Topics in Subtropics Newsletter

University of California Cooperative Extension

Fresno, Kern, Madera, Riverside, San Bernardino, San Diego, San Luis Obispo, Santa Barbara,Tulare,&Ventura Counties

News from the Subtropical Tree Crop Farm Advisors in California

Volume 4, No. 1
January – March 2006

Editor's Note:

Please let us know if your mailing address has changed, or you would like to add someone else to the mailing list. Call or e-mail the farm advisor in the county where you live. Phone numbers and e-mail addresses can be found at the end of this newsletter.

Please also let us know if there are specific topics that you would like addressed in subtropical crop production. Copies of Topics in Subtropics may also be downloaded from the county cooperative Extension websites of the Farm Advisors listed at the end of this newsletter.

Mark W. Freeman
Editor of this issue

In this issue:

Farm Advisors

Gary Bender – ***Subtropical Horticulture, San Diego***
Phone: (858) 694-2856
Email to: gsbender@ucdavis.edu
Website: http://cesandiego.ucdavis.edu

Mary Bianchi – ***Horticulture/Water Management, San Luis Obispo***
Phone: (805) 781-5949
Email to: mlbianchi@ucdavis.edu
Website: http://cesanluisobispo.ucdavis.edu

Ben Faber – ***Subtropical Horticulture, Ventura/Santa Barbara***
Phone: (805) 645-1462
Email to: bafaber@ucdavis.edu
Website: http://ceventura.ucdavis.edu

Ben Faber – ***Subtropical Horticulture, Ventura/Santa Barbara***
Phone: (805) 645-1462
Email to: bafaber@ucdavis.edu
Website: http://ceventura.ucdavis.edu

Peggy Mauk – ***Subtropical Horticulture, Riverside***
Phone: (951) 683-6491, ext. 221
Email to: pamauk@ucdavis.edu
Website: http://ceriverside.ucdavis.edu

Neil O'Connell – ***Citrus/Avocado, Tulare***
Phone: (559) 685-3309 ext 212
Email to: nvoconnell@ucdavis.edu
Website: http://cetulare.ucdavis.edu

Craig Kallsen – ***Subtropical Horticulture & Pistachios, Kern***
Phone: (661) 868-6221
Email to: cekallsen@ucdavis.edu
Website: http://cekern.ucdavis.edu

Eta Takele – ***Area Ag Economics Advisor***
Phone: (951) 683-6491, ext 243
Email to: ettakele@ucdavis.edu
Website: http://ceriverside.ucdavis.edu

Mark Freeman – ***Citrus & Nut Crops, Fresno/Madera***
Phone: (559) 456-7265
Email to: mwfreeman@ucdavis.edu
Website: http://cefresno.ucdavis.edu

Liquid-Sugar Ant Bait Stations are Nearing Registration for Agriculture

Beth Grafton-Cardwell[1] and Kris Godfrey[2]
University of California Riverside, Kearney Agricultural Center, Parlier, CA
CDFA, Biological Control Program, Sacramento, CA

Until recently, development of baited toxicants for ant control in agricultural crops focused on the red imported fire ant, *Solenopsis invicta*, because of the severity of problems that it causes for human health and agricultural crops. Red imported fire ant is attracted to the oil covering corn cob grit bait and is fairly well-controlled by a number of toxicants including abamectin (Clinch) and pyriproxyfen (Esteem ant bait). These baits also control the native southern fire ant, *Solenopsis xyloni*, found throughout California. In California, red ants are agricultural pests primarily due to their damage to nut meats and to the bark of young trees. Growers find that the oil coated corn cob grit baits mixed with a toxicant scattered on the ground are more effective than ground sprays of an organophosphate such as chlopryrifos (Lorsban). This is because ground sprays only kill the worker ants on the surface while the baits are taken into the nest by the worker ants and so kill additional stages.

There are more than 200 different ant species found in urban and agricultural situations in California. Many of them are not attracted to oil or protein baits, but instead are easily attracted to sugar in liquid form. These ant species are serious pests in crops because they protect homopteran insect pests (scales, mealy bugs, whiteflies, aphids and psyllids) from natural enemies (Daane et al. 2004). The ants harvest the honeydew produced by these pests, return to their nest, and feed the liquid sugar (via trophalaxis) to their young. There are many species of ants that show this type of liquid-sugar feeding behavior and protect pests from natural enemies in California. The most well-known of these ant species is the invasive Argentine ant (*Linepithema humile*). Argentine ants are aggressively displacing other ant species as they spread through California and so development of liquid-sugar baits that take advantage of their feeding habits is critical for long-term ant control. Ants in the genus *Formica* are currently important crop pests (vineyards and citrus orchards) in regions of California that Argentine ant has not yet invaded.

Native gray ant, *Formica aerata*, is common in orchards and vineyards in the San Joaquin Valley and the gray ant *F. perpilosa* is common in vineyards in the Coachella Valley of California...

Developing a liquid-sugar bait for agriculture is not a simple process. The concentration of toxicant has to be carefully balanced with the concentration of sugar (25%) so that the toxicant can not be detected by the ants. The toxicant has to act slowly (1-4 days until kill) so that it does not kill the foraging ant before it returns to the nest and passes the toxicant along to the larvae. The container has to protect the liquid from evaporation so that the concentration of toxicant doesn't increase and become detectable by the ants and doesn't concentrate the sugar too much so that it grows mold. The volume of liquid in the dispenser has to be large enough that the liquid does not have to be refilled too frequently each season, due to the high cost of labor. The container has to be animal and human tamper proof. Both the container and the formulation of the liquid toxicant must be registered by Cal DPR specifically for agriculture. These constraints, until recently, limited the interest of insecticide companies in developing products for agriculture.

On February 23 and 24, 2006, a symposium on the control of sugar-feeding ants using liquid baits was held in Visalia CA. The idea for this symposium came from a meeting held in the late spring of 2005 that highlighted the need for effective control of sugar-feeding ants in California crops. The 2006 symposium was attended by 65-70 people representing growers, pest control advisors, commodity groups, chemical and organic products industries, USDA, UC researchers and extension farm advisors and CDFA.

The symposium began with presentations by University of California researchers reviewing what is known about the sugar-feeding ants and the most recent research results using liquid baits in grapes, citrus, and subtropical crops. Next, dispenser designs and issues were discussed.

The Environmental Protection Agency has approved the use of 4 liquid-bait station designs and also outlined the general criteria that must be met for future dispensers to be designated for "non-food use". Next in the symposium, formulation needs of the baits and new technologies were discussed. A panel of growers and pest control advisors discussed their current ant situation and what they would like to see in the future for ant

On the second day of the symposium, the participants devised an action plan to identify gaps in our knowledge of the biology of the sugar feeding ants, identify attributes needed to effectively use bait stations (such as number per acre, time of placement, servicing interval, etc.), attempts to improve formulations of the liquid baits, and work on how ant control will fit into crop pest management plans.

In addition, products that may be useful in ant control were listed and the information needed to assist in registering these products was identified. From this list, there appear to be 3 liquid baits that may be on the market in California possibly as soon as 2007 or 2008. One product is Impetus Liquid Ant Bait (Bayer CropScience) that has imidacloprid as a toxicant. The other two products, Gourmet Liquid Ant Bait (Innovative Pest Control) and Terro Ant Bait use boric acid as a toxicant. All of these companies are in the process of obtaining registration for agricultural crops.

To growers, it appears to be a slow process getting liquid-sugar bait stations to full registration. However, some very serious hurdles had to be overcome. First, while many toxicants are effective in killing ants, including imidacloprid, hydramethylnon, thiamethoxam, fipronil, pyriproxyfen, boric acid and others (Klotz et al. 2003, 2004; Tollerup et al. 2004), the formulation of each must be developed for this use and a label specifically for ant control in bait stations in agricultural crops must be prepared. Secondly, some of these toxicants do not have food tolerances established

That initially meant that many of the insecticides could only be used in urban situations and not agriculture.

However, during 2005, Keith Dorschner of the IR4 program successfully convinced EPA that the rates of insecticides used in ant bait stations are extremely low and containerized so residues do not make contact with the crop.

The EPA recently ruled that food tolerances are not required and this allows for more types of insecticides to be registered for ant bait stations. Thirdly, EPA has to register the container that holds the liquid toxicant.

EPA recently approved the following stations: AntPro (KM Ant Pro LLC, Nokomis, FL), University of California PVC pipe (K. Tollerup, Dept. of Entomology), University of California PVC bait station (plastic bottle station; Mark Battany and Kent Daane, UCCE) and the Ace Bait Station (Whitmire Micro-Gen Research Laboratories, St. Louis, MO) for use with liquids. These recent achievements will allow chemical companies to register their agricultural products faster. The efficacy of liquid-sugar ant bait stations varies with the climate, the crop, the ant species and the toxicant. Much more work needs to be done to determine the spacing, number of stations, refill frequency, efficacy, and cost effectiveness of these stations for agriculture. However, we are encouraged by the collaboration of the University of California, USDA, CDFA, IR-4, EPA, growers and the chemical industry and the accelerated pace of development of these products.

Daane, K. M., K. R. Sime, M. L. Cooper, and M. C. Battany. 2004. Ants in your vineyard? UC Plant Prot Quarterly 11 (2): 1-3.

Klotz, J. H., M. K. Rust, D. Gonzalez, L. Greenberg, H. Costa, P. Phillips, C. Gispert, D. A. Reierson and K. Kido. 2003. Directed sprays and liquid baits to manage ants in vineyards and citrus groves.

Klotz, J. H., M. K. Rust, and P. Phillips. 2004. Liquid bait delivery systems for controlling Argentine ants in citrus groves (Hymenoptera: Formicidae). Sociobiology 43: 419-427.

Tollerup, K. E., M. K. Rust, K. W. Dorschner, P. A. Phillips, J. H. Klotz. 2004. Low-toxicity baits control ants in citrus orchards and grape vineyards. California Agriculture 58: 213-217

Huanglongbing, Citrus Greening: Preparing For The Future

Lee, R. F.[1], Keremane, M. L.[1], M. Williams[2] and Georgios Vidalakis[3]

[1] USDA ARS National Clonal Germplasm Repository for Citrus and Date; [2] California Department of Food and Agriculture and [3]University of California, Department of Plant Pathology, Riverside

Huanglongbing (HLB), more commonly known as citrus greening disease, was found in Florida in August 2005; *Diaphorina citri* Kuwayama, the Asian citrus psyllid and insect vector of HLB, was found in Florida in 1998. Since the initial discovery, the presence of HLB has been confirmed by polymerase chain reaction (PCR) assay in 12 counties in Florida as of March 7, 2006. The presence of HLB in Florida, coupled with citrus canker (*Xanthomonas axonopodis* pv *citri*), presents severe challenges to continued economic production of citrus and has a major impact on nursery operations. We briefly describe greening disease, the research underway at the National Clonal Germplasm Repository for Citrus and Dates (NCGRCD) to develop more robust detection methods, and the plans of California Department of Food and Agriculture (CDFA) for a statewide survey for HLB.

HLB is considered to be one of the most destructive diseases of citrus. There is no cure for citrus greening disease; trees decline while the fruit produced are small, lopsided, not fully colored, and bitter tasting. The disease is caused by a phloem-limited bacteria which has not yet been cultured. HLB is spread by propagation of infected material and by two species of psyllids; *D. citri* which is present in most of Asia, South America, areas of Central America, Mexico, Florida, Texas, and the Caribbean Basin) and *Trioza erytreae* (del Guercio), the African citrus psyllid which occurs in Africa, the Persian Gulf, and islands in the Indian ocean. Both nymphs and adult psyllids can acquire the bacterial pathogen. Once acquired, it can be transmitted throughout the psyllid's life. Both psyllid species feed and survive primarily on citrus and citrus relatives. *D. citri* will feed on tender flush, secret a waxy exudate, and their feeding often causes a characteristic leaf notching (Figure 1).

At one time HLB was thought to be caused by a virus because it is graft transmissible. By electron microscopy examinations and demonstration of remission of symptoms in infected trees with some antibiotics, it was realized that the disease is caused by a phloem-limited fastidious bacterium. By characterization of the 16S RNA and interspace region of the ribosomal DNA gene, three species of HLB have been recognized: *Candidatus* Liberibacter africanus (African greening), *Ca.* L. asiaticus (Asian greening), and a new species found in Brazil in 2004, *Ca.* L. americanus. The Asian greening has been found in Florida and in Brazil, although the most common species in Brazil is the *Ca.* L. americanus. Generally, Asian greening expresses symptoms at a higher temperature than African greening. During cool weather, new flush tissue may be asymptomatic if the tree is infected with Asian greening.

Detection of HLB infected trees is primarily by visual symptoms; because of irregular distribution of the bacterium in plant tissue and inhibitors in plant tissue extracts, the PCR assay can only confirm the presence of HLB in symptomatic tissue and may not give a positive result if asymptomatic tissue is sampled. Symptoms associated with HLB are yellow shoots (huang-long is Chinese for yellow dragon), blotchy mottle on leaves, and lopsided fruit which remain green at the stylar end and usually contain aborted seed (Figure 2). Depending on location, there are variations; for example in Brazil and Florida it is common for mottling to appear on fruit and the fruit columella may be yellow colored in lopsided fruit (Figure 3). HLB affected fruit have a bitter, sour, and/or medicinal taste and are unmarketable.

The NCGRCD has a joint project with University of Florida and Florida Division of Plant Industry to develop a more robust PCR assay for detection of HLB and to monitor preserved adult psyllids and nymphs caught and identified in Florida (Figure 4). This research should help develop more sensitive detection methods for HLB in asymptomatic tissue and will be useful for future screening of germplasm coming into California.

In the spring of 2006, CDFA Pest Detection plant pathologists will conduct a statewide survey for HLB, looking for symptoms of the disease and for the vector, *D. citri*. The purpose of the survey is to detect the presence of HLB and/or its vector in California before either has a chance to become established. The HLB survey will emphasize urban settings and ethnic fars, as these are the areas where HLB is most likely to be found according to the experience in Florida. Additionally, ornamental nurseries and garden centers will be surveyed for *D. citri*. Commercial citrus will be sampled in locations where citrus canker surveys are being conducted. Call 1-800-491-1899 to report any suspect trees.

Additionally, a project coordinated by Georgios Vidalakis, with J. Morse, P. Mauk, UCR, and several cooperators will enable surveys of the CCPP foundation materials and other collections at the University and to survey for *D. citri* in Southern California.

For more information on HLB and its vectors, you may go to these resources:

Bove, J. M. 2006. Huanglongbing: A destructive, newly-emerging, century-old disease of citrus. J. Plant Pathology 88: 7-37 (http://scotmail.ucr.edu/attach/Bove 2 2006.pdf)

Halbert, S. E., and K. L. Manjunath. 2004. Asian citrus psyllids (Sternorrhyncha: Psyllidae) and greening disease of citrus: a literature review and assessment of risk in Florida. Florida Entomolgist 87(3): 330-353. (http://scotmail.ucr.edu/attach/2004 Halbert and Manjunath.pdf)

Roistacher, C. N. Huanglungbing (Greening disease) Part I [Ecoport slideshow at www.ecoport.org] (http://ecoport.org/ep?SearchType=slideshowView&slideshowId=181&checkRequired=Y)

Roistacher, C. N. and Manjunath, K. L. Greening Part II: The bacterium, vectors and detection [Ecoport slideshow at www.ecoport.org] (http://ecoport.org/ep?SearchType=slideshowView&slideshowId=197&checkRequired=Y)

Roistacher, C. N. and Manjunath, K. L. Greening disease (Huanglongbing) of citrus Part III. Epidemiology and control [Ecoport slideshow at www.ecoport.org] (http://ecoport.org/ep?SearchType=slideshowView&slideshowId=197&checkRequired=Y)

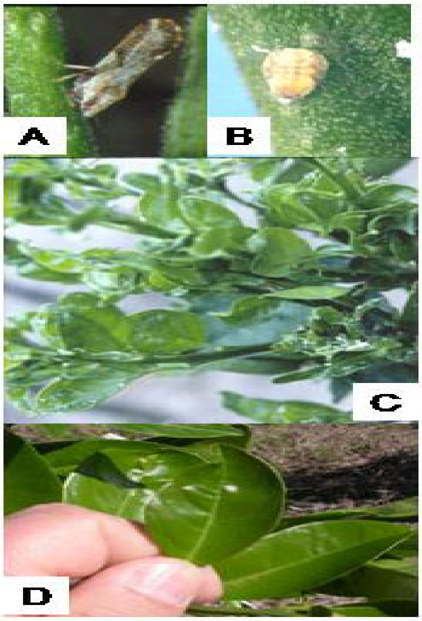

Figure 1. *Diaphorina citri* Kuwayama, the Asian citrus psyllid, and symptoms associated with psyllid feeding. A. The adults are 3-4 mm long and are brownish mottled in color. B. The *D. citri* nymphs are very small; about 0.25 mm for the 1st instar to 1.7 mm for the 5th instar. They usually are yellow-orange in color but can be green or brown. C. Colonization of young citrus flush by *D. citri* results in deposits of a waxy secretion on the leaves. Leaves will be distorted, and close examination with a hand lens usually reveals eggs which may be white, yellow, or orange depending on their age. D. Leaf notching and indentations in the leaves are usually a sign that psyllids have been feeding. (A, B from Jeff Lotz, and C from S. E. Halbert, both FDACS, Gainesville, FL)

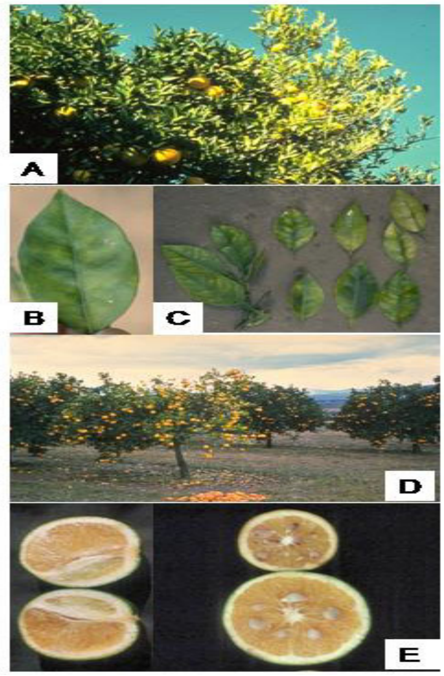

Figure 2. Symptoms associated with HLB. A. Often the first symptom of HLB will be a shoot with characteristic mottle developing on large leaves. Subsequently, yellow shoots having small leaves that point upward occur. These shoots can appear anywhere on the tree canopy, shown here in the top. B. Leaf mottle on a sweet orange leaf. C. Leaf mottling and interveinal chlorosis on mandarin leaves. D. A young trees showing one sector affected by HLB with small fruit and fruit drop. E. HLB affected fruit are lopsided, smaller, seed is aborted, and have a sour, bitter, and/or medicinal taste.

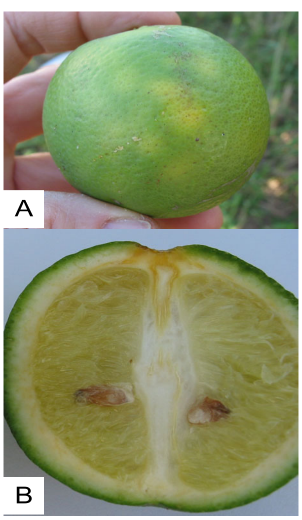

Figure 3. A. Mottling often occurs on HLB affected fruit in Brazil and Florida. B. Fruit columellas often have a yellowish stain in HLB affected fruit from Brazil and Florida; this has not been reported in other areas having greening.

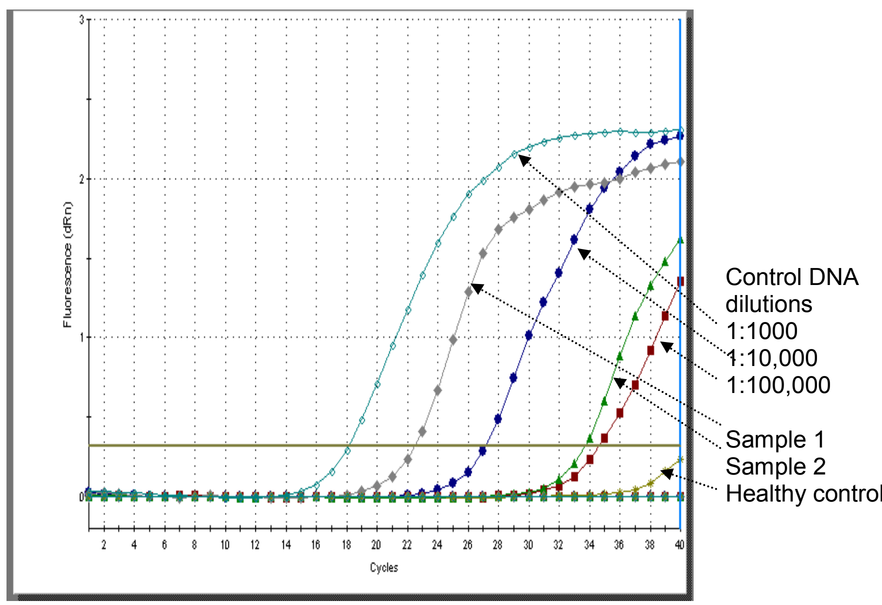

Figure 4. Amplification plots from real time PCR using the SYBR green detection method for diagnosis of HLB in citrus psyllids. The figure shows amplification plots for three dilutions of a positive control DNA (plasmid) in comparison to DNA extractions from two samples of psyllids carrying the HLB bacterium and another psyllid from a greening-free area. Psyllids are preserved in alcohol for shipment and storage before being prepared for detection analysis.

Citrus Herbicide Charts and Tables

Kurt Hembree, Farm Advisor, Fresno County

Chart 1. Susceptibility of Annual Broadleaf Weeds to Herbicides Registered in Citrus Groves in California

	Preemergence														**postemergence**									
C = Control **P = Part control** **N = No control** **-- = No info.**	**Bromacil+Diuron**	**Bromacil**	**Diuron**	**EPTC**	**Flumioxazin**	**Isoxaben**	**Napropamide**	**Norflurazon**	**Oryzalin**	**Oxyfluorfen**	**Pendimethalin**	**Simazine**	**Thiazopyr**	**Trifluralin**	**Carfentrazone**	**Clethodim**	**Diquat**	**DSMA**	**Fluazifop**	**Glyphosate**	**MSMA**	**Oxyfluorfen**	**Paraquat**	**Sethoxydim**
Broadleaves																								
A. morningglory	C	C	C	--	C	C	P	C	P	C	N	C	--	C	C	N	P	P	N	C	P	C	P	N
Cheeseweed	C	C	P	N	C	C	P	P	P	C	P	P	C	N	C	N	C	P	N	P	N	C	C	N
Chickweeds	C	C	P	C	C	C	C	P	C	P	C	C	C	C	P	N	C	C	N	C	C	N	C	N
Clovers, annual	P	P	P	N	--	P	P	N	N	P	N	C	--	N	P	N	P	N	N	P	N	N	P	N
Cocklebiurs	C	C	C	N	--	--	P	C	N	P	N	C	--	N	P	N	C	P	N	C	P	C	C	N
Cudweeds	C	C	C	P	--	C	C	C	N	N	N	C	C	N	--	N	C	N	N	C	N	C	C	N
Fiddleneck	C	C	C	C	--	C	C	P	C	C	C	C	C	C	C	N	C	N	N	C	N	C	C	N
Filarees	C	C	C	P	C	C	C	P	P	C	N	C	C	P	--	N	C	N	N	P	N	C	P	N
Goosefoot	C	C	C	C	C	C	C	P	C	C	C	C	C	C	--	N	C	N	N	C	N	C	C	N
Groundcherries	C	C	C	C	C	C	N	C	N	C	N	C	P	P	C	N	C	N	N	C	P	C	C	N
Groundsel	C	C	N	C	C	C	P	P	N	C	N	P	C	N	--	N	C	N	N	C	N	C	C	N
Hairy fleabane	C	C	P	C	P	C	N	P	N	P	N	C	P	N	P	N	P	N	N	C	N	P	P	N
Henbit	C	C	C	C	C	C	N	P	C	C	C	C	P	P	--	N	C	C	N	P	C	C	C	N
Horseweed	C	C	P	C	C	C	N	P	N	P	N	C	P	N	P	N	C	N	N	C	N	P	P	N
Knotweed	C	C	C	P	--	C	C	P	C	P	C	C	C	C	--	N	P	N	N	P	N	N	P	N
Lambsquarters	C	C	C	C	C	C	C	P	C	C	C	C	C	C	--	N	C	N	N	C	N	C	P	N
London rocket	C	C	C	C	C	C	C	P	N	C	P	C	P	N	C	N	C	N	N	C	N	P	C	N
Mullein, turkey	P	P	N	N	--	C	P	P	N	P	N	N	C	P	--	N	P	N	N	P	N	N	P	N
Mustards	C	C	C	N	C	C	P	P	N	C	P	C	P	N	P	N	C	N	N	C	N	P	C	N
Nettles	C	C	C	C	C	C	P	C	P	C	N	C	C	N	C	N	P	N	N	N	N	C	C	N
Nightshades	C	C	C	P	C	C	N	C	N	C	N	C	P	N	P	N	C	N	N	C	N	C	C	N
Pigweeds	C	C	C	C	C	C	C	P	C	C	C	C	C	C	--	N	C	N	N	C	N	C	C	N
Prickly lettuce	C	C	C	C	P	C	C	P	N	C	N	C	C	N	--	N	C	N	N	C	N	P	P	N
Primrose, evening	C	C	P	--	--	C	P	N	P	P	P	C	C	P	--	N	C	--	N	C	N	P	C	N
Puncturevine	C	C	P	N	C	C	P	C	P	P	P	P	P	P	--	N	C	P	N	C	P	P	C	N
Purslanes	C	C	C	C	C	C	C	C	C	C	C	C	C	C	N	N	C	N	N	C	N	P	C	N
Russian thistle	C	C	P	P	C	C	P	C	P	P	P	C	P	P	--	N	P	N	N	C	N	N	P	N
Shepherd’s-purse	C	C	C	P	C	C	P	P	N	C	P	C	C	N	P	N	C	N	N	C	N	C	C	N
Sowthistles	C	P	C	C	P	C	C	P	N	C	N	C	C	N	N	N	C	N	N	C	N	C	C	N
Spotted spurge	P	P	N	N	C	C	C	C	P	C	P	P	P	P	--	N	C	N	N	C	N	N	C	N
Wild radish	C	C	C	N	C	C	P	P	N	C	N	C	C	N	P	N	C	N	N	C	N	P	C	N
Willowherb	C	C	N	--	C	P	N	P	P	C	--	N	--	--	--	N	P	N	N	P	--	N	P	N

Bromacil + Diuron (Krovar)	Fluazifop (Fusilade) - NB	Oxyfluorfen (Goal) – NB
Bromacil (Hyvar X)	Flumioxazin (Chateau)	Paraquat (Gramoxone)
Carfentrazone (Shark)	Glyphosate (Roundup, etc.)	Pendimethalin (Prowl) – NB
Clethodim (Prism) – NB	Isoxaben (Gallery T&V) – NB	Sethoxydim (Poast)
Diquat (Reglone) – NB	MSMA (MSMA) – NB	Simazine (Princep)
Diuron (Karmex/Direx)	Napropamide (Devrinol)	Thiazopyr (Visor)
DSMA (DSMA) – NB	Norflurazon (Solicam)	Trifluralin (Treflan)
EPTC (Eptam)	Oryzalin (Surflan)	NB = Non-bearing only

This is not an endorsement for of any trade names listed, nor does the omission of specific trade names reflect the view of the author. Please refer to your local dealer or chemical representative for specific herbicide products available.

This chart is not intended to be a recommendation for the use of herbicides. Refer to the appropriate label for application recommendations. Proper weed identification, timing, and accurate application are imperative for effective control. The information in this chart is tentative and may change as warranted. Always follow the label carefully when using herbicides. Kurt J. Hembree, Farm Advisor, Fresno County. Feb. 2006

Citrus Herbicide Charts & Tables

Kurt Hembree, Farm Advisor, Fresno County

Chart 2. Susceptibility of Annual Grass and Perennial Weeds to Herbicides Registered in Citrus Groves in California

	Preemergence														Postemergence									
C = Control **P = Part control** **N = No control** **-- = No info.**	**Bromacil+Diuron**	**Bromacil**	**Diuron**	**EPTC**	**Flumioxazin**	**Isoxaben**	**Napropamide**	**Norflurazon**	**Oryzalin**	**Oxyfluorfen**	**Pendimethalin**	**Simazine**	**Thiazopyr**	**Trifluralin**	**Carfentrazone**	**Clethodim**	**Diquat**	**DSMA**	**Fluazifop**	**Glyphosate**	**MSMA**	**Oxyfluorfen**	**Paraquat**	**Sethoxydim**
Annual grasses																								
Annual bluegrass	C	C	C	C	C	N	C	C	C	P	C	C	C	C	N	C	P	N	N	C	N	N	C	N
Barnyardgrass	C	C	C	C	C	N	C	P	C	P	C	P	C	C	N	C	P	P	C	C	P	P	P	C
Bromegrasses	C	C	C	C	P	N	C	C	C	P	C	--	C	C	N	P	--	N	P	C	--	N	C	P
Canarygrass	C	C	C	C	P	N	C	C	C	P	C	P	C	C	N	C	P	N	C	C	N	N	C	C
Crabgrass, large	C	C	C	C	C	N	C	P	C	N	C	N	C	C	N	C	C	C	C	C	C	N	C	C
Fescues	--	--	C	C	P	N	C	C	C	N	C	P	P	C	N	P	C	N	P	C	--	N	C	P
Foxtails	C	C	C	C	C	N	C	P	C	N	C	C	C	C	N	C	P	--	C	C	--	N	P	C
Junglerice	C	C	C	C	C	N	C	P	C	P	C	P	C	C	N	C	P	P	C	C	P	P	P	C
Lovegrass	C	C	C	C	C	N	C	P	C	C	C	P	P	C	N	C	P	--	C	C	--	N	C	C
Ryegrass, Italian	C	C	C	C	P	N	C	C	C	N	C	P	C	C	N	C	P	N	C	C	N	N	C	C
Sandbur	C	C	C	C	C	N	C	C	C	N	C	C	C	C	N	C	P	N	C	C	C	N	P	C
Sprangletops	C	C	P	C	P	N	C	P	P	N	P	N	C	C	N	C	N	N	C	C	N	P	P	C
Wild barley	C	C	C	C	P	N	C	C	C	P	C	P	C	C	N	C	P	N	C	C	N	N	C	C
Wild oats	C	C	P	C	C	N	C	C	P	P	P	C	P	P	N	P	P	N	C	C	N	N	C	C
Witchgrass	C	C	C	C	P	N	C	P	C	P	C	P	P	C	N	C	P	N	P	C	N	N	C	P
Perennials (seedling)																								
Bermudagrass	C	C	C	C	N	N	C	C	C	P	C	P	C	C	N	C	P	N	C	C	N	N	C	C
Dallisgrass	C	C	C	C	--	N	C	C	C	P	C	C	C	C	N	C	P	C	C	C	C	N	C	C
Johnsongrass	C	C	C	C	C	N	C	C	C	P	C	C	C	C	N	C	P	C	C	C	C	N	C	C
Field bindweed	C	C	P	N	--	C	N	P	P	P	P	P	P	P	C	N	P	N	N	C	N	N	C	N
Perennials (established)																								
Bermudagrass	P	P	N	N	N	N	N	P	N	P	N	N	N	N	N	C	N	N	C	C	N	N	N	C
Dallisgrass	P	P	N	N	N	N	N	P	N	P	N	N	N	N	N	C	N	P	C	C	C	N	N	C
Johnsongrass	P	P	N	N	N	N	N	C	N	P	P	N	P	P	N	C	N	N	C	C	N	N	N	C
Field bindweed	P	P	N	N	N	N	N	N	N	N	P	N	P	P	P	N	P	N	N	P	N	N	P	N
Nutsedge, purple	C	C	N	P	N	N	N	P	N	N	N	N	P	N	N	N	P	P	N	C	P	N	P	N
Nutsedge, yellow	C	C	N	P	N	N	N	P	N	N	N	N	C	N	N	N	P	P	N	C	C	N	C	N

Bromacil + Diuron (Krovar)	Fluazifop (Fusilade) - NB	Oxyfluorfen (Goal) – NB
Bromacil (Hyvar X)	Flumioxazin (Chateau)	Paraquat (Gramoxone)
Carfentrazone (Shark)	Glyphosate (Roundup, etc.)	Pendimethalin (Prowl) – NB
Clethodim (Prism) – NB	Isoxaben (Gallery T&V) – NB	Sethoxydim (Poast)
Diquat (Reglone) – NB	MSMA (MSMA) – NB	Simazine (Princep)
Diuron (Karmex/Direx)	Napropamide (Devrinol)	Thiazopyr (Visor)
DSMA (DSMA) – NB	Norflurazon (Solicam)	Trifluralin (Treflan)
EPTC (Eptam)	Oryzalin (Surflan)	NB = Non-bearing only

This is not an endorsement for of any trade names listed, nor does the omission of specific trade names reflect the view of the author. Please refer to your local dealer or chemical representative for specific herbicide products available.

This chart is not intended to be a recommendation for the use of herbicides. Refer to the appropriate label for application recommendations. Proper weed identification, timing, and accurate application are imperative for effective control. The information in this chart is tentative and may change as warranted. Always follow the label carefully when using herbicides. Kurt J. Hembree, Farm Advisor, Fresno County. Feb. 2006.

Citrus Herbicide Charts and Tables

Kurt Hembree, Farm Advisor, Fresno County

Table 1. Performance of Preemergence Herbicides in Citrus Groves in California

Herbicide	Conditions favoring effective weed control and crop safety
bromacil (Hyvar-X)	Used at 3.2-6.4 lb a.i./acre in groves at least 4 years old. It can be applied as a single or split application in winter and spring. Rainfall or irrigation occurs within 21 days of treatment. Refer to agricultural commissioner for permit if in a Ground Water Protection Area (GWPA).
bromacil + diuron (Krovar)	Used at 3.2-4.8 lb a.i./acre in groves at least 3 years old. It can be applied as a single or split application in winter and spring. Rainfall or irrigation occurs within 21 days of treatment. It can cause injury to citrus and other trees if runoff water contacts their roots. Refer to agricultural commissioner for permit if in a Ground Water Protection Area (GWPA).
diuron (Karmex, Direx)	Used at 2.4-3.2 lb a.i./acre in groves at least 1 year old. Use lower rates for lighter soils, especially under drip or other low-volume irrigation. Works well under furrow irrigation. It can be mixed with simazine for broader control. Refer to agricultural commissioner for permit if in a Ground Water Protection Area (GWPA).
eptc (Eptam)	Used at 2.1-3.0 lb a.i./acre in bearing and non-bearing groves. It is incorporated 2" deep with rotary hoe or water-run on level soils. Provides short-term residual control (4-6 weeks). 15 day PHI.
isoxaben (Gallery T&V)	Used at 0.66-1.33 lb a.i./acre in non-bearing groves only. Application made after trees have completely settled into the soil. Rainfall or irrigation of at least 0.5" needed within 21 days of treatment. Used only where broadleaf weeds are expected; does not control grasses or nutsedge.
flumioxazin (Chateau)	Used at 0.188-0.38 lb a.i./acre in non-bearing groves. Applied as a directed spray, being careful to avoid contact with young wood or foliage. Rainfall/irrigation of ¼ to ½" needed within 21-28 days of treatment. It can be tank-mixed with other residual products for broader weed control and glyphosate for improved burn down of weeds. It provides about 1 month residual control for each 2 oz/acre product used. It helps provide preemergence control of annual grasses, marestail, hairy fleabane, and other annual weeds.
napropamide (Devrinol)	Used at 4.0 lb a.i./acre in bearing and non-bearing groves. It must be incorporated by rainfall or sprinkler irrigation within 7 days of treatment. Residual control is reduced under frequent, low-volume drip or micro-sprinkler irrigation. It should be combined with post-emergence herbicides if weeds are emerged. Soil surface is clear of leaves and other debris. Residual period is 4-10 months.
norflurazon (Solicam)	Used at 1.0-4.0 lb a.i./acre in bearing and non-bearing groves. Use lower rates on coarse soils under low-volume irrigation. Rainfall or irrigation needed within 28 days. It can help to reduce low to moderate nutsedge levels. An 18 month plant-back period; follow the label regarding planting restrictions. 30 day PHI. Refer to agricultural commissioner for permit if in a Ground Water Protection Area (GWPA).
oryzalin (Surflan)	Used at 2.0-6.0 lb a.i./acre in bearing and non-bearing groves. Apply to soil free of leaves and other debris. Rainfall or irrigation of 0.25-2" needed within 21 days of treatment. It can be mixed with other herbicides for broader weed control. A post-emergence herbicide should be added if weeds are emerged. Applied at 6 lb a.i. for longer residual control. Residual period is 4-10 months.
oxyfluorfen (Goal)	Used at 1.2-2.0 lb a.i./acre in non-bearing groves only. Applied in 20-60 gal water/acre. Rainfall or irrigation of at leas 0.75" needed within 21-28 days of treatment. Do not disturb the soil following treatment, or poor weed control will result. It is often combined with oryzalin for broad-spectrum weed control. Refer to the label for use period, cut-off dates, and other restrictions. Residual period 4-10 months. Used at 0.5-1 lb a.i./acre for burn-down.
pendimethalin (Prowl)	Used at 2.0-4.0 lb a.i./acre in non-bearing groves only. Applied in 20-40 gal water/acre to soil surface. Rainfall, irrigation, or mechanical incorporation needed within 4 days of treatment. Applied as a directed spray, avoiding contact with tree foliage.
simazine (Princep)	Used at 2.0-4.0 lb a.i./acre in groves at least 1 year old. Rainfall or flood irrigation occurs within 28 days of treatment. Do not use on sandy soils. Adjust rate to soil type. Mixed with diuron at 1-2 lb a.i./acre each for broad-spectrum control. Refer to agricultural commissioner for permit if in a Ground Water Protection Area (GWPA).
thiazopyr (Visor)	Used at 0.5-1.0 lb a.i./acre in bearing and non-bearing groves. Applied in 20-40 gal water/acre. Applied at 0.5 lb a.i. in the fall and again in the late-winter for nutsedge control. Rainfall is needed within 21 days of treatment. Increased rainfall improves nutsedge control. Tank-mixed with Goal (in non-bearing) for broader residual control. Residual period is 5-8 months. 90 day PHI.
trifluralin (Treflan)	Used at 0.5-1.0 lb a.i./acre before or after planting and disk incorporated 2-4" deep. Useful for helping eradicate Johnsongrass prior to planting. Granular formulation can be used after planting and incorporated immediately after planting.

This is not an endorsement for of any trade names listed, nor does the omission of specific trade names reflect the view of the author. Please refer to your local dealer or chemical representative for specific herbicide products available.

Numerous factors influence the performance of herbicides. The observations and comments in this table assume proper weed identification and accurate application and timing of treatments. Consult Charts 1 and 2 and the proper herbicide labels for the effectiveness of the registered herbicides to control your specific weeds. This table is not intended to be a recommendation for the use of herbicides. Always follow the label carefully when using herbicides. Kurt J. Hembree, Farm Advisor, Fresno County. Feb. 2006.

Citrus Herbicide Charts and Tables

Kurt Hembree, Farm Advisor, Fresno County

Table 2. Performance of Postemergence Herbicides in Citrus Groves in California

Herbicide	Conditions favoring effective weed control and crop safety
Carfentrazone (Shark)	Used at 0.024-0.031 lb ai/acre and no more than 0.124 lb ai/acre/season. A spray adjuvant is required and ammonium sulfate added at 10-15 lb/100 gal may improve control. Ph of spray solution should be 5-8. Weeds are less than 4" tall. Control is improved during warm, dry weather. Use nozzles and procedures that provide thorough weed coverage.
clethodim (Prism)	Used at 0.09-0.25 lb a.i./acre in non-bearing groves only. A crop oil concentrate (1% v/v) or a non-ionic surfactant (0.25% v/v) is added. Applied in 20-40 gal water/acre with thorough weed coverage. Gives selective control of annual bluegrass and other annual grasses (except bromes and fescues) that are actively growing, before tillering, and not stressed. Repeat applications are required on perennials when their growth is according to label.
diquat dibromide (Reglone)	Used at 0.375-0.5 lb a.i./acre in non-bearing groves only. A non-ionic surfactant is added at 0.25% v/v. Applied in 20-60 gal water/acre with thorough weed coverage. Weeds are less than 4" tall. Control is improved during warm, dry weather.
dsma (DSMA)	Used at 2.4-4.8 lb a.i./acre in bearing and non-bearing groves. A non-ionic surfactant is added at 0.25% v/v. Applied in 20-60 gal water/acre with thorough weed coverage. Gives best control when applied during warm, dry weather. Suppresses nutsedge.
fluazifop-p-butyl (Fusilade)	Used at 0.25-0.375 lb a.i./acre in non-bearing groves only. A crop oil concentrate (1% v/v) or a non-ionic surfactant (0.25% v/v) is added. Applied in 20-40 gal water/acre with thorough weed coverage. Gives selective control of annual grasses (except annual bluegrass, bromes, and fescues) that are actively growing, before tillering, and not stressed. Repeat treatments are required on perennials when their growth is according to label.
glyphosate (Roundup, etc.)	Used at 0.5-4.0 lb a.i./acre in bearing and non-bearing groves. Applied by ground with low-pressure, flat fan nozzles, controlled droplet applicator, or smart sprayer. Add AMS at 5-10 lb/100 gal water to improve control. For annual weeds, use 1.0 lb a.i. in 3-40 gal water/acre. Apply to young, growing annuals or perennials when they are flowering. Some perennials require highest label rate. Hairy fleabane and horseweed can be controlled it treated in the seedling stage. Avoid drift onto green wood or foliage of trees. Weeds should not be cultivated for 7-14 days after treatment. Can be combined with low rates of oxyfluorfen (non-bearing) for broader weed control, as well as combined with pre-emergence herbicides.
msma (MSMA)	Used at 2.0 lb a.i./acre in non-bearing groves only. Trees are >1 year old. Applied on yellow nutsedge with fewer than 5 leaves in 60 gal water/acre. Multiple applications may be needed. Air temperature is around 85ºF for best activity.
oxyfluorfen (Goal)	Used at 0.5-1.0 lb a.i./acre in non-bearing groves only. Applied to weeds at the 4-leaf stage or sooner. Combined with glyphosate or other post-emergence herbicides to control specific weeds.
paraquat (Gramoxone)	Used at 0.3-0.9 lb a.i./acre in bearing and non-bearing groves. A non-ionic surfactant is added at 0.5% v/v. Applied in 20-60 gal water/acre with thorough weed coverage. Weeds are less than 4" tall. Repeat applications needed as new growth occurs. Do not allow drift to contact fruit, or injury will occur. A restricted herbicide, requiring a permit from the county agricultural commissioner for purchase and use.
sethoxydim (Poast)	Used at 0.28-0.47 lb a.i./acre in bearing and non-bearing groves. A crop oil concentrate is added at 1% v/v. Applied in 20-40 gal water/acre with thorough weed coverage. Gives selective control of annual grasses (except annual bluegrass, bromes, and fescues) that are actively growing, before tillering, and not stressed. Repeat treatments are required on perennials when their growth is according to label.

This is not an endorsement for of any trade names listed, nor does the omission of specific trade names reflect the view of the author. Please refer to your local dealer or chemical representative for specific herbicide products available.

Numerous factors influence the performance of herbicides. The observations and comments in this table assume proper weed identification and accurate application and timing of treatments. Consult Charts 1 and 2 and the proper herbicide labels for the effectiveness of the registered herbicides to control your specific weeds. This table is not intended to be a recommendation for the use of herbicides. Always follow the label carefully when using herbicides. Kurt J. Hembree, Farm Advisor, Fresno County. Feb. 2006.

Bear Citrus Thrips Resistance in Mind When Deciding Whether and How to Treat in 2006

Joseph G. Morse and Elizabeth E. Grafton-Cardwell, Department of Entomology
University of California, Riverside

Citrus thrips, *Scirtothrips citri* (Moulton), has a history of developing resistance to pesticides that are used repeatedly for its control. In the San Joaquin Valley, citrus thrips resistance to Dimethoate (= Cygon) appeared in the early 1980's, to Carzol in the late 1980's, and to Baythroid with cross resistance to other pyrethroids (e.g., Danitol) in the mid 1990's.

Note that citrus thrips resistance appeared in some groves but not in others – it was mainly a matter of how often sprays of the same material went on in each grove. Since it was registered in 1998, Success has been the major material used for citrus thrips control although many growers used other products such as Veratran or AgriMek or they use Dimethoate, Carzol, Baythroid, or Danitol in areas where resistance has not developed or on populations that have not been treated with these materials for several years, allowing resistance to revert.

One problem with resistance is that once it appears in a population, although resistance may revert if that class of chemistry is not used for several years, it often reappears relatively quickly if such treatments are used too often or too soon after reversion.

Veratran has been used for citrus thrips control since 1948 and it is one of the few materials that has been used for an extended period of time and for which citrus thrips resistance has not been reported. This is partially because it is not a very persistent material -- it continues to kill citrus thrips for less than a week – residues and/or the sugar or molasses, used as a bait, break down relatively quickly (Veratran is a stomach poison with little contact activity – it must be ingested by thrips to be effective).

Pesticides having a long persistence have the advantage of controlling thrips for an extended period of time but this is a two-edged sword because long persistence selects for resistance over multiple thrips generations, leading to resistance evolution more quickly. It is likely citrus thrips could develop resistance to Veratran if it were used too often on citrus. Avocado thrips, *Scirtothrips perseae* Nakahara, is in the same genus as citrus thrips, has a similar biology, and resistance to Veratran was observed in two avocado groves in Ventura County in 1999. Although resistance to Veratran reverted when intensive use was discontinued after other products were available for rotation with Veratran, this shows that heavy use of Veratran has the potential to lead to resistance.

A major problem is that in areas of California where citrus thrips has developed resistance to Dimethoate, Carzol, Baythroid, and or Danitol, we have relatively few effective chemicals available to rotate for citrus thrips control (see Table 1 below). Both Veratran and Assail are materials to consider in rotation with Success. We have run citrus thrips grower-cooperator pesticide efficacy tests on San Joaquin Valley navel oranges on three occasions over the past two years and Veratran, Assail, and AgriMek have all looked fairly good in comparison with Success. As mentioned above, Veratran is not as persistent as the other three materials and if thrips pressure is high and/or prolonged, a second spray may be needed. Assail is fairly effective against citrus thrips but is relatively less selective against natural enemies than are Veratran (very selective) or AgriMek and Success (both relatively selective, some impacts on predaceous mites) and should probably not be used if a biologically-based IPM program is being used (e.g., with *Aphytis melinus* releases for California red scale control).

It is presently unclear whether we would expect to see cross resistance between AgriMek and Success. Although these two materials are in different IRAC classes (Table 1) and many believe they will not show cross resistance, we have two pieces of evidence from unpublished research suggesting there may be cross resistance potential between AgriMek and Success. If this is true, then these two materials are not ideal resistance rotation partners.

First, we have seen low-level loss of susceptibility (i.e. not yet true resistance) to AgriMek in a citrus thrips population in Ventura Co. that was selected repeatedly with this material due to 8 sprays for citrus bud mite control over 7 years. Note that we saw concurrent low-level loss in susceptibility to Success, despite this material not being used in the past at this site. Second, researchers in Australia who selected for Success resistance in a western flower thrips population found what appeared to be low-level cross resistance to AgriMek (it was interesting that based on current opinion that cross resistance between these two materials was not likely, they were reluctant to run the test for us but when they did so, they reported to us "there may be some cross resistance to AgriMek").

A second major problem is that relatively few new effective pesticides are likely to become available for citrus thrips control in the near future and even when a new product becomes available for experimental testing, it is often 3-5 years or more before it is registered for commercial use. We first started testing AgriMek, Baythroid, and Success in 1982, 1989, and 1993, respectively (compare these dates to the year in Table 1 when these materials were registered).

We have been looking for pesticides with new modes of action for citrus thrips control for the last 10 years and it is frustrating how few new products become available each year for testing. At present, we have only a single new product with new chemistry (first tested in 2005) which has shown promise against citrus thrips and at present, it is unclear whether it will clear environmental toxicology screening, and even if it does, it would likely not be available until at least 2009.

For the near future, it is likely that the pesticides listed in Table 1 will be all we have for citrus thrips control. Although citrus thrips fly around a good deal, field studies we have done suggest that resistance in a particular grove results mostly from past pesticide use in that particular field. Thus, if a grower uses Success or other products each year in succession or multiple times within a year, resistance is more likely to appear <u>in that field</u>, making future citrus thrips control problematic.

Because so few pesticides are likely to become available for citrus thrips control in the near future, we strongly suggest the following means of reducing the potential for citrus thrips to develop resistance to Success (and other materials) in your field. First, scout for levels of citrus thrips on fruit after petal fall and withhold treatments unless economic citrus thrips levels are present (i.e. in many years a treatment is not needed). Second, if a treatment is needed, rotate among the available pesticides both within a year and across successive years. Keep in mind we are not yet sure whether to expect cross resistance between Success and AgriMek so although rotating between these two products is better than using two treatments of either material alone, try to rotate in other products with different chemistry as much as possible.

Third, if you had resistance some time in the past with Dimethoate, Carzol, Baythroid or Danitol, consider rotating in one of these materials only after a number of years has passed allowing resistance to revert (you could test this with a treatment on a small part of the grove). If such resistance has been present in the past, you should probably not use that material too often (perhaps once every 4-5 years). Also bear in mind all of the chemical treatments you put on in your grove each year over the period March – October are likely selecting the citrus thrips population in your grove. The bottom line is that if you use Success or other products too often for citrus thrips control, few new materials are available to help you deal with citrus thrips in the future. With resistance, prevention is much more effective than trying to deal with a resistance problem after it has occurred.

Table 1. Pesticides available for control of citrus thrips

Trade Name	*Common Name*	*Year Registered on citrus*	*Class of Chemistry*	*IRAC class*[a]
Veratran D	sabadilla	1948	two plant alkaloids	Not classified
Cyron	dimethoate	1962[b]	organophosphate	1B
Carzol	formetanate	1972[c]	carbamate	1A
AgriMek	abamectin	1994	avermectin	6
Baythroid	cyfluthrin	1997[d]	pyrethroid	3
Success	spinosad	1998	spinosyn	5
Danitol	fenpropathrin		pyrethroid	3
Assail	acetamiprid		neonicotinoid	4A

[a] IRACclass=Insecticide Resistance Action Committee classification, see their website at http://www.irac-online.org and especially the "New MOA Classification Scheme").

[b] 1962 registration was for use on non-bearing trees only. Not registered for use on bearing trees in California until 1980.

[c] Not used heavily on citrus for citrus thrips control until after the early 1980's when citrus thrips resistance to dimethoate appeared in some areas of California.

[d] Although not registered until 1997, cyfluthrin was available to growers 1991-1996 under a Section 18 emergency exemption.