Sampling and Treatment Thresholds for Spider Mite Management in Field-grown Rose Plants

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Abstract. Spider mites [including *Tetranychus pacificus* McGregor (Pacific mite) and *T. turkestanii* Ugarov & Nikolski (strawberry mite)] are the most important invertebrate pests of the roses (*Rosa hybrida*) grown in Kern County, Calif. (the major production area in the United States). However, sampling methods and treatment thresholds have been subjective. A rapid presence-absence field sampling method has been developed, and treatment thresholds for mites have been evaluated based on the method. Roses exhibit a higher tolerance for spider mite populations than previously thought.

Kern County, Calif., produces about two-thirds of U.S. rose plants, with 800 ha harvested annually. Cultivars destined for use as outdoor plants comprise most of the area. Most of these roses are grown on a 2-year production cycle. Spider mites of several species feed on roses, causing loss of leaf chlorophyll and, presumably, loss of vigor. The absence of summer rainfall and daily temperature maxima frequently $>35^{\circ}\text{C}$ favor spider mite development. Generation time can be ≤ 12 days (Ohlendorf, 1985). High populations can cause defoliation, which results in solar injury, rendering plants unmarketable. Spider mites have been the most commonly treated invertebrate pest of roses in Kern County since the 1950s. As many as 13 applications of acaricides per field have been made during the growing season (Ben Erickson, personal communication, 1988). Frequent applications are suspected of selecting resistant mite populations. In California, the paucity of registered acaricides for this crop is reason to preserve the efficacy of remaining compounds. Worker safety and environmental concerns also argue for reducing acaricide applications. Spider mite management has been based on subjective evaluation of population and its anticipated effect. To our knowledge, no published studies have addressed sampling methods,

thresholds, or the interaction between mite population, final grade, and yield of rose plants. Growers have suggested a midseason population depression. Documentation of this or other predictable population trends could justify delay or elimination of acaricide applications.

Binomial spider mite sampling schemes are used widely in California agriculture (Wilson et al., 1983; Zalom et al., 1984a, 1984b). Population level is evaluated in the field based on the presence or absence (P/A) of mites on leaves rather than counting total numbers of mites.

Our first objective was to develop a P/A sampling system for evaluating spider mite population in field-grown roses; our second objective was to use the sampling method to develop provisional treatment thresholds. The third objective was to obtain background information about spider mite population dynamics in field roses.

Development of background sampling data, 1987–89. In 1987, we collected background data by sampling in six grower-managed rose fields to determine whether first-year fields harbored higher mite populations than second-year fields. We sampled 30 randomly selected plants in each field weekly from 30 June to 1 Sept. Three leaves were selected from three strata on each plant—lower-third, middle-third, and highest-third. The newest expanded leaves and those at the very bottom of the plant were not sampled. We noted the P/A of mites on each leaflet of the leaf.

As expected, there was a strong correlation between percent infested leaves and percent infested leaflets. The relationship was similar among high, middle, and lower strata of rose plants. Samples taken from different strata of the same plants had similar populations of mites as determined by P/A in first-year fields (data not shown); results from second-year fields were similar (Fig. 1). The relationship between infested leaves and infested leaflets also was similar between first- and second-year fields (Fig. 2). Therefore, leaves could be selected anywhere in the plant, avoiding leaves in extreme high or low positions on the plant, and whole leaves could be used as the sampling unit.

In 1987, spider mite populations in first-year fields remained high until August but then decreased (data not shown). Mite populations in second-year fields were low in June and rose in August before plummeting in September (data not shown). As measured by P/A, mite populations were higher in first-year than in second-year fields.

In 1989, we collected further background data by sampling in seven grower-managed fields weekly. Thirty plants were sampled per field, with one leaf per plant taken from the middle portion of the plant, visually inspected, and P/A of mites noted. Results were similar to those of 1987 with a midseason depression of mite numbers (data not shown).

1990–91 Study. To quantify the relationship between P/A of mites and mite counts and to evaluate the effects of different mite population levels on rose plant growth and yield, a

Fig. 1. Relationship between percent spider mite-infested leaves and percent infested leaflets for three strata of second-year rose plants.

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field study was begun in 1990. Two rows of 'Dr. Huey' rootstock, spaced 15 cm within the row, were planted in January according to customary industry practice (Pryor et al., 1987). Plants were budded with 'Peace' scions later in the spring. Two guard rows buffered plants to the west, and numerous rows acted as buffers to the east. The randomized complete-block design was arranged with two 7.6-m rows per plot. Weekly sampling was done in the center 6 m of each plot by selecting 10 leaves, one leaf from each of 10 rose plants in each of two rows (total of 20 leaves per plot). These leaves were noted for P/A of mites, combined into a single sample, and transported to the laboratory. Spider mites were brushed onto a glass plate with a mite-brushing machine (Henderson and McBurnie, 1943),

and the plate was counted in concentrically. Mite species present were identified as predominately Pacific mite with some strawberry mite.

Four treatment thresholds (10%, 25%, and 40% of leaves infested and nontreated) were assigned to plots with 10 replications. When a plot exceeded its P/A threshold for two consecutive weeks, it was treated with abamectin (Avid; Merck & Co., Rathway, N.J.) at 5.26 g a.i./ha in the equivalent of 467 liters water/ha, with no surfactant added. Abamectin was chosen because of its efficacy, selectivity, and low phytotoxicity to roses (Karlik and Harwood, 1994; Karlik et al., 1994) and current use in rose production in Kern County. The plots remained in place for the two years of the growing cycle.

Results

During 1990, mite levels were held to 25% or 40% leaf infestation (LI) (Fig. 3). Despite repeated acaricide applications, it was not possible to maintain a mean 10% LI across plots assigned this treatment. As would be expected, more frequent acaricide applications were required to attempt to hold mites to respectively lower levels (Table 1). Plants in nontreated plots neither reached 100% LI nor defoliated.

In 1991, mite population of all plots followed about the same course as in 1990. Again, acaricides were used more frequently on plots with lower thresholds (Table 1). Nontreated plots did not show evidence of extreme mite pressure leading to defoliation.

A strong correlation existed between mites brushed and counted and P/A counts of leaves for first-year and second-year plants. However, the regression lines had significantly different slopes at $P \leq 0.01$, based on a t test (Steel and Torrie, 1980). Mite counts were higher relative to percentage of infested leaves on second-year plants (1991) compared to first-year plants (Fig. 4).

Yield results were measured beginning Sept. 1991, when a live plant count was taken. Plant counts were similar among all plots, indicating that higher treatment thresholds had not affected the overall stand. In December, plants were mechanically defoliated and mowed in preparation for harvest in early January. Thereafter, the 15 plants from each row of the plot were weighed and graded according to industry standards. The mean plant weights were 284, 275, 269, and 263 g for 10%, 25%, and 40% LI and nontreated

Fig. 2. Relationship between percent spider mite-infested leaves and percent infested leaflets taken from the middle stratum of first- and second-year rose plants.

Fig. 3. Percentage of leaves infested with spider mites (presence-absence) in first-year 'Peace' roses during the 1990 growing season. The leaf infestation treatment threshold levels were (■) 10%, (□) 25%, (◆) 40%, and (◇) nontreated; 27 Mar. is day 0 and 5 Sept. is day 161.

plants, respectively. Differences in weight among treatments were not significant. Grade also was similar among treatments ($P \leq 0.05$); 74% to 78% of plants were grade 1, and <4% were substandard or culls. Grade 1 plants had three canes ≥ 46 cm long, two with basal diameters ≥ 10 mm, and one with a basal diameter ≥ 8 mm, or four canes ≥ 46 cm long with basal diameters of 8 mm. Grading involved measurements of cane length (± 0.5 cm) and diameter (± 0.5 mm). Rows were evaluated separately because of a difference in cultural practice introduced by the grower midway through the experiment. Data for the west row repre-

sented standard cultural practice. Data from the east row showed the same trends. Therefore, spider mite population was not a primary determinant of plant size or quality in this study.

Discussion

The P/A method for evaluating spider mites in rose fields is a quantitative indicator of population. It provides an index of mite activity, which can be related to numerical values obtained by brushing and counting. The P/A method is well-suited for use in the field because it gives a rapid evaluation and is easy for field scouts to learn. Although a population drop in midseason can be anticipated, mite counts in a specific field are difficult to predict. Also, proximity of roses to almonds [*Prunus dulcis* (Mill.) D.A. Webb] resulted in an increase in mite counts compared to roses farther away. In the 1990–91 study, spider mite counts were higher in plots closer to almonds than those farther removed, an effect statistically removed by blocking.

Previously, spider mite thresholds had not been quantitatively established. Although within the range of our treatment thresholds we found no difference in yield or quality, our results provide quantitative working thresholds for crop managers and a method of monitoring spider mite populations. During monitoring, especially in the 1990–91 study, mite predators, such as western flower thrips (*Frankliniella occidentalis* Pergande), minute pirate bug (*Orius tristicolor* White), and predatory mites, among others, often were noted in the field. Few insecticide or acaricide applications to the surrounding mother block and

none to guard rows probably allowed the reservoir of beneficial insects to aid in mite control.

At some time, most rose growers have experienced difficulty in obtaining control of mites in a portion of a field, resulting in obvious injury and economic loss. Our data do not imply that treatment for spider mites is never warranted. The availability of an effective acaricide allows a higher treatment threshold because the mite population can be suppressed if necessary.

Crop modeling work in greenhouse roses (Lieth and Pasian, 1990) has indicated that most photosynthetic contributions to the plant are made by leaves of intermediate age in the crop canopy. Field observation suggests that the same may be true of field roses, where vigorous plants apparently are able to outgrow the effects of mites and other antagonists. Although senescing leaves are normally present at the base of the canopy, new leaves are formed fast enough to mitigate plant damage. However, an infestation of spider mites, leading to defoliation of plants in the field followed by solar injury and subsequent unmarketability, must be prevented.

Our work suggests that fewer acaricide applications are necessary to preserve rose plant quality than generally assumed. Reduction in acaricide use is advantageous from the standpoints of worker safety, environmental protection, and economic benefit to growers.

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Table 1. Mean number of spray applications of abamectin to first- and second-year rose plots required at three spider mite threshold levels.

No. spray applications	Plots sprayed (no.)		
	% Thresholds for leaves infested		
	10%	25%	40%
1990			
6	5	1	0
5	0	1	1
4	3	1	0
3	1	4	3
2	1	1	4
1	0	2	1
0	0	0	1
Median	5	3	2
Mean	4.7	3.2	2.3
1991			
3	6	2	0
2	2	2	3
1	2	4	4
0	0	2	3
Median	3	1	1
Mean	2.4	1.4	1

Fig. 4. Relationship of percent infested leaves to spider mite counts on one-sixth of a circular glass brushing plate for first- (1990) and second-year (1991) 'Peace' roses.