

Taking advantage of predator populations, alternate prey species, grass cover, and sprinkler irrigation may all contribute to successful control of spider mite populations in raisin vineyards of the San Joaquin Valley.

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THE SPIDER MITES, *Tetranychus pacificus* McGregor and *Eotetranychus willamettei* Ewing have increased to abundance in San Joaquin Valley vineyards since the beginning of the general use of organic insecticides after World War II. Spider mites are now the most serious pests in many vineyards. In most of these vineyards, organic pesticides have upset the balance between the spider mites and their natural enemies. Moreover, a review of acaricides which have provided excellent control of spider mites in the past, indicates that many have outlived their usefulness. They now require repeated applications, or need be combined with other materials. What makes the problem even more serious is the fact that these repeated applications and combinations have a dual effect of increasing resistance, and reducing the effectiveness of biological control measures. The problem is further complicated because of the difficulties and long delay in developing and registering effective acaricides.

With the support of the table grape, raisin, and wine industries, field and laboratory studies have been under way for several years to develop programs of pest management for the control of spider mites and associated pests in the San Joaquin Valley. A part of this research emphasized the importance of learning to manipulate vineyard cultural practices as a pest management tool.

The experienced viticulturist often can predict where in his vineyard spider mite outbreaks will occur. For example, spider mite outbreaks are frequently observed in grapevines bordering well-traveled roadways. Both Willamette mite and Pacific mite problems are encouraged by dusty conditions. In an effort to produce cleaner fruit, most table grape

TABLE 1. EFFECT OF SUDANGRASS AS A COVERCROP ON WILLAMETTE MITE DENSITIES, R. SAAK THOMPSON SEEDLESS VINEYARD, POPLAR, TULARE COUNTY, 1968

Treatment	Average number Willamette mites per leaf
Clean cultivated (repeated diskings)	252*
Sudangrass	101*

* Significantly different at the 5% level (t-test)—count shown was made when populations were at peak density, all stages counted.

TABLE 2. INFLUENCE OF WEEDS ON PREDATOR AND PREY RELATIONS IN EASTERN TULARE COUNTY THOMPSON SEEDLESS RAISIN VINEYARD, PERTERSON VINEYARD, POPULAR, 1966

Habitat Conditions	Willamette mites	Two-spotted mites	M. occidentalis
	no.*	no.	no.
Without weeds	1,069	1	195
With weeds	22	150	96

* No. = predators and prey per 160 leaves, calculated from samples taken from each habitat condition on June 21, July 1, July 15, and August 1, 1966. Forty leaves were collected for each sample. All stages of prey and predators were counted.

growers have regularly sprayed road oil alongside heavily traveled roads and on vineyard avenues to reduce the drift of dust onto their vines. As a side effect, they have noted far fewer mite problems next to these roadways. Raisin growers might well follow this practice of oiling roadways to prevent dust drift.

Grass cover

Raisin growers also may inadvertently aggravate spider mite problems with dust resulting from repeated cultivations to maintain weed-free vineyards. Again, in an effort to keep dust to a minimum, table grape growers allow natural weeds and grasses (grass culture) to grow in the row middles during the summer. Their practice is to disk the row middles approximately two times in the spring, and then put in furrows to be used for irrigation throughout the summer. The natural cover is mowed three or four times during the summer to keep the growth under control. Either summer covercropping or allowing natural grasses to grow in raisin vineyards would reduce the number of cultivations needed and greatly reduce dust. Since natural raisins are dried on paper trays placed on bare soil in the vineyard, it would be necessary to disk the cover under by mid-July in order to have a clean surface for tray lay by late August.

Another practice, which could be used to accomplish about the same result, would be to delay turning in a winter covercrop until about mid-June. However, rather than typical winter covercrop such as vetch and/or barley, lower growing and self-seeding covercrops such as sub clover, bur clover, Cucamonga

Influence of environment ON SPIDER MITE Thompson Seedles

brome or Blando brome are preferred. The bromes should be mowed once for better frost protection in late March and early April. After mowing they should be left to mature. Mowing is not necessary for the sub clovers since they are such low growers. Both the clovers and bromes suggested reseed well, so once planted they will come back year after year if they are allowed to mature before turning under. The effect of a "delayed winter covercrop" needs further evaluation.

Troublesome Pacific mite outbreaks frequently occur in the same spot within a vineyard year after year. The spots in the vineyard in which Pacific mites are likely to occur are generally characterized by weaker vine growth and by vines under moisture stress. These spots are a result of sand streaks, shallow soils, compacted soils, high spots, poor water penetration, nematode problems, or any set of factors which produce weak vines. These Pacific-mite-infested spots may be improved, and sometimes eliminated, by management practices which restore vine vigor. Moisture stresses may be alleviated by more frequent or longer irrigations, touch-up grading, altering furrow arrangement, adding gypsum to low salt water, and summer covercropping to improve water penetration. Practices which improve vigor such as nematode control, fertilization, and reduction of crop load through careful pruning are also helpful. Since Pacific mites may reduce yields, the management practices required to restore vigor are generally repaid in higher yields and better fruit maturity.

Treatment history

Vineyards with histories of numerous pesticide treatments often have widely dispersed and damaging spider mite populations. In such vineyards, spider mite outbreaks are not confined to localized spots or along dusty roads. Predators are often absent in heavily treated vineyards, or they build up far too late in the season to prevent serious vine injury. The problem is further aggravated

ment and cultural practices

ABUNDANCE IN SOUTHERN SAN JOAQUIN

vineyards

TABLE 3. INFLUENCE OF CATTAIL POLLEN ON TYDEID MITE AND *M. OCCIDENTALIS* POPULATIONS ON GRAPEVINES, R. SAAK THOMPSON SEEDLESS VINEYARD, POPLAR, TULARE COUNTY, 1969

Treatment	Tydeid mites	<i>M. occidentalis</i>
No pollen	no.*† 1,199	no.* 107
Pollen‡	2,065	171

* Significantly different at the 5% level (t-test)
 † Number of prey and predators on 480 leaves. Seven samples of 60 leaves (six leaves from each of ten vines) were taken from each treatment from August 19 through November 10.
 ‡ Cattail pollen (*Typha* sp.) freely dusted on 10 grapevines August 6 and October 7 with Hudson garden duster.

and perpetuated by treatments needed to prevent additional mite injury. Summer covercropping has been shown to sometimes help to reduce or even eliminate costly treatments. For example, table 1 shows that a sudangrass covercrop in a Thompson seedless raisin vineyard significantly reduced the abundance of Willamette mites. Predator action in this vineyard was inadequate because of past pesticide programs. The reduced Willamette mite population in the covercrop plots was possibly due to less dusty conditions. Other studies have shown that raisin and wine vineyards can tolerate levels of Willamette mites as high as those exhibited in the covercrop plots (table 1) without yield or quality reductions. Thus, in this situation, covercropping eliminated the need for treatment.

Where Pacific mites have become serious pests because of past pesticide programs, studies and observations revealed that summer cover alone usually does not eliminate the need for treatment. Pacific mites are much more injurious to grapevines than Willamette mites. Grapevines can tolerate high densities of Pacific mite for only short periods. Moreover, unsatisfactory control often results when treatments are directed at high densities of this species, rather than low densities. However, summer cover has been observed to retard the explosive growth of Pacific mite populations. In some vineyards, this has been sufficient to eliminate the need for treatment, in others, the need for treatment was delayed and reduced.

Predator population

In these situations, fewer treatments were necessary because advantage could be taken of the recuperation of predator populations and the effectiveness of selective acaracides. By waiting longer before treating, the predators became numerous and dispersed enough to prevent resurgence of the pest after treatments with selective acaracides. Treatments were also more effective where covercropping is practiced. Perhaps poor pesticide deposits occur when the leaves are dusty. Moreover, Pacific mites produce considerably more protective webbing on dusty vines.

In addition to the benefit obtained by growing summer cover to make vineyards less environmentally favorable for spider mites, the covercrops or natural weed growth may improve the efficiency of predators, particularly the phytoseiid mite, *Metaseiulus occidentalis* (Nesbitt). It often has been observed in weedy vineyards along the eastern side of the San Joaquin Valley that two-spotted mites, *Tetranychus telarius* Koch, move from adjacent weeds onto grapevines and improve the efficiency of predation by *M. occidentalis*. Table 2 shows that vines in a weedy section of a vineyard present more two-spotted mites and less Willamette mites than vines growing in a relatively weed-free part of the same vineyard. Two-spotted mite is not a pest of grapes in the southern San Joaquin Valley, so it is beneficial to encourage it as an alternate prey by covercropping or letting natural weeds grow. However, two-spotted mite has been found to be less important as an alternate prey in western Fresno County, even in vineyards under "grass culture."

Alternate prey species

The studies also revealed that other alternate prey species which are not pests, or are less serious pests than Pacific mites, may be used to advantage as alternate prey. For example, economic level studies revealed that Thompson

TABLE 4. EFFECT OF SPRINKLER IRRIGATION ON PACIFIC MITE AND *M. OCCIDENTALIS* DENSITIES, GEORGE MIGUEL VINEYARD, BIOLA, FRESNO COUNTY, 1968

Treatment	Pacific mite*	<i>M. occidentalis</i>
	Average number per leaf†	
Furrow irrigation	177	3.6 NS
Sprinkler irrigation	90	3.5 NS

* Significantly different at 5% level (t-test).
 † Average of 10 samples (May 22 to Sept. 17) of 40 leaves each. All stages of prey and predators counted.
 NS: not significant.

seedless grapevines cultured for wine or raisin production can tolerate very high populations of Willamette mites without significant reductions in yield or raisin quality. Thus, in some areas of the Valley (such as the Biola area of west Fresno County) where Pacific mite and Willamette mite populations co-exist on grapevines, Willamette mite should not be treated, but left to act as an alternate prey or food source for the predatory mite, *M. occidentalis*. Without an alternate source of food, the predators may not be able to increase in sufficient numbers to control Pacific mite. In the Biola area, for example, treatments which disrupt the predator-prey relationship between *M. occidentalis* and Willamette mite ultimately lead to outbreaks of Pacific mites.

More recent studies have shown that minute mites in the family Tydeidae also serve as important alternate prey for *M. occidentalis* on grapevines. The tydeid mites, *Pronematus anconai* and *P. ubiquitous*, inhabiting grapevines in the San Joaquin Valley are not pests. They appear to feed primarily on wind-disseminated pollen and fungi. Table 3 shows that cattail pollen (*Typha* sp.) dusted on grapevines significantly increased the abundance of tydeid mites in a Thompson seedless vineyard in eastern Tulare County. Predators were also significantly higher on the pollen-dusted vines, presumably because of a greater abundance of tydeids as prey. At the time of pollen applications, spider mites were virtually nil on the vines. Similar tests made in western Fresno County failed to produce

significant results. Nevertheless, since tydeids are important as alternate prey for *M. occidentalis* throughout the valley, covercropping practices which encourage wind-blown pollen might be beneficial.

The covercropping studies revealed predation on spider mites from an unexpected source. Upon maturing and drying of the Cucamonga and Blando brome covercrops in late spring (early June), western flower thrips (*Frankliniella occidentalis*) was observed to move onto grapevines in large numbers and feed upon Pacific mite eggs. Laboratory observations indicate that this plant feeding insect may also develop on spider mite eggs. Usually, western flower thrips is thought of as a pest of agricultural crops, including certain varieties of table grapes. Perhaps this sort of general predation is an important facet of natural control in complex environments. Certain covercropping practices may help simulate such conditions.

Finally, the studies have shown that Pacific mites may be kept under control in grapevines in western Fresno County vineyards by irrigation with overhead sprinklers. Table 4 summarizes the 1969 trial results. Similar results were obtained in 1968 and 1970. Pacific mites are suppressed by the washing and drowning action of sprinklers. However, populations of *M. occidentalis* were little affected by overhead sprinklers. Laboratory studies revealed that Pacific mites quickly drown when submerged in water, while *M. occidentalis* can withstand prolonged submergence.

The tests indicated that more frequent than usual sprinkler application for irrigation may be needed. For example, it was necessary to sprinkle approximately every 10 days during late June and July to keep the Pacific mite in check. Also, sprinkling should be discontinued in Thompson seedless by the end of July or early August to prevent berry cracking. Normally, raisin growers do not irrigate later than July, so this should present no great problem.

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A YELLOWING OF LEAF MARGINS appeared in the summer of 1970 on mustard plants grown commercially on Bay Farm Island in Alameda County. The symptoms had a drastic effect on the saleability of the crop, and the yields were reduced by almost half.

Several clues to the problem were provided by the grower. In the past he had used manure fertilizers with great success. As housing tracts closed in on the farming area, municipal authorities forced him to abandon the use of manure because of disagreeable odors and the influx of flies to the newly developed community. Instead of manure, ammonium sulfate and phosphate became the chief source of fertilization.

A test of the soil reaction with a pH meter revealed a pH slightly below 5. This suggested a possible acid toxicity. In addition, the yellow leaf borders strongly resembled the symptoms found on lettuce plants grown on acid soils. The use of ammonium fertilizers also pointed in the direction of an acidity problem. A hypothesis was formed that the symptoms were induced by excess manganese as a result of the use of physiologically acid fertilizers.

Analysis of the plants showed high concentrations of manganese in the leaves, especially in the margins where the yellow color appeared.

It was recommended that the grower add 2 tons of dolomite per acre, while greenhouse tests were initiated to test the hypothesis. Soils from the field were placed in pots and treated with the physiologically acid fertilizers ammonium

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TABLE 1. EFFECT OF LIME ON SOIL pH AND MUSTARD YIELD USING DIFFERENT NITROGEN FERTILIZERS

Fertilizer treatment	Soil pH		Yield (dry weight)	
	+lime	-lime	+lime	-lime
	pH		grams	
Ca(NO ₃) ₂	6.2	5.3	3.03	2.31
NH ₄ NO ₃	5.5	4.9	3.13	2.82
(NH ₄) ₂ SO ₄	4.8	4.3	2.73	2.06

nitrate and sulfate, and the physiologically basic fertilizer calcium nitrate. Half the pots were treated with dolomitic lime. The pots were seeded to mustard and placed in the greenhouse. Following a month of growth the plants were harvested and pH values were obtained for the soils (table 1).

In the absence of lime, yellow margins developed on the leaves of all plants, the severity of the symptoms increasing directly with acidity. Where lime was added, only the ammonium sulfate treatment showed any visible chlorosis.

The island soil is a light textured loamy sand, low in organic matter with a weak buffering capacity which allows the pH to shift rapidly with nutrient uptake by the plants. With a higher organic matter content the soil would be able to maintain a more stable pH.

Within three months of the time lime was applied to the soil, the disease was completely eliminated and the pH of the soil had risen to values near the neutral mark. Analysis of leaf tissue from plants grown in the field showed a marked decrease in manganese in all leaf parts of plants from the area where the soil had been limed (graph 1). The figure shows