OVIPOSITION SITE SELECTION BY *TETRANYCHUS URTICAE* KOCH (ACARI: TETRANYCHIDAE) IN RESPONSE TO FENVALERATE AND PERMETHRIN RESIDUES ON SOYBEAN

R. M. McPherson[1], D. J. Donahue[2], and S. L. Poe[3]
Department of Entomology
Virginia Polytechnic Institute & State University
Blacksburg, VA 24061
(Accepted for publication 27 May 1988)

ABSTRACT

The oviposition site selection of *Tetranychus urticae* Koch in response to fenvalerate and permethrin residues on soybeans was examined in the laboratory. Five leaf treatment regimes were evaluated on potted soybeans (half-area vs. whole area and partial coverage vs. complete coverage) plus a distilled water control. Over 95% of the eggs were deposited on untreated halves of leaflets on which the other half was treated with either fenvalerate or permethin. Similar oviposition behavior was observed for both partial spray coverage, ca. 10% of the leaf area, or total coverage of the treated half leaflet. Over 95% of the eggs were observed on the leaf surface in the control, whereas, 40% and 30% of the eggs were suspended off the leaf surface that was totally covered with permethrin and fenvalerate, respectively. No differences were observed in the vertical distributions of eggs between control, and the permethrin and fenvalerate half-leaf treatments. More than 95% of the total eggs were observed on the leaf surface; however, few eggs were laid on the leaflet half containing the pyrethroid residue.

Key Words: *Tetranychus urticae,* oviposition, two spotted spider mite, pyrethroid residues, soybean.

J. Entomol. Sci. 24(1): 26-33 (January 1989)

INTRODUCTION

Concern regarding pyrethroid induced outbreaks of spider mites has increased in recent years due to the widespread use of these pesticides in a wide array of agricultural crops. Pyrethroid insecticides have been reported to influence the dispersal behavior of the two spotted spider mite, *Tetranychus urticae* Koch (TSSM) on lima beans (Iftner and Hall 1983) and French dwarf beans (Penman and Chapman 1983). Spider mites escape pyrethroid residues by walking to plant surfaces devoid of residue, or by descending from the treated surface on silk threads (Penman and Chapman 1983). This dispersal behavior in response to pyrethroid treatment may explain the resurgence of spider mites (Penman and Chapman 1983; Iftner and Hall 1983), through a reduction in intraspecific density-

[1] Current address: University of Georgia, Department of Entomology, Coastal Plain Experiment Station, Tifton, GA 31793.
[2] Current address: Red Jacket Orchards, Rt 5 & 21 West, Geneva, NY 14456.
[3] Current address: 102 Waywood Dr., Jackson, MS 39212.

dependent population regulation, as well as escape from predators. Hall (1979) observed more TSSM eggs on pyrethroid-free leaf surface than treated surface on apple foliage. Similar oviposition behavior may occur on other crops.

T. urticae is a major pest of soybean throughout the entire growing region of the U.S. (Turnipseed and Kogan 1976). Soybean crop losses can be severe (McPherson and Allen 1981), and pesticidal control is often inadequate. Studies have evaluated the effects of crop phenology and host plant resistance on *T. urticae* infestations in soybeans (Hildebrand et al. 1986).

Specific effects of pyrethroid insecticides on spider mite oviposition in soybeans are not fully documented or understood. Therefore, this study was initiated to evaluate TSSM oviposition behavior on soybeans treated with two widely used pyrethroid insecticides, fenvalerate and permethrin, at two levels of residue deposition.

MATERIALS AND METHODS

The TSSM used in these experiments were from a laboratory colony maintained on 'Essex' soybeans held at 20° - 30°C, 30 - 60% RH, and 16:8 (L:D). Plants were raised in 10 cm × 10 cm pots filled with Metro-Mix 500® potting medium, and held outdoors in the spring, 1984. Two plants were grown in each pot and utilized while in the V3 or early vegetative stage of plant development (Fehr and Caviness 1977).

A leaf cage (designed according to Hughes et al. 1966) was centered over the midrib of the middle leaflet, first trifoliate, and attached to the abaxial surface. Each 4.0 cm^2 plastic tubing cage served as a replicate for one of the leaf treatment schemes. Seven leaf treatments were tested (Figure 1) plus a control. Water emulsions of fenvalerate (Pydrin® 2.4 EC, 120 ppm) and permethrin (Pounce® 3.2 EC, 120 ppm) were prepared. These solutions approximated the field use rate of 0.11 kg AI/ha. Insecticide was applied to the leaf surface enclosed by each cage (397 mm^2) using a 3/0 sable artists' brush. Twelve 1.5 mm-diam. drops were placed on partial treatment leaf halves (10% of the leaf area), whereas the entire surface was covered in the complete coverage treatment. Leaf area to the right of the midrib was not treated in the half area treatments. Distilled water was applied to the controls with a brush. Treatments were allowed to dry one hour. Insecticide treatment schemes were replicated four times.

The young soybeans were too weak to support the weight of the leaf cages, so leaf cage support brackets were constructed. A perpendicular cross brace 21 cm long was attached approximately midway on a 42 cm × 2 cm × 0.5 cm wooden upright stake. A small wire brad was inserted at each end of the crossbrace, facing downward. One support was placed on each pot, each brad gripping the cork portion of a leaf cage, securing the cage in an upright position.

A 3/0 camel's hair brush was used to transfer three adult female TSSM into each cage, one mite to the left, one to the right, and one on the midrib. The experimental units were placed in a plant growth chamber and held for 72 hours at 25°C/19°C ± 0.5°C and 16:8 (L:D). Relative humidity ranged from 50 to 70%. Following the developmental period, the experimental units were removed from the chamber, the cages opened, and the number and location of eggs determined under 20X magnification. Egg location was recorded as: Left half, surface; Left half, suspended; Right half, surface; Right half, suspended. Eggs oviposited on cage walls, attached to trichomes, or held off the surface by a network of silk threads, were classified as "suspended."

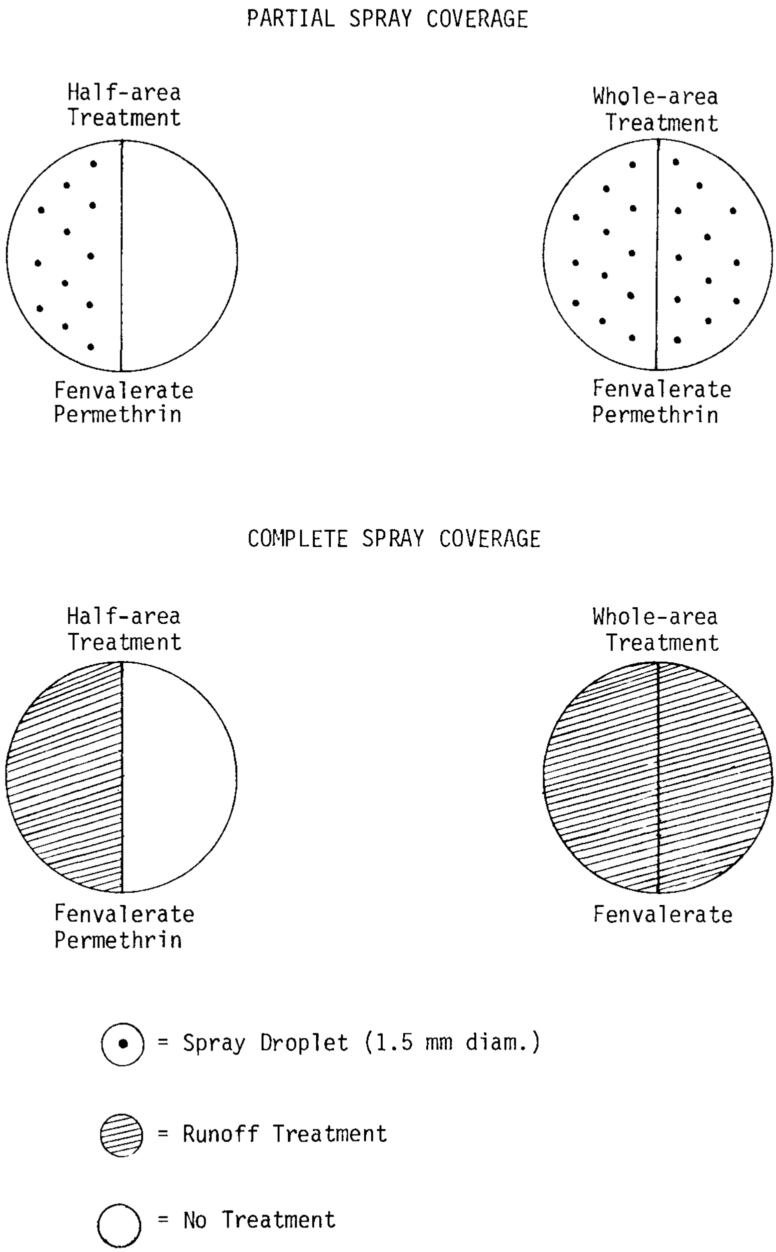

Fig. 1 Diagramatic representation of pyrethroid insecticide treatments applied to soybean leaflets. Circles represent the leaf surface inside cages. Droplets approx. 1.5 mm in diam.

Egg distribution in the horizontal plane was analyzed by arcsine transformation of the replicate frequencies associated with eggs oviposited in the right half of the cage. The horizontal plane was defined as lying parallel to and in contact with the leaf surface (not including trichomes). Transformed data were tested for homogeneity of variance using the Bartlett's Test (Sokal and Rohlf 1981). Differences between treatments were analyzed using a one-way analysis of variance (P = 0.01), with means separated by Duncan's New Multiple Range Test (Duncan 1955). Egg distribution in the vertical plane also was analyzed by arcsine square root probability transformation. The verticle plane was defined as lying perpendicular to but not contacting the leaf surface proper. Transformed data were tested for homogeneity of variance using the Bartlett's Test. Differences between treatments were analyzed using a one-way analysis of variance with means separated by Duncan's New Multiple Range Test.

RESULTS AND DISCUSSION

The total numbers of eggs oviposited by the mites maintained in the pyrethroid treatments for 72 hr. ranged from 112 to 382, with the control mites ovipositing 275 eggs. Eggs in the controls were distributed nearly equally between the right and left halves of the leaf cage. Egg distribution was significantly shifted toward the right (untreated) halves of the leaf cages in the permethrin (> 95%) and fenvalerate (> 95%) half-leaf treatments (Figures 2 and 3). No significant difference was observed between the two coverage schemes. The partial coverage treatments, with only ca. 10% of the leaf surface covered with pyrethroid, produced an effect similar to the 100% coverage treatments. No significant differences were found in the horizontal distribution of eggs between the control, whole-leaf permethrin (Figure 2) and whole-leaf fenvalerate (Figure 3) treatments; all approximated an equal distribution between halves.

Greater than 95% of the eggs on water-treated leaves were found on the leaf surface. A significant proportion of eggs were laid off the leaf surface in the permethrin (49%) (Figure 4) and fenvalerate (approx. 30%) (figure 5) whole-leaf treatments. No significant differences were found in the vertical distribution of eggs between the control, permethrin and fenvalerate half-leaf treatments, with greater than 95% of the total eggs laid on the leaf surface.

Spider mites demonstrated a clear preference for oviposition away from fenvalerate and permethrin residues. TSSM females were able to differentiate treated and untreated leaf surfaces, ovipositing almost exclusively (95%) on untreated surfaces. Once untreated surface was located, > 90% of the eggs were oviposited directly on the leaf surface. If pyrethroid-free leaf surface was not available, a substantial proportion (> 30%) of the eggs were suspended off the leaf surface in a network of silk threads.

These results suggest that pyrethroid residues directly influence TSSM oviposition site selections. This supports an interpretation offered by Iftner and Hall (1984) as an explanation for reduced TSSM oviposition in the presence of pyrethroid residues. The added energy and time required to oviposit away from the residues may lead to a reduction in egg production. However, another possibility is that pyrethroid residues may cause intoxication, and mites on treated surfaces lay fewer eggs because they are sick.

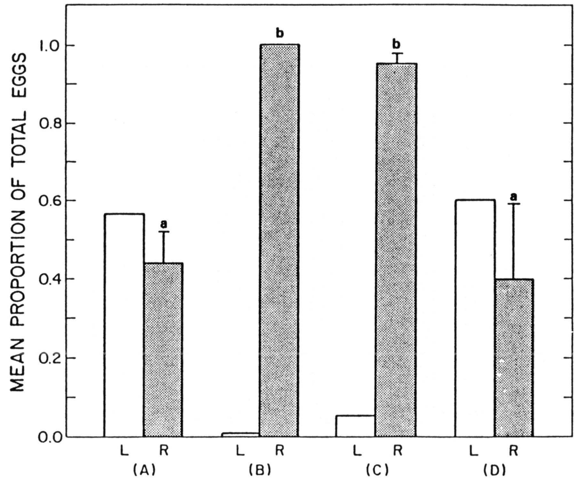

Fig. 2 *T. urticae* oviposition site selection in response to permethrin residues on soybean leaves. Mean proportion of total eggs distributed between the treated left (L) and untreated right (R) halves of the leaf cages. Differences in lower case letter indicates significance (P = 0.01). Small bar represents the standard error of the mean.

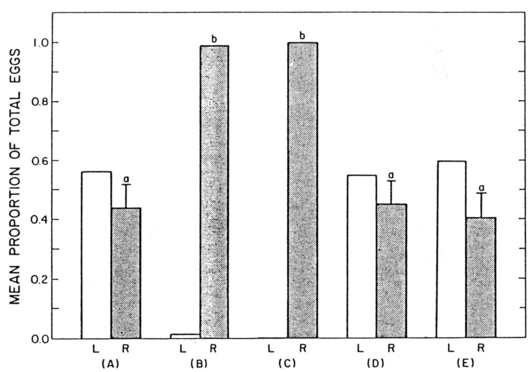

Fig. 3 *T. urticae* oviposition site selection in response to fenvalerate residues on soybean leaves. Mean proportion of total eggs distributed between the treated (L) and untreated (R) halves of the leaf cages. Difference is lower case letter indicates significance (P = 0.01). Small bar represents the standard error of the mean.

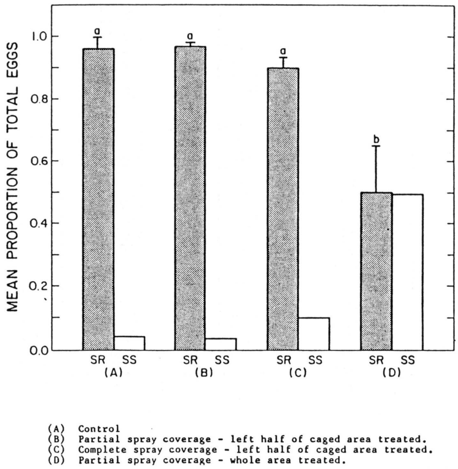

Fig. 4 *T. urticae* oviposition site selection in response to permethrin residues on soybean leaves. Mean proportion of total eggs oviposited on the leaf surface (SR) vs. suspended above the leaf surface (SS). Differences in lower case letter indicates significance (P = 0.01). Small bar represents the standard error of the mean.

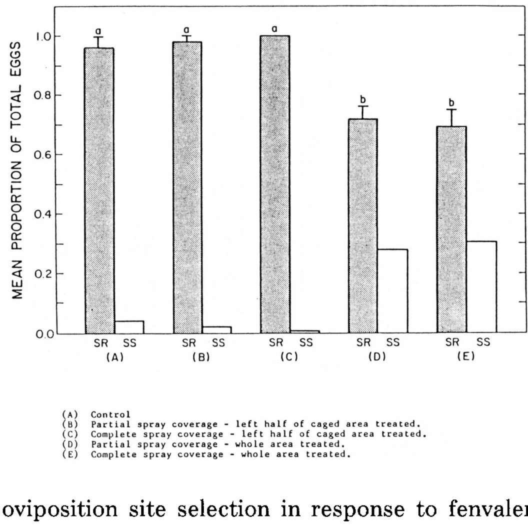

Fig. 5 *T. urticae* oviposition site selection in response to fenvalerate residues on soybean leaves. Mean proportion of total eggs oviposited on the leaf surface (SR) vs. suspended above the leaf surface (SS). Difference is lower case letter indicates significance (P = 0.01). Small bar represents the standard error of the mean.

An alternative explanation involves a more passive oviposition site selection response. Since TSSM females exhibit a general avoidance response in the presence of pyrethroid residues (Iftner and Hall 1983; Penman and Chapman 1983), TSSM females might be expected to increase the amount of time spent off the leaf surface, traversing a network of silk threads, when pyrethroid-free leaf surface is unavailable. Boudreaux (1963) noted that tetranychid eggs are often observed in the vicinity of veins on the undersides of host plant leaves. Eggs in this location are considered to be in a favorable "protected" position. This observation implies some degree of oviposition site selection. However, in a more general interpretation, oviposition by phytophagous mites appears to be carried out in a "haphazard" manner (Jeppson et al. 1975). TSSM eggs can usually be found anywhere on the leaf surface (or off the leaf surface), suggesting that oviposition site selection is not an active response.

No significant differences were observed in egg distribution between the two levels of "spray" coverage, with either fenvalerate or permethrin. Discontinuous deposits of pyrethroid residue may present enough of an irritation to the mite so that the untreated leaf tissue in the vicinity of the deposits is not attractive. In a more practical sense, TSSM females in the field may be more likely to colonize untreated foliage, rather than partially treated foliage.

These findings help explain the relationship between mite behavior and pyrethroid induced outbreaks of spider mites in soybeans and other agricultural crops. Pyrethroid insecticides can alter the dispersal, and hence oviposition behavior, of egg laying females, causing them to seek untreated areas. This results in a more rapid expansion of the infestation. This knowledge can be incorporated into integrated pest management programs. In field situations where mite infestations are localized, use of pyrethroids may be less desirable. In fields were outbreaks are likely to occur (i.e., hot/dry conditions) the pyrethroid insecticides should be considered as contributory to secondary outbreaks of spider mites.

ACKNOWLEDGMENTS

This research was supported in part by funds received from the Virginia Agricultural Council and the Virginia Soybean Board.

LITERATURE CITED

Boudreaux, H. B. 1963. Biological aspects of some phytophagous mites. Annu. Rev. Entomol. 8: 137-54.

Duncan, D. B. 1955. Multiple range of multiple F tests. Biometrics 11: 1-41.

Fehr, W. R., and C. E. Caviness. 1977. Stages of soybean development. Iowa Coop. Ext. Serv. Spec. Rpt. 80: 12 pp.

Hall, R. F. 1979. Effects of synthetic pyrethroids on major insect and mite pests of apple. J. Econ. Entomol. 72: 441-46.

Hildebrand, D. F., J. G. Rodriguez, G. C. Brown, and C. S. Volden. 1986. Two-spotted spider mite (Acari: Tetranychidae) infestations on soybeans: Effect on composition and growth of susceptible and resistant cultivars. J. Econ. Entomol. 79: 915-21.

Hughes, P. R., R. E. Hunter, and T. F. Leigh. 1966. A light-weight leaf cage for small arthropods. J. Econ. Entomol. 59: 1024-25.

Iftner, D. C. and F. R. Hall. 1983. Effects of fenvalerate and permethrin on *Tetranychus urticae* Koch (Acari: Tetranychidae) dispersal behavior. Environ. Entomol. 12: 1782-86.

Iftner, D. C., and F. R. Hall. 1984. Effects of fenvalerate and permethrin on *Tetranychus urticae* Koch fecundity and rate of development. J. Agric. Entomol. 1: 191-200.

Jeppson, L. R., and H. H. Keifer, and E. W. Baker. 1975. *Mites Injurious to Economic Plants.* Univ. Calif. Press. Los Angeles. 614 pp.

McPherson, R. M. and W. A. Allen. 1981. Drought and Insects: Bad news for beans. Agrichem. Age 25(4): 16, 18, 42.

Penman, D. R. and R. B. Chapman. 1983. Fenvalerate-induced distributional inbalances of two-spotted spider mite on bean plants. Entomol. Exp. Appl. 33: 71-8.

Sokal, R. R., and F. J. Rohlf. 1981. *Biometry.* W. H. Freeman and Co. New York. 859 pp.

Turnipseed, S. G. and M. Kogan. 1976. Soybean Entomology. Ann. Rev. Entomol. 21: 247-82.