and Natural Resources

compiled by Steve Tjosvold

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Author: G. Billikopf, UC Cooperative Extension
Order form:
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Black Scale: Pest Notes for Home and Landscape
Black scale causes economic damage to olive and citrus crops, and can also affect a large variety of fruit and nut trees and ornamental plants. Learn how to identify, manage and control this insect pest.

Author: E. J. Fichtner, M.W. Johnson
ANR Publication #74160
http://anrcatalog.ucanr.edu/Items/74160.aspx

Goldspotted Oak Borer: Pest Notes for Home and Landscape
Goldspotted oak borer attacks xylem and phloem layers near the base of oak trees and can girdle and kill mature oaks. A San Diego area pest, it may eventually spread to other areas of California. Learn identification and treatment methods.

Author: M. L. Flint et al.
ANR Publication Number #74163
http://anrcatalog.ucanr.edu/Items/74163.aspx

Poison Hemlock: Pest Notes for Home and Landscape
The leafy parts of poison hemlock have some resemblance to those of its relatives carrot, celery, and parsnip, as well as a variety of leafy herbs. It is, however, toxic to humans and other animals. Learn how to manage this vigorous, competitive weed.

Author: Ditomaso, Roncoroni, et al.
ANR Publication #74162
http://anrcatalog.ucanr.edu/Items/74162.aspx

Ants: Pest Notes for Home and Landscape
(Recently Updated)
Ants are among the most prevalent pests in households and commercial buildings where they can find food and water. On outdoor (and sometimes indoor) plants, ants protect and care for honeydew-producing insects such as aphids, soft scales, whiteflies, and mealybugs, increasing damage from these pests. Ants also perform many useful functions in the environment, such as feeding on other pests (e.g., fleas, caterpillars, termites), dead insects, and decomposing tissue from dead animals. Also available in Spanish.

Author: M. K. Rust, D.H. Choe
Publication #7411
http://anrcatalog.ucanr.edu/Items/7411.aspx

UCNFA Educational Programs for 2013

information at http://ucanr.org/sites/UCNFA/

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May 14, 2013 Salinas

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June 4, 2013 Watsonville

ABCs de la Horticultura (Sesión en Español)
June 5, 2013 Watsonville

ABCs of Nursery and Greenhouse Pests (English & Spanish)
June 13, 2013 Ventura

ABCs of Plant Diseases (English & Spanish)
July 23 and 24, 2013 Parlier

Water Treatment Conference
September 25, 2013 San Marcos

California Nursery Conference
October 9, 2013 Etiwanda

ABCs of Fertilizers and Plant Nutrition (English & Spanish)
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ABCs of Fertilizers and Plant Nutrition (English & Spanish)
October 22, 2013 Parlier

Nursery/Floriculture Insect Mgmt Symposium
December 12, 2013 Watsonville

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