approximately four to five days.

The adult male is smaller (0.11 mm) and faster-moving than the female. The greatly enlarged hind legs are used to pick up the female nymph and place her at right angles to his body for later mating. Since other tarsonemid species found on citrus do the same, this is not a good field identification character for the broad mite.

Detection

Low levels of the broad mite can be detected by examining the shaded side of small fruit (2 to 3 cm in diameter) on the interior of trees with the thickest canopies. This preference for the shaded side of the fruit often results in only one side of the fruit being damaged. In some cases one can walk through a grove without seeing damage, but on closer examination find that the shaded side of almost every fruit is silvered.

Broad mite infestations have occurred as far north as Santa Barbara County, a few miles east of Santa Paula in Ventura County, and south to Oceanside in San Diego County. In spring of 1980, there were scattered pockets of broad mite in several groves in Ventura County, but high populations were not detected until summer (late July to September). Similarly, in 1981 the mites were found in June, but did not reach damaging levels until mid to late July. Discoveries of broad mites were made progressively farther east (inland) in Ventura County as the summers progressed. Generally, it has not been necessary to spray in the spring, but if the broad mite is found in the summer, especially July and August, it is almost certain to reach damaging levels within a very short time. Populations requiring control can occur in September or later in the fall.

Control

None of the acaricides tested in the laboratory or in five field studies (in San Diego, Orange, and Ventura counties) seemed to give more than six to eight weeks' control when applied during the worst broad mite period (July and August) (table 2). This may be due to the lack of residue on new (post-spray) growth where the broad mite prefers to feed. Many contact pesticides work well on this mite, but residual activity is also necessary, because no material examined has been effective against eggs.

Sulfur and oxythioquinox (Morestan) have given consistently good control of the broad mite. Sulfur is also effective against the citrus rust mite; oxythioquinox controls citrus red mite *Panonychus citri* (McGregor) and is fairly effective against citrus rust mite. In an infestation of all three mites, oxythioquinox is the recommended material. Neither material can be mixed with oil.

Chlorpyrifos (Lorsban), which recently received federal registration on citrus for California red scale, has given good control of the broad mite. It has also shown some efficacy against the citrus bud mite but not against the citrus red mite. Chlorpyrifos is compatible with oil.

Fenbutatin-oxide (Vendex) did not provide acceptable control in four of our tests. However, in a San Diego County test, it provided very good, although somewhat delayed, control, possibly because predatory mites were present. We feel that predatory mites surviving the fenbutatin-oxide application were able to control the broad mite population, which had been lowered by the chemical. The addition of oil increases the efficacy of fenbutatin-oxide against the broad mite. Since oil also must be added to this pesticide to control the citrus bud mite, *Eriophyes sheldoni* Ewing, fenbutatin-oxide probably should not be used on coastal lemons without oil.

Formetanate hydrochloride (Carzol) and some other carbamates abruptly halted egg laying by the broad mite in the laboratory, even at very low rates (one-tenth the lowest recommended field rate). Formetanate hydrochloride is sometimes used in coastal areas for citrus thrips control, but is not recommended because it interferes with biological control of some other pest species, particularly brown soft scale. Propargite (Omite) and amitraz (Baam, Mitac) did not control the broad mite.

Predatory phytoseiid mites have been seen feeding on broad mite in the field and may contribute significantly to their control, especially in the spring, when conditions are relatively unfavorable for the broad mite but favorable for predators. There is some evidence that the introduced predator *Euseius* (= *Amblyseius*) *stipulatus* is a better control agent for broad mite than *E. hibisci*, the most common predatory mite on California citrus.

The apparent success of these predators in controlling spring populations of the broad mite indicates that the acaricide must be carefully chosen. For example, dicofol (Kelthane) is fairly toxic to predatory mites and probably should be used only when broad mite population pressure is high or when predatory mites are at a minimum or not present. Fenbutatin-oxide and oxythioquinox are safer to predator mites than sulfur, dicofol, or formetanate hydrochloride (in that approximate order).

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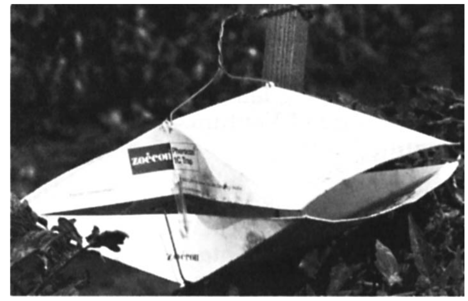


The tomato pinworm (TPW) is a major pest of tomatoes in southern California, Florida, southeastern Texas, and Mexico. In California, it is especially serious on fall-crop tomatoes, where it attacks both foliage and fruit and may cause extensive fruit damage if not controlled.

Growers now control the pinworm by weekly applications of broad-spectrum insecticides. Such measures not only are costly but also suppress parasites of TPW and may result in secondary outbreaks of russet mites and vegetable leafminers, requiring additional applications. The use of pheromone traps to monitor the fall population buildup of TPW and time the initiation of insecticide treatments would prevent unnecessary applications in the early fall.

We conducted four years of trials on tomato pinworm, *Keiferia lycopersicella*, at the University of California South Coast Field Station, Santa Ana, on fall-crop fresh market stake tomatoes (Peto Seed 7718VF). We used fall-crop tomatoes, because a preliminary pheromone-trap study indicated that TPW is not normally a problem during the spring and summer crops.

Insecticide treatments were with methomyl (0.45 pound active ingredient with 100 gallons of water per acre, applied by high-clearance ground sprayer), because it was the only effective insecticide registered with a short preharvest interval (three days). After these studies were conducted, Pydrin also received registration under a Special Local Need permit. (Consult the county agricultural commissioner for current status of the permit.)

We used Pherocon 1C pheromone traps to monitor the male TPW population, checking the traps at three- and four-day intervals and changing the pheromone fibers every six weeks. One trap was placed in the center of each replicate and periodically adjusted to a level equal to the top of the foliage.

To monitor larval populations, we collected all TPW-mined leaflets from 1 to 6 row-meters of foliage per replicate and examined the foliage in the laboratory for live larvae. We evaluated fruit infestation by harvesting all pink and red fruit at three- and four-day intervals

Pheromone traps to time tomato pinworm control

Robert A. Van Steenwyk □ Earl R. Oatman □ Nick C. Toscano □ Jeff A. Wyman

from the center two rows of each replicate and inspecting the fruit for TPW damage. We counted and weighed all fruit to obtain yield and size. All replicates were six rows wide and 33 to 54 feet long.

1978 study

Two treatments were repeated four times in a matched pair design: (1) weekly applications (a total of 9) and (2) an untreated control. Monitoring indicated that pinworm density could reach 10 to 30 moths per trap per night (M/T/N) for one to two weeks before weekly insecticide treatments needed to begin, because at least one small peak in moth activity usually occurs before the main population increase. Larval population closely paralleled adult levels, but larval peaks occurred about a week later than adult peaks.

1979 study

Four different treatments were evaluated: (1) weekly methomyl applications during the entire test period (11 weeks); (2) weekly applications (total of 5) beginning when an average of 15 TPW moths were caught per trap per night for 1½ weeks; (3) weekly applications (total of 3) beginning when M/T/N averaged 30 for 1½ weeks; (4) an untreated control.

Although the percentage of infested fruit was significantly greater in the 15 and 30 M/T/N levels and in untreated controls than in the weekly methomyl schedule, the three were not significantly different from one another. The results indicated that TPW densities of 15 or 30 M/T/N before initiation of insecticide applications were too high, and once a TPW population is established in foliage, it is difficult to control with insecticides.

1980 study

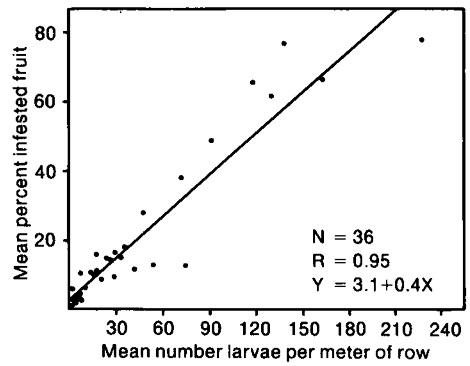
Because of the 1979 results, the test was repeated in 1980 but the pheromone trap catches for initiation of treatment were reduced to 10 and 15 M/T/N. These two treatment schedules were compared with weekly applications for the test period and an untreated control in two different tomato plantings. When insecticide treatments began at 10 M/T/N, the mean percentage of TPW-infested fruit was not significantly different from that in the weekly scheduled treatments in both plantings (see table). However, when insecticide treatments began at 15 M/T/N, TPW-infested fruit was significantly higher than in the weekly scheduled treatments in the first planting.

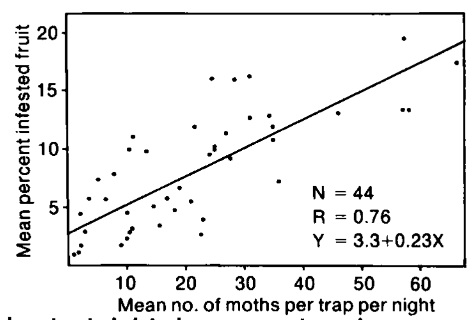
The 1980 results showed that when weekly methomyl treatments were initiated at 10 M/T/N, control of TPW was as effective as under weekly scheduled applications. In the first and second plantings, a total of 11 and 14 weekly scheduled applications were made, respectively, as compared with 8 and 12 when insecticide treatments began at 10 M/T/N. Thus, a reduction of two to three insecticide applications was obtained without significantly increasing the percentage of infested fruit. In commercial fields, growers usually began treatments earlier in the season. Under such circumstances, delay in treatment until 10 M/T/N would have resulted in even greater savings in control costs.

1981 study

Insecticide treatments based on pheromone trap catches could not be investigated as planned in 1981, because TPW populations were already too high (over 15 M/T/N) by the first sampling date. Consequently, we collected population and harvest data for only the untreated controls and examined the relationship between larval infestation in the foliage and the percentage of infested fruit, using data from the untreated control plots from 1978 through 1981. The relation between moth flight activity and infested fruit was examined using data from 1978 through 1980.

There was a strong statistical relationship between the mean percentage of infested fruit and mean number of larvae per meter in the foliage (correlation coefficient 0.95). We estimated that three larvae per meter would result in about 4 percent infested fruit one week





In untreated plots, larvae per meter and percentage of infested fruit one week later were strongly related statistically (top graph). Relation between moths trapped and infested fruit two weeks later was weaker.

Mean yield and percentage of fruit injured by the tomato pinworm on fresh market tomatoes grown under different insecticide treatment regimes, South Coast Field Station, Santa Ana, California, 1980

Treatments*	No. insecticide applications	Mean no. fruit harvested†	Mean wt/ fruit (kg)	Mean % TPW injured fruit
First planting				
Schedule	11	1,830 a	0.16 a	1.2 a
10 M/T/N	8	1,784 a	0.15 a	1.6 ab
15 M/T/N	5	1,731 a	0.17 a	3.0 b
Control	0	1,863 a	0.14 a	6.0 c
Second planting				
Schedule	14	1,048 a	0.17 a	2.2 a
10 M/T/N	12	1,112 a	0.17 a	3.6 a
15 M/T/N	10	1,132 a	0.17 a	6.1 ab
Control	0	1,125 a	0.17 a	13.0 b

* Initiation of a methomyl treatment schedule was based on the number (10 to 15) TPW moths per trap per night (M/T/N) over a 1½-week period.
† Means followed by the same letter in each column are not significantly different at the 5% level based on DMRT.

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TPW control, continued

later, if the larval population were not controlled. We found a weaker statistical relationship between the mean percentage of infested fruit and the mean number of M/T/N (r=0.76) (see graphs), probably because of inherent variability in pheromone trapping. We estimated that 15 M/T/N would result in about 6.8 percent infested fruit two weeks later if the adult population were not controlled.

Conclusions

From these studies, it appears that initiation of an insecticide control program when 10 M/T/N are captured over a 1½-week period will reduce insecticide applications while at the same time maintaining commercially acceptable fruit. Once an infestation has become established, it is difficult to bring under control.

The use of the pheromone trap to initiate an insecticide treatment program for TPW has been studied in a number of commercial tomato fields in Orange, Ventura, Santa Barbara, Fresno, and San Diego counties. In all areas, the traps have been a valuable aid in determining the need for control, and insecticide applications for TPW have been largely eliminated in the spring and summer crops. However, in commercial growing areas in San Diego County, where the winter is mild with no host-free period, and where three consecutive overlapping crops are grown annually, the trapping program has not been as effective in reducing insecticide applications in the fall crop as in other growing areas. High trap counts have been recorded without an increased foliage infestation by TPW larvae. However, even in the San Diego area, the traps have decreased insecticide usage by eliminating some early fall crop applications.

Max Badgley

Max Badgley

Tomato pinworm moth can cause extensive damage to fall-crop tomatoes by laying its eggs around the cap end of the fruit. As they hatch, larvae burrow into the tomato to feed. Below, senior author R. A. Van Steenwyk and assistant check test plot at South Coast Field Station for TPW damage to fresh-market stake tomatoes.

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