
Two-spotted spider mite harms appearance of rose leaves.

Biological control of spider mites on greenhouse roses

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A genetically improved strain of predatory mite shows promise


Experiments show that a pesticide-resistant strain of a spider mite predator, *M. occidentalis,* can be integrated into a rose pest control system but will need the assistance of low rates of a selective acaricide during its establishment phase.

As many as 18 applications of acaricides are used annually to control the two-spotted spider mite, *Tetranychus urticae* (Koch), on commercially grown greenhouse roses in California. This mite can cause both a reduction in flower yield and aesthetic injury to the rose leaves. Because this pest also readily develops resistance to pesticides, effective biological control is especially desirable.

Europeans have had some success in biological control of spider mites on a variety of greenhouse vegetable crops, and also report limited success on ornamental plants. The predatory mite *Phytoseiulus persimilis* Athias-Henriot is released repeatedly on large areas of greenhouse-grown tomato, cucumber, and sweet pepper crops. This predatory mite has been used relatively infrequently on ornamental greenhouse crops, because only a low level of damage can be tolerated on these crops as compared with vegetable crops, and because the predatory mites cannot survive pesticides applied to control other pests and diseases.

In an attempt to overcome these problems, we evaluated two laboratory-selected strains of *Metaseiulus (Typhlodromus) occidentalis* (Nesbitt) as potential biological control agents of two-spotted spider mite on greenhouse roses. Both predator strains are resistant to a number of organophosphorus (OP) insecticides, such as diazinon, azinphosmethyl, and phosmet, and to the carbamate insecticide carbaryl. In addition, one of the strains had been selected for the inability to diapause, or overwinter in a dormant state.

Such *M. occidentalis* strains may have

an advantage over *P. persimilis* in that they are resistant or tolerant to a wide range of pesticides. Also, *M. occidentalis* has the potential to regulate spider mite numbers at a lower density and for longer periods than can *P. persimilis*. The main advantage of *P. persimilis* over *M. occidentalis* is the speed with which it can control two-spotted spider mite populations, which is useful in short-term vegetable crops. However, *M. occidentalis* may be better suited on semipermanent greenhouse crops such as roses and gardenias, where long-term control could result from a single inoculative release of these predators.

We investigated factors that could affect the suitability of *M. occidentalis* as a long-term biological control agent during a two-year greenhouse experiment at the University of California, Berkeley. Pesticides commonly used on roses were tested for effects on both the predator and the two-spotted spider mite. The ability of the carbaryl-OP-resistant, nondiapausing strain of *M. occidentalis* to tolerate a range of extreme relative humidities was evaluated, because this predator normally occurs in relatively dry, irrigated crops. We studied conditions that would induce diapause in the greenhouse, using the carbaryl-OP-resistant strain. Since diapausing females do little feeding and do not reproduce, biological control of spider mites could be lost during the winter.

Pesticide resistance

In the laboratory, 11 pesticides commonly used on greenhouse roses were tested for the effects on the carbaryl-OP-resistant, nondiapausing predator strain and on a strain of the two-spotted spider mite resident in the Berkeley greenhouses. Survival of adult females, their egg production, egg hatch rates, and survival of larvae were evaluated on rose leaf discs sprayed with half, normal, and five times the label rate for each pesticide. Controls were treated with distilled water. One to three hours after discs were sprayed, mites were placed on them and held at 82°F under an 18-hour daylength until progeny had developed to the protonymphal stage. The results are shown in figures 1 and 2.

The impact of these pesticides on adults, eggs, and larvae were then summarized as toxicity ratings, with a negative impact on the adult female predator having three times the weight of negative impacts on the eggs or larvae. Acephate at the label rate was the only material rated highly toxic to the carbaryl-OP-resistant, nondiapausing predator strain. All the other materials received low toxicity ratings in tests with this strain.

Using the same rating system, hexakis

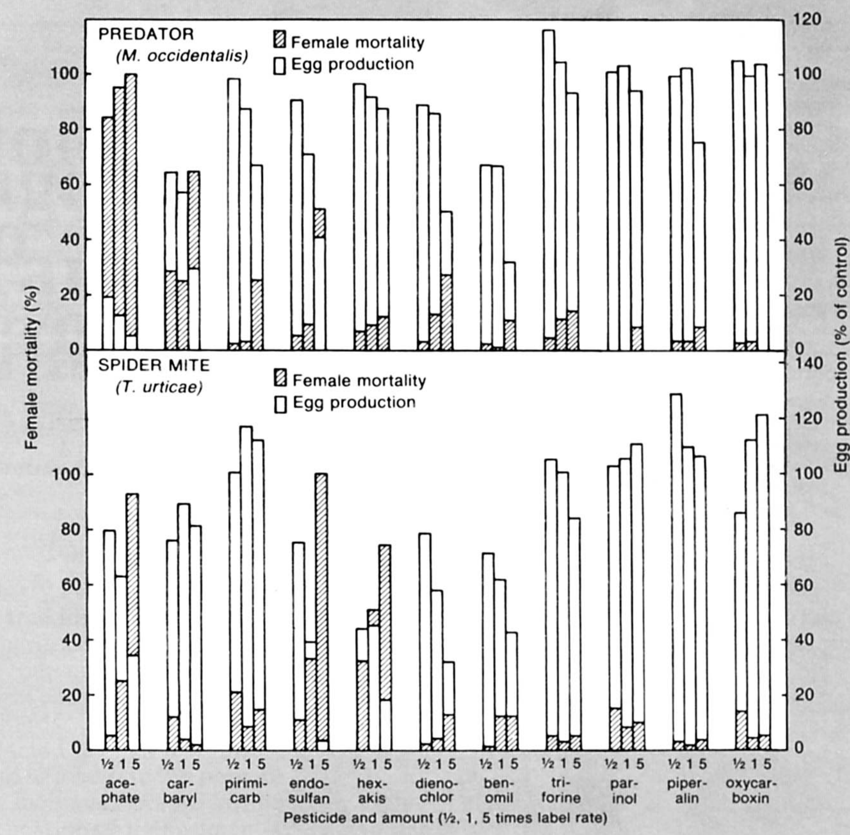

Fig. 1. Adult female mortality and egg production after exposure to one-half, one, and five times pesticide label rate.

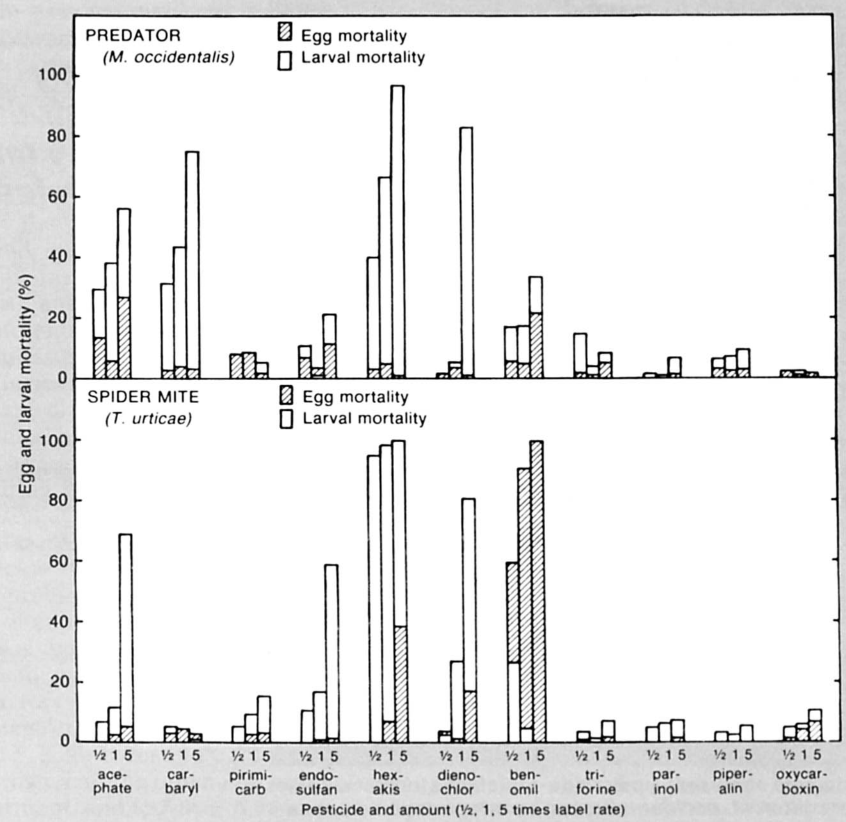

Fig. 2. Egg and larval mortality after exposure to pesticides.

and benomyl were highly toxic to the spider mite at normal label rates. Endosulfan was moderately toxic, and all other pesticides were of low toxicity. Because dienochlor is slow-acting, the 48-hour mortality tests were considered to be an inadequate evaluation of this acaricide.

Diapause

A series of laboratory and greenhouse experiments showed that predator strains with a normal diapause probably cannot control two-spotted spider mites in greenhouses during the winter when the daylength drops below 12 hours and the temperatures average 70°F or less. Under such greenhouse conditions, many females entered diapause. Laboratory tests showed that the availability of prey also influenced the incidence of diapause: at 12-hour daylengths, more predator females entered diapause when food was scarce than when it was plentiful. This characteristic may be a safeguard against overexploitation of the food supply and could prevent starvation of the predators before stronger diapause-inducing conditions begin (shorter days and lower temperatures).

However, the laboratory-selected nondiapausing strain of the predator had a very low incidence of diapause (less than 20 percent) even under eight-hour daylengths, and it had a normal fecundity, longevity, and sex ratio. Such characteristics should enable it to be an effective predator throughout the year in greenhouses.

Humidity tolerance

The nondiapausing predator strain was also assessed for its tolerance to a range of relative humidities. The survival of eggs and larvae was determined at low (24 to 32 percent), medium (70 to 74 percent), and high (93 to 97 percent) relative humidities at 68° and 86°F. Eggs were susceptible to drying at low relative humidities. Only 1 and 32 percent of the eggs hatched at the lowest relative humidity and temperatures of 86° and 68°F, respectively. Only 53 percent of the larvae matured at 86°F under 93 percent relative humidity. However, these restrictions probably will not greatly reduce the effectiveness of this predator strain on roses, because the low humidities are unlikely to occur on the rose leaf surface and growers avoid high humidities to prevent rust from developing on the foliage and *Botrytis* on the flowers.

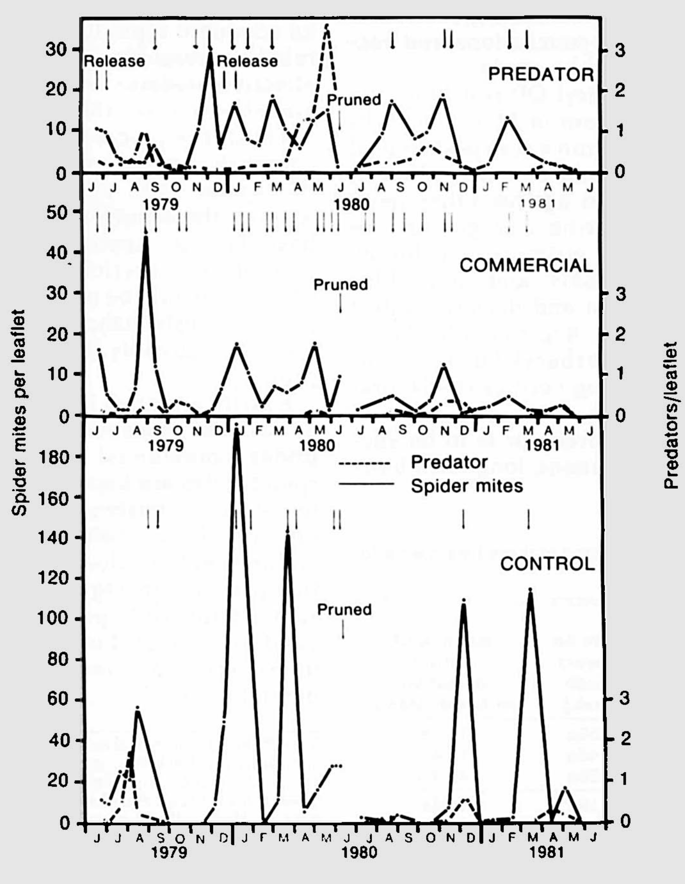

Fig. 3. Spider mite and predator numbers in three treatments. Predators exerted some, but not complete, control where released (top). (Unlabeled arrows indicate acaricide applications.)

Greenhouse study

A two-year study assessed spider mite control by both the carbaryl-OP and the carbaryl-OP-nondiapausing strains of the predator on small, experimental greenhouse rose plots at UC Berkeley. Two carbaryl-OP-resistant predator females were placed on each of 34 bushes of the long-stem red variety Royalty (predator treatment) in June-July 1979; these bushes received acaricide treatments "as needed." Thirty-four other bushes did not receive predators and were treated regularly with acaricides to reduce mite damage (commercial treatment). Eight more bushes received no predators or acaricide applications (control treatment) until the roses were near defoliation, and then chemicals were used to limit the spread of spider mites to the other treatments. The predator and commercial treatments were each arranged into separate groups of bushes consisting of either 12 plants (two replicates) or 10 plants (one replicate). These six groups of plants were arranged radially around the eight control plants. Groups were about 3 feet apart and 3 feet from the central control bushes.

During the late fall of 1979, the carbaryl-OP-resistant strain entered diapause, but the spider mites remained active, resulting in a breakdown of the biological control established during the summer and autumn (fig. 3). The nondiapausing strain was then released in late December 1979; although it became established and exerted considerable control over the spider mites, especially during the following spring and summer, it failed to control the mites through the winter of 1980-81. Interbreeding between the previously released diapause strain, which survived in low numbers, and the nondiapausing strain may have resulted in the loss of the nondiapausing character.

Yield and damage were measured throughout the experiment (see table). Stem length, number of leaflets per flower stem, and number of flowers per bush did not differ significantly between treatments in either year. However, in both years, spider mites caused significantly more damage on roses with predators than on those receiving the commercial treatment, and they caused the most damage on the control roses. The predator contributed to control of the spider mite on the predator release roses, although complete biological control was not achieved. Movement of the predators onto the commercial and control plots (fig. 3) probably resulted in

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fewer acaricide applications being required on those plots during the second year (table).

Two-spotted spider mite damage downgrades quality of greenhouse roses.

Conclusions

Since these small-plot experiments were conducted with high spider mite populations on the adjacent control roses and in the surrounding areas of the greenhouse, the test conditions were more severe than might be encountered in a commercial greenhouse. However, several conclusions and recommendations can be made.

First, the carbaryl-OP-resistant and nondiapausing strain of *M. occidentalis* can be integrated into a rose pest control system without being seriously affected by chemicals used against other pests and diseases. During our greenhouse studies, carbaryl, pirimicarb, trifoline, oxycarboxin, hexakis, and dienochlor were used for pest and disease control without apparent negative effects on either of the carbaryl-OP-resistant strains. This finding verifies the laboratory results.

Second, if this predator is to be successful on a permanent, long-term basis against the two-spotted spider mite on greenhouse roses, a nondiapausing, pesticide-resistant strain should be used. Strains of the predator with a diapause should be excluded from the greenhouse to prevent loss of the nondiapause characteristic through interbreeding. The nondiapausing strain has an adequate reproductive potential and relative humidity tolerance to be an effective predator of this spider mite on greenhouse roses throughout the year.

Third, the predator is unlikely to accomplish complete biological control of the spider mite on greenhouse roses without the occurrence of excessive foliage damage. Applications of low rates of a selective acaricide such as hexakis (Vendex) would be necessary during the predator's establishment phase after release, and possibly following the annual pruning.

Fourth, although the predator persisted in the greenhouse for two years, under commercial conditions where spider mites are kept to lower densities, long-term persistence might be more difficult. Large-scale commercial tests are needed to evaluate the efficiency of this predator in regulating two-spotted spider mite while preventing excessive yield loss and aesthetic injury to greenhouse roses or other long-term ornamental crops.

Yield and damage measurements from greenhouse roses (cv Royalty) subjected to three treatments for the control of spider mites, 1979-80 and 1980-81

Year	Treatment*	No. of acaricide treatments†	Mean stem length (cm)‡	Mean no. leaflets /flower stem‡	Mean no. flowers /bush week‡	Mean % of leaflets damaged on flower stem‡
1979-80	Commercial	17	57.4a	38.0a	1.50a	11.3a
	Predator	6	58.5a	38.5a	1.43a	19.4b
	Control	8	57.5a	38.3a	1.56a	40.4c
1980-81	Commercial	8.3	42.1a	29.9a	1.19a	14.8a
	Predator	5.3	41.4a	29.4a	1.18a	19.9b
	Control	2	39.3a	29.7a	1.26a	29.7c

* Commercial = no predator releases; treated regularly with acaricides to reduce mite damage. Predator = two carbaryl-OP-resistant predator females placed on each bush; acaricides applied as needed. Control = no predator or acaricide treatments until roses near defoliation, when chemicals were applied.
† Fractions indicate that not all replicates of a given treatment were sprayed on same dates.
‡ Values in columns for a given year followed by a different letter are significantly different. Statistical comparisons do not apply between the two years.

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