Toxicity of pesticides to western predatory mite

Marjorie A. Hoy □ Janet Conley

Because of its effectiveness in controlling spider mites, the western predatory mite plays an important role in integrated mite management in California almond orchards. When monitoring indicates that the predator, *Metaseiulus occidentalis* (Nesbitt), needs help in controlling the pest mites, however, it is necessary to apply acaricides that will suppress the spider mites but not the predators. Use of selective insecticides and fungicides to control insect pests and diseases is also crucial, since some materials can disrupt predator effectiveness through direct or indirect toxicity.

Evaluating the survival of *M. occidentalis* in the field after treatment with pesticides in replicated spray plots is expensive and time consuming. Such field trials do not always provide useful data on pesticide selectivity, since predator populations can be reduced through starvation and emigration from the orchard or increased through immigration into the orchard on air currents. Laboratory tests provide repeatable and replicated information at a substantially lower cost.

We have used a leaf spray technique to assess mortality of *M. occidentalis* after treatment with pesticides. We sprayed both predators and spider mites with a pesticide on a leaf substrate, and then noted their survival on the residues after 48 hours. The laboratory trials cannot be translated into field efficacy with full reliability, however, because coverage in the field is rarely as complete, and such trials provide no information on the effect of weather on residues.

Test methods

Leaf spray tests involved placing five young gravid females per pinto bean leaf (*Phaseolus vulgaris* L.) disc about ¾ inch in diameter with two-spotted (*Tetranychus urticae* Koch) and Pacific (*T. pacificus* McGregor) spider mites as prey. Fifty females from each colony were tested at each dose. The leaf discs, resting on moist cotton in plastic trays, were sprayed thoroughly with formulated pesticides for about five seconds with a fluorocarbon spray system (Crown Spra-Tool). After keeping the treated discs at 78° to 84°F for 48 hours, we recorded the number of

TABLE 1. Toxicity of pesticides listed in UC Leaflet 21343 to western predatory mite, *Metaseiulus occidentalis (M.o.)*, as determined in laboratory tests

Material (formulation) and rate tested as field rate*	Toxicity to predatory mite	Comments
Azinphos-methyl (Guthion 50 WP) 4 lb 50 WP/400 gal	Low to moderate	Most native *M.o.* populations are resistant, but variability exists. COS-resistant strain is resistant.
Benomyl (Benlate 50 W) 0.5 lb AI/100 gal	High or low, depending on colony used	Reduces egg production of native *M.o.* COS strain is resistant.
Captan (Orthocide 50 W) 8 lb 50 WP/400 gal	Low	Both well fed and starved females tolerated sprays well.
Carbaryl (Sevin Sprayable) 4 lb 50 WP/100 gal	High or low	Native *M.o.* are susceptible, COS strain is resistant.
Chlorpyrifos (Lorsban 4 E) 2 qt 4 E/400 gal	Moderate	Toxicity rating could be lower in orchards in winter, since predators are in diapause and hidden in crevices. (60% mortality occurred at field rate on leaf discs [50 W].)
Cyhexatin (Plictran 50 W) 2 lb 50 WP/400 gal	Low with WP formulation	Flowable formulation was also tested and was more toxic than WP formulation to *M.o.* at equivalent rates. (Flowable formulation is not yet registered in almonds. Field rate of flowable is not known.)
Diazinon (Diazinon 50 W) 1 lb 50 WP/100 gal	Low	Most native *M.o.* are resistant. COS strain is also resistant.
Dithane (see maneb)		
Fenbutatin-oxide (Vendex 4 L) 2 pt 4 L/400 gal	Low	Only 4 L formulation was tested at field rate (2 pt/acre).
Guthion (see azinphos-methyl)		
Imidan (see phosmet)		
Lorsban (see chlorpyrifos)		
Maneb (Manzate, Dithane M-22) 8 lb 80 WP/400 gal	Low	Both well fed and starved females tolerated sprays well.
Methidathion (Supracide 2 E) 6 qt 2 E/400 gal	High	Toxicity rating could be lower in winter since predators are in diapause and hidden in crevices. (100% mortality at half the field rate on leaves.)
Oils. Supreme or superior-type narrow-range oils at 4 to 8 gal/acre	Low	Rating based on tests with summer oils and literature data.
Omite (see propargite)		
Orthocide (see captan)		
Parathion	Low	Based on literature data.
Phosmet (Imidan 50 WP) 1 lb 50 WP/100 gal	Low	Most native *M.o.* populations are resistant to Imidan, as is the COS strain.
Plictran (see cyhexatin)		
Propargite (Omite) 2.5 lb 30 WP/100 gal	Moderate to high	Only WP formulation tested: moderate at 5-10 lb/100 gal; high at 10-20 lb/100 gal. Strains of *M.o.* could vary in tolerance.
Sevin (see carbaryl)		
Supracide (see methidathion)		
Thiophanate methyl (Topsin M) 2 lb/400 gal	Low	No mortality at 5 times field rate.
Vendex (see fenbutatin-oxide)		
Ziram (Ziram 76 W) 12 lb 76 W/400 gal	Low	Both well-fed and starved females tolerated sprays well.

NOTE: Toxicity ratings to western predatory mite (M.o.) are based on the laboratory leaf spray technique. Actual field toxicities could be different, and individual orchard populations of the predator could vary in their responses.
*Materials: WP = wettable powder; W = wettable; AI = active ingredient; E = emulsifiable; L = liquid; ED = emulsifiable concentrate; SC = suspension concentrate.

predators alive, dead, run off, and absent. Mites able to walk when touched lightly with a fine camel's hair brush were recorded as alive, all others as dead.

Pesticide rates tested included a control (water only) and one-fourth, one-half, one, and five times the field rate. Pesticides were rated as having a high toxicity if over 50 percent of the predators were killed at one-fourth and one-half the field rate. Pesticides were considered low in toxicity if predators were unaffected by rates of one or five times the field rate. A moderate toxicity rating was given if about 50 percent of predators were killed at the field rate. We also noted whether the material was toxic to the spider mite prey.

Native *M. occidentalis* populations vary in their dose responses to organophosphorus (OP) insecticides. We believe these differences reflect past treatment histories in specific orchards or vineyards. Such variability has been found in California pears, grapes, and almonds. We therefore tested two colonies of *M. occidentalis* with the pesticides listed in Leaflet 21343, *A Guide to Controlling Almond Pests, Diseases, and Micronutrient Deficiencies* (UC Division of Agriculture and Natural Resources, 1983). The two colonies were a wild strain collected from an almond orchard in Stanislaus County with a moderate level of resistance to OP insecticides, and the carbaryl-OP-sulfur-resistant (COS) strain, which is being mass-reared commercially and released in almond orchards.

Toxicity ratings

Because all ratings are from laboratory data, they may need to be amended if field data indicate the pesticides are more or less toxic to the predatory mite. Based on our experiences, and discussion with several experienced farm advisors and pest control advisors, we believe it is likely that pesticides with low toxicity ratings in the laboratory will have a low impact in the field. Likewise, pesticides with a high rating will probably cause high mortality in the field. The most difficult ratings to interpret are those in the moderate category. Such pesticides could have a high, moderate, or low rating, since a number of factors influence their field impact: thoroughness of spray coverage, duration of residues, effect of pesticides on

In toxicity tests, mite predators were placed on leaf discs along with spider mites as prey. They were sprayed with various pesticides and later checked to record the number of predators alive, dead, or missing.

spider mite prey, and pesticide formulation.

If some ratings are controversial, we suggest that field trials be conducted to resolve them. Because populations of western predatory mite from different orchards vary in their responses, particularly to organophosphorus insecticides such as Guthion (azinphosmethyl), Diazinon, and Imidan (phosmet), ratings should be

TABLE 2. Toxicity of pesticides not listed in Leaflet 21343 (1983) and those not currently registered, in laboratory tests on western predatory mite

Material (formulation and rate tested as field rate*)	Type†	Toxicity to predatory mite	Comments
Abamectin (see avermectin)			
Ambush (see permethrin)			
Apollo (see clofentezine)			
Avermectin B_{1a} (not registered) 3 ppm	A,I	Moderate to high	This experimental material is less toxic to *M.o.* than to spider mites, but at this field rate would be likely to kill most *M.o.*
Bacillus thuringiensis	I	Low	Not toxic to *M.o.* if lacking the beta-exotoxin.
Clofentezine (not registered) 1 oz 50 SC/100 gal	A	Low	No negative effects found.
Danitol (see fenpropathrin)			
Dibeta (see thuringiensin)			
Dibrom (see naled)			
Dicofol (not registered)	A	High	Toxic to predator, based on literature data.
Endosulfan 4 lb 50 WP/400 gal	I	Low	Native and COS-resistant strains are tolerant.
Fenpropathrin (not registered) 6 gal/100 liters	I,A	High	Toxic to COS strain.
Fenvalerate (not registered for almonds) 0.2 lb AI/400 gal	I	High	Toxic to all native *M.o.* tested.
Funginex (see triforine)			
Hexythiazox (not registered) 3.5 oz AI/400 gal	A	Low	No negative effects found in the laboratory.
Iprodione (not registered) 3 g 50 WP/100 liter	F	Low	COS strain is very tolerant.
Kelthane (see dicofol)			
Malathion 8 lb 25 WP/100 gal	I	Low to moderate	Native and COS strains may tolerate low field rate (0.5 lb AI/100 gal). Less than 50% survival at 2 lb AI/100 gal.
Naled 1 pt 8 E/100 gal	I	Moderate	Survival of 16% at field rate and 44% or 80% at half the field rate, for native and COS strains respectively.
Permethrin 2 g AI/100 liters	I	High	Toxic to all native *M.o.* tested.
Phosalone 6 pt 3 EC/100 gal	I	High	COS strain is slightly more tolerant than native strains.
Pounce (see permethrin)			
Pydrin (see fenvalerate)			
Rovral (see iprodione)			
Savey (see hexythiazox)			
Sulfur 4 lb 80 WP/100 gal	F,A	Low to high	Toxic to native *M.o.* in almonds, *M.o.* from many vineyards and COS strain tolerate sulfur.
Thiodan (see endosulfan)			
Thuringiensin (not registered) 20 g AI/100 gal	A,I	Moderate to high	This experimental material is less toxic to *M.o.* than to spider mites, but at proposed field rates would be likely to kill most *M.o.*
Triforine (not registered) 16 oz 1.6 EC/100 gal	F	Low	Native and COS strains are tolerant.
Zolone (see phosalone)			

NOTE: See table 1 NOTE.
* See table 1 asterisk (*) footnote.
† Type: A = acaricide; I = insecticide; F = fungicide.

used as general guidelines only. Actual toxicities in specific orchards may be different.

In addition to testing the pesticides listed in Leaflet 21343, we tested several that were not listed, including some that are not currently registered for use in almonds or are not registered in California at this time. We included those to determine which are most promising for future incorporation into an integrated mite management program for almonds.

Results

Pesticides in table 1 are from Leaflet 21343. Table 2 lists pesticides that are not registered or are not recommended in the leaflet.

Acaricides that were low in toxicity to *Metaseiulus occidentalis* included Plictran, Vendex, Omite, Apollo, and Savey. The Plictran, Vendex, and Omite application rates used are important, because the higher recommended rates were toxic to this predator. The integrated mite management program has thus encouraged the use of low rates of these materials to preserve both the predator and the prey. Abamectin, Dibeta, and Kelthane were toxic to the predator. Abamectin and Dibeta, which are currently unregistered, might be used in a selective manner if rates were very low, but such use would have to be determined by field trials.

Insecticides that were generally low in toxicity to the predator included Guthion, Diazinon, Parathion, Imidan, *Bacillus thuringiensis,* and Thiodan. Sevin had low toxicity to the COS strain, but was toxic to native populations. At higher rates, Guthion and Malathion showed moderate toxicity to native strains of the predator. Lorsban, Dibrom, and Dibeta were moderately toxic to all colonies tested. Supracide, Pounce, Danitol, Pydrin, Ambush, and Zolone appeared to be highly toxic to the predator.

Among the fungicides, Captan, Maneb, Ziram, Funginex, and Rovral appeared to have low toxicity to the western predatory mite. Benlate and sulfur had low toxicity to the COS stain, but were generally toxic to the native populations from almond orchards.

Our laboratory assays suggest that growers and pest control advisors wishing to preserve *M. occidentalis* populations can choose among several options in controlling diseases, insects, and spider mites.

Marjorie A. Hoy is Professor, and Janet Conley is Staff Research Associate I, Department of Entomological Sciences, University of California, Berkeley.
This research was supported by UC/IPM, Almond Board of California, and W-84 Regional Research Project. The authors thank William Barnett, Frank Zalom, Lonnie Hendricks, Walter Bentley, Robert Curtis, Mary Louise Flint, and Michael Stimmann for their assistance.

Tiny *Anagrus epos* wasp is an effective biological control of grape leafhopper but not of variegated grape leafhopper.

Biological control of variegated grape leafhopper

Charles H. Pickett □ Lloyd T. Wilson □ Daniel Gonzalez
Donald L. Flaherty

Within the past few years, variegated grape leafhopper has invaded the San Joaquin Valley, where it is now a serious pest of grapes. This leafhopper, *Erythroneura variabilis,* has been a pest of grapes in southern California since the 1930s, but wasn't reported in the San Joaquin Valley until 1980. Populations reach high densities on grapes in late summer, causing fruit spotting of table grapes and complete defoliation of vines. A reduction in yield and fruit quality is anticipated for vineyards repeatedly defoliated late in the season.

Grape leafhopper, *Erythroneura elegantula*, a close relative of variegated grape leafhopper, is native to the San Joaquin Valley. Grape leafhopper is frequently kept below damaging levels by natural control, in which the parasitic wasp *Anagrus epos* (Hymenoptera: Mymaridae) plays an important part. Although this parasite attacks the egg stage of several closely related species of leafhoppers, it displays a strong preference for grape leafhopper over variegated grape leafhopper. Studies indicate parasitism of grape leafhopper often exceeds 90 percent on Thompson Seedless grapes, while parasitism of variegated grape leafhopper is typically less than 20 percent. High densities of variegated grape leafhopper in late summer probably result from the low rates of parasitism by the wasp and the lack of other effective natural enemies.

Variegated grape leafhopper was probably introduced near the Fresno area and is now found from Kern County in the south to just north of Modesto in Stanislaus County. Studies show that this species is rapidly displacing grape leafhopper in many areas. Adult leafhoppers have been found inside automobiles next to vineyards and could easily be carried long distances. Variegated grape leafhopper is likely soon to reach the remaining grape-growing regions where grape leafhopper is currently established, including the wine-producing valleys of northern California.

The importation and establishment of new parasites of variegated grape leafhopper could greatly reduce the need for applying insecticides against this pest and would alleviate problems associated with resistance and secondary pests. We have therefore conducted a field evaluation of variegated grape leafhopper parasites collected in the western United States outside central California (near Grand Junction, Colorado, and Coachella, California) and in northern Mexico (near Caborca, Sonora). The foreign exploration for new variegated grape leafhopper parasites was limited to areas where variegated grape leafhoppers were abundant on and around commercially grown grapes.

Two look-alike imported biotypes of a parasitic wasp are being tested against the variegated grape leafhopper in the San Joaquin Valley.

Most parasites collected from these different regions were identical in appearance to *A. epos.* Results from this