EVALUATION OF ACARICIDE ROTATION STRATEGIES FOR MANAGING RESISTANCE IN SPIDER MITES ON COTTON IN THE SAN JOAQUIN VALLEY OF CALIFORNIA: A THREE YEAR STUDY

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Abstract

Field studies of rotation of acaricides were conducted in a cotton field that had Kelthane and Comite resistant *T. urticae*. A three year study demonstrated that Kelthane resistance could be reduced through the use of Comite or Zephyr. No change in Comite resistance was observed when Kelthane or Zephyr were used. Treatments that relied on Kelthane or Comite throughout the season were not efficacious because of resistance in *T. urticae*. The most efficacious treatments and those that helped to reduce pesticide resistance were Kelthane/Zephyr, Temik/Kelthane/Zephyr, and Zephyr/Comite. Single or multiple applications of Zephyr within a season were effective, but should be avoided because they will result in resistance to Zephyr. Both *T. urticae* and *T. turkestani* continue to show no resistance to Zephyr and the latter mite species is still susceptible to Kelthane and Comite.

Introduction

Spider mites belonging to the species *Tetranychus* continue to be the principal early season arthropod pests of cotton in the San Joaquin Valley (SJV) of California. However, in contrast to the two previous cropping seasons ('94 & '95) when *T. turkestani* was the dominant spider mite species early in the season, in most of the SJV during the 1996 season, the two-spotted mite (*T. urticae*) was the dominant spider mite species. Among the consequences of this change in early season spider mite species abundance were numerous complaints from growers across the SJV that early applications of Kelthane (dicofol) did not produce satisfactory control of spider mites in their cotton fields. *T. urticae* resistance to Kelthane as well as to Comite (propargite) was reported in 1981 (Dennehy and Granett, 1982) and 1987 (Dennehy et al., 1987; Grafton-Cardwell et al., 1987) respectively, and during the past two seasons (Bruce-Oliver and Grafton-Cardwell, 1995; 1996). To date, we have not observed spider mite resistance to Zephyr (abamectin).

The acaricide rotation project, now in its third and final year, was initiated to attempt to reduce resistance of spider mites to Kelthane and Comite and to attempt to prolong the efficacy of Zephyr in cotton. Because of the slow pace with which new acaricides are developed, registered, and made available to the market, there is also a need for non chemical methods to reduce selection pressure and help prolong the useful life of the acaricides that are currently available.

Materials and Methods

The experimental field site was an approximately 200 acre plot of Acala 'Maxxa' cotton at Corcoran, California. Nine acaricide treatments (Table 1) were applied in the same replicated 4.3 acre plots, using a randomized block experimental design during three years of field trials (Bruce-Oliver & Grafton-Cardwell, 1995; 1996). For the 1996 season, the field site was planted on April 18. Early and mid season acaricide treatments were applied approximately four weeks apart on June 11 and July 10, 1996, respectively. In addition to collecting spider mite species abundance and cotton yield data, we estimated spider mite resistance or susceptibility to Kelthane, Comite, and Zephyr using residual and rapid bioassays. Rapid bioassays were performed on spider mite populations from one time only (i.e., single dates) pre-, in-between and post-treatment samples using petri dishes coated with discriminating concentrations of 56.2 ppm dicofol (Kelthane 4 MF, Rohm and Haas Co., Philadelphia, PA), 1000 ppm propargite (Omite 30 WP, Uniroyal Chemical Co., Bethany, CT.) and 3 ppm abamectin (Agri-mek 0.15EC, Merck and Co., AgVet Division, Rahway, N. J.) dissolved in 90% alcohol. The control petri dishes were coated with only 90% alcohol. All rapid bioassays were replicated twice and scored after 24 hours. In contrast, whole-leaf (for Kelthane and Zephyr) or Plexiglas cell (for Comite) residual bioassays were performed using discriminating concentrations of 1,000 ppm dicofol, 1,000 ppm propargite and 1 ppm abamectin in distilled water and replicated six times. The controls were single cotton cotyledons dipped in distilled water mixed with Triton X-100 surfactant. Residual bioassays testing mortality response to Comite and Zephyr were scored after 72 hours and after 48 hours for Kelthane, under 80◦F constant temperature in the growth chamber. Mean seed cotton yield (0.34 acre/plot) was analyzed for treatment effects using the Least Significance Difference Test (SigmaStat, Jandel Corp.)

Results and Discussion

Population dynamics and species composition:
During 1996, the dominant spider mite species throughout was *T. urticae*. *T. turkestani*, the only other spider mite species observed, was present only in low numbers in the early season in a few of the pre-treatment samples. During the previous two seasons, *T. turkestani* which is fully susceptible to Kelthane, Comite, and Zephyr, has been the dominant spider mite in cotton before acaricides treatments were applied. The result was that all acaricides then showed efficacy as a first application in 1994 and 1995. Because resistant *T. urticae* dominated in the 1996 season,

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the early to mid season treatments of Kelthane and Comite did not control *T. urticae* very well.

Figures 1 and 2 show that -/Kelthane, Kelthane/Kelthane, -/Comite, and Kelthane/Comite did not effectively control spider mites in 1996 because *T. urticae* was resistant to these acaricides. The Zephyr treatment was also ineffective because it was applied very late when spider mite densities were high. Evidence for lack of efficacy was spider mite density above the economic threshold of 7-10 mites per leaf. Additional evidence for poor control was a trend in lower yields for Zephyr, Kelthane, Kelthane/Kelthane, and Comite treatments (Table 2).

Resistant frequencies:

Rapid bioassays **-** The gross trends observed from the rapid bioassays were as follows: 1) high percentage mortality (i.e., susceptibility) of spider mite populations from all pre-treatment samples when bioassayed with Kelthane, Comite or Zephyr, 2) after treatments of Kelthane or Comite were applied, susceptibility of spider mites to these acaricides decreased, 3) at the end of the season, susceptibility increased again for both Kelthane and Comite, and 4) nearly complete mortality (range of 99-100%) of all spider populations bioassayed with Zephyr regardless of treatment, confirming that we still have susceptibility to Zephyr.

Residual bioassays **-** Four populations of *T. turkestani* were tested and each population was shown to be susceptible to all three acaricides. Mean percentage *T. turkestani* mortality was 99%, 92% and 85% when bioassayed with Zephyr, Kelthane and Comite, respectively. *T. urticae* populations showed high susceptibility to Zephyr (mean mortality = 97%; n = 64) but not to Kelthane and Comite.

T. urticae response to Kelthane **-** All early treatments of Kelthane (-/Kelthane, Kelthane/Kelthane, Kelthane/Comite, Temik/Kelthane/ Zephyr, and Kelthane/Zephyr) increased resistance of the spider mites to Kelthane. If that first treatment was followed by Comite or Zephyr, then resistance to Kelthane declined (plots that received Kelthane/Comite, or Kelthane/Zephyr rotation treatments showed nearly complete susceptibility for 8-9 weeks). Thus rotations of Comite or Zephyr with Kelthane reduced *T. urticae* resistance to Kelthane and maintained susceptibility until the end of the season. A single mid season Comite, Zephyr treatment, or two treatments of Zephyr also showed a marked reduction in *T. urticae* resistance to Kelthane, suggesting that Kelthane resistance in spider mites also declined in the absence of Kelthane use for three years.

T. urticae response to Comite **-** We found no distinct trends in the mortality response of *T. urticae* to Comite bioassays in any treatment. Applications of Comite did not appear to worsen the Comite resistance. However, neither the single nor the multiple consecutive Kelthane or Zephyr treatments resulted in reduced resistance to Comite.

Three years of field evaluation of the effects of Kelthane, Comite, and Zephyr rotations on the resistance of *T. urticae* to these three different classes of acaricides, provided us with several conclusions. First, applications of Kelthane, Comite, Kelthane/Kelthane, and Kelthane/Comite were not effective in controlling spider mites because of resistance. Second, applications of Comite or Zephyr reduced resistance to Kelthane and so these rotations were helpful. Third, applications of Kelthane or Zephyr did not reduce resistance to Comite, however the Comite resistance problem did not worsen in the 3 year period. Finally, the most effective treatments in terms of efficacy and reduction of Kelthane resistance were Kelthane/Zephyr, Temik/Kelthane/Zephyr, Zephyr/Zephyr, and Zephyr/Comite. The Zephyr/Zephyr treatment should be avoided because it will eventually lead to resistance to Zephyr.

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References

Bruce-Oliver, S. J. and E. E. Grafton-Cardwell. 1995. Initiation of a program to assess the effects of acaricide rotations on spider mite (Acari: Tetranychidae) resistance, pp. 64-66. *In* Addendum, 1995 Proceedings of the Beltwide Cotton Conference, National Cotton Council, Memphis, TN.

Bruce-Oliver, S. J. and E. E. Grafton-Cardwell. 1996. Evaluation of two seasons of acaricide rotation trials on spider mite (Acari: Tetranychidae) resistance in San Joaquin Valley cotton. pp. 1128-1130. *In* 1996 Proceedings of the Beltwide Cotton Conference, National Cotton Council, Memphis, TN.

Dennehy, T. J. and J. Granett. 1982. Improved detection of dicofol-resistant spider mites in cotton. Calif. Agric. 36: 11-12.

Dennehy, T. J., J. Granett, T. F. Leigh, and A. Colvin. 1987. Laboratory and field investigations of spider mite (Acari: Tetranychidae) resistance to the selective acaricide propargite. J. Econ. Entomol. 80: 565-574.

Grafton-Cardwell, E. E., J. Granett and T. F. Leigh. 1987. Spider mite response (Acari: Tetranychidae) to propargite: the basis for an acaricide resistance management program. J. Econ. Entomol. 80: 579-587.

Table 1. Acaricide treatments applied early and mid-season in acaricide resistance trials in cotton in the San Joaquin Valley.

Treatment	Early season Application	Mid-Season Application
1	Kelthane (3 pts)	Kelthane (3 pts)
2	Kelthane (3 pts)	Zephyr (8 oz.)
3	Kelthane (3 pts) +Temik at planting	Zephyr (8 oz.)
4	Zephyr (4 oz.)	Zephyr (8 oz.)
5	Zephyr (4 oz.)	Comite (2 pts)
6	Kelthane (3 pts)	Comite (2 pts)
7	-	Comite (2 pts)
8	-	Zephyr (8 oz.)
9	-	Kelthane (3 pts)

Table 2. Cotton yield (lbs of seed cotton/0.34 acre) from 30 rows x 500 ft of 9 replicated acaricide treatment plots at Corcoran, California, for 1996 season.

Treatment	Mean Lbs. Seed Cotton
Zephyr/Comite	2320.5
Zephyr/Zephyr	2222.0
Temik/Kelthane/Zephyr	2126.0
Kelthane/Comite	2084.0
Kelthane/Zephyr	2058.5
-/Kelthane	1923.0
-/Zephyr	1916.0
Kelthane/Kelthane	1860.5
-/Comite	1574.0

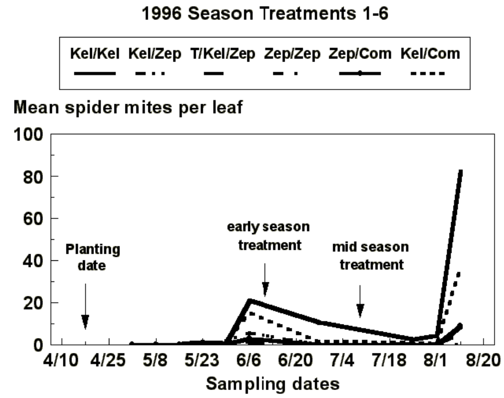

Figure 1. Spider mite densities for treatments 1 - 6 during 1996 season at Corcoran, CA.

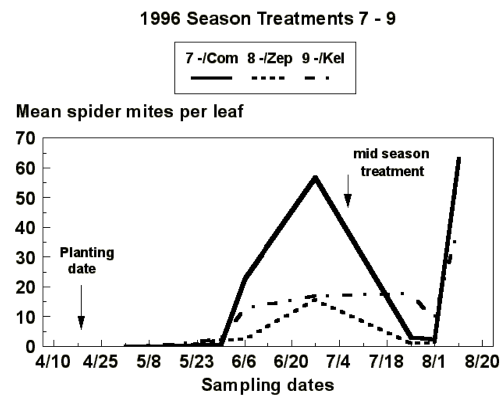

Figure 2. Spider mite densities for treatments 7 - 9 during 1996 season at Corcoran, CA.