Sampling Scheme for Determining Population Intensity of *Tetranychus cinnabarinus* (Boisduval) (Acarina: Tetranychidae) in Cotton

J. A. MOLLET, J. T. TRUMBLE, G. P. WALKER, AND V. SEVACHERIAN

Department of Entomology, University of California, Riverside, California 92521

Environ. Entomol. 13: 1015–1017 (1984)

ABSTRACT The spatial dispersion of *Tetranychus cinnabarinus* was studied for 2 years in insecticide-treated and untreated cotton. Spider mite distributions and population density were not affected by the pesticides tested. The linear regression of log variance against log mean ($r^2 = 0.95$) provided a better fit to the data than did the linear regression of mean crowding on the mean ($r^2 = 0.80$). The former regression was used as a basis for a sampling plan designed to estimate population densities of *T. cinnabarinus* with fixed levels of precision.

AN IMPORTANT aspect of any pest management program is having a sampling procedure that adequately estimates pest populations within reasonable time limits. This is especially important in sampling mite populations, which unlike most pest species can reach levels exceeding tens of thousands per plant. Counting all mites on a single cotton leaf often takes an hour or more. Consequently, few researchers or pest control advisors are willing to commit the time necessary for sampling whole plants for mites (Wilson et al. 1981).

Practical sampling plans for spider mites infesting cotton have been developed for the San Joaquin Valley, Calif. (Carey 1982, Wilson et al. 1983). However, these sampling plans may be misleading or inaccurate when applied to the Imperial Valley, Calif., because the two valleys differ in geographical and agricultural aspects that may affect mite sampling. In the San Joaquin Valley, a complex of mites consisting of *Tetranychus urticae* Koch, *T. pacificus* McGregor, and *T. turkestani* (Ugarov and Nikolski) occurs, none of which are common in cotton from the Imperial Valley. *T. cinnabarinus* (Boisduval) is the prevalent spider mite in Imperial Valley cotton (Leigh and Burton 1976). Thus, specific work on *T. cinnabarinus* was needed to better understand its impact on the cotton agroecosystem.

Multiple applications of pesticides for control of the pink bollworm, *Pectinophora gossypiella* (Saunders), a pest not present in the San Joaquin Valley, are required to produce marketable cotton in the Imperial Valley (Van Steenwyk et al. 1975). In order to determine if our sampling strategy for *T. cinnabarinus* would be compatible with present cotton production procedures, data were collected in plots treated with a variety of pesticides in use or being considered for registration for use against pink bollworm.

Materials and Methods

During the 1982 and 1983 field seasons, tests were conducted on 'DPL-61' cotton at the Imperial Valley Field Station, near El Centro, Calif. In 1982, treatments were replicated four times in a randomized block design. Each replicate was eight rows with 96-cm centers by 38 m length. In 1983, treatments were replicated eight times in a randomized block design. Each replicate was eight rows with 96 cm centers by 19 m length.

Pesticides were applied weekly when cotton balls susceptible to pink bollworm were present. Applications were made with a Hi-Cycle 600 Sprayer dispensing 225 liters/ha. In 1982 there were six treatments: an organophosphate (monocrotophos 5E, 0.56 kg [AI]/ha), a carbamate (U-56295 85WP [Upjohn], 0.73 kg [AI]/ha), three pyrethroids (cypermethrin 2.5E and FMC-54800 0.8EC [FMC] and FCR-1272 1.67EC [Bayer] all at 0.04 kg [AI]/ha), and an untreated control. Only three treatments were compared in 1983: cypermethrin 2.5EC and FMC-54800 2EC (both at 0.05 kg [AI]/ha) and an untreated control. In both years, treatments were assessed by sampling 96 plants per week; 4 plants per plot in 1982, 3 plants per plot in 1983.

The number of adult female mites were recorded from the fifth mainstem node leaf of each plant. Cotton grows as a mainstem with two branches occurring at each node. These branches include the primary branch, which is a leaf attached directly to the mainstem, (=mainstem node leaf), and a secondary branch, which has many leaves as well as fruiting bodies. During much of the season, most mites are found on mainstem node leaves (Carey 1982), and the number of mites on mainstem node leaves can be related to mite density on the whole plant (Wilson et al. 1983). Pre-

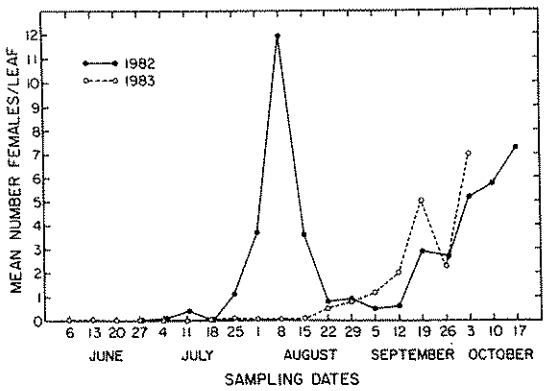

Fig. 1. Mean number of adult female *T. cinnabarinus* on mainstem node leaf 5 of cotton during 1982 and 1983 growing seasons.

vious studies in the Imperial Valley showed that mainstem node leaf 5 (uppermost leaf = 1) either had the highest number of *T. cinnabarinus* or a density of mites which was not significantly different from the most heavily infested leaf (J. A. Mollet and V. Sevacherian, unpublished data). Additionally, Marcano-Brito (1980) demonstrated that numbers of adult females could be utilized to estimate total mite populations. These relationships were used to assess mite populations in the Imperial Valley rapidly and efficiently.

For each sampling date, the estimated population mean ($\bar{x}$ and variance (s^2)' were calculated within treatments. Lloyd's (1967) mean crowding index ($\overset{*}{m}$) was also generated for each date. Both the linear regressions of $\overset{*}{m}$ on m (Iwao 1968, Iwao and Kuno 1971) and log s^2 on log m (Taylor 1965) were computed using the Proc GLM procedure of SAS (Helwig and Council 1979).

Results and Discussion

In 1982 the mean number of females per mainstem node leaf 5 initially increased from 0.09 to

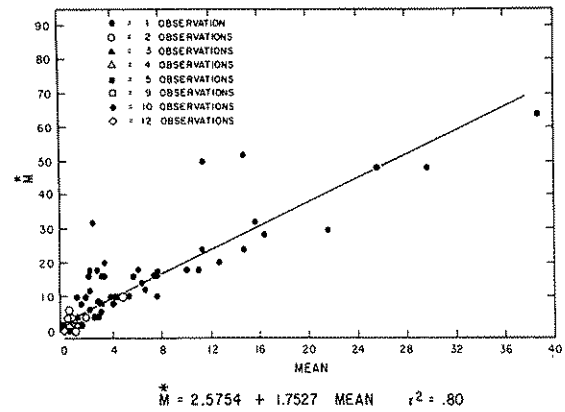

Fig. 2. Linear regression of $\overset{*}{m}$ against the mean for counts of adult female *T. cinnabarinus* in cotton in the Imperial Valley during 1982 and 1983.

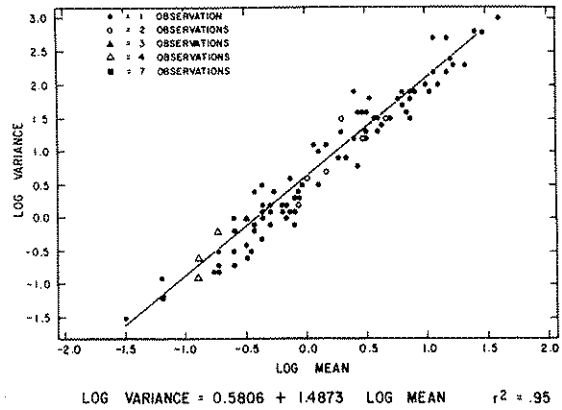

Fig. 3. Linear regression of log variance against log mean of *T. cinnabarinus* in cotton during 1982 and 1983.

11.89, and then decreased to 0.33. Another increase started mid-September with mite populations reaching 7.22 females per leaf (Fig. 1). These increases and decreases were independent of chemical treatment, and may have been tied to crop physiology or climatic conditions.

During the 1983 season, mite populations were lower. The early season population peak seen in 1982 did not occur in 1983, but by late in the

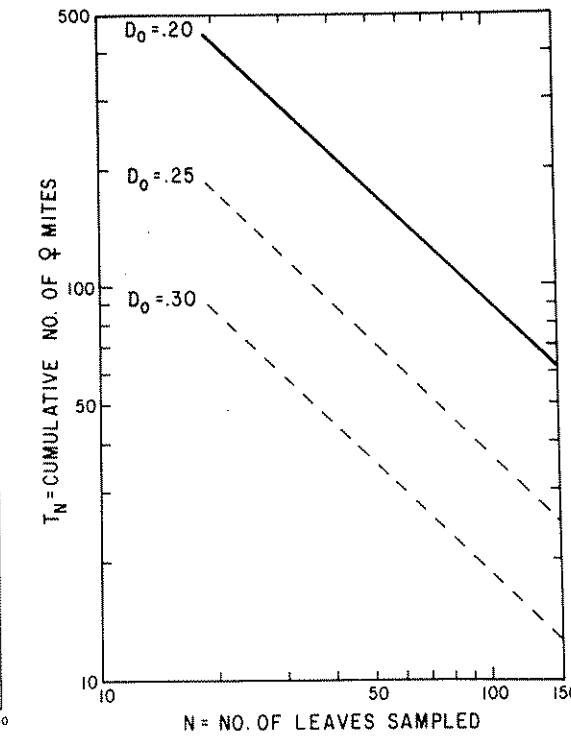

Fig. 4. Sequential sampling graph for *T. cinnabarinus* in cotton in the Imperial Valley. Both *Tn* (cumulative total for sample *n*) and *n* are logarithmic scales. Stop lines are calculated for precision levels (D_o) of 0.20, 0.25, and 0.30.

season, populations increased to an average of 6.98 per leaf (Fig. 1). Due to the extremely low population levels early in 1983, only 1982 and late 1983 data (8 August–3 October) were used in our analysis.

Regression of m on the mean produced a good fit of the data ($r^2 = 0.80$) (Fig. 2). However, regression of log variance on log mean produced a better fit ($r^2 = 0.95$) (Fig. 3), and was therefore chosen as the statistical basis for sequentially sampling *T. cinnabarinus* in cotton to fixed levels of precision by the method of Green (1970).

To express the relationship between the cumulative number of mites sampled (Tn) and the total number of samples taken (n) Green (1970) derived the equation:

$$\log Tn = \log(D_o^2/a)/(b - 2) + (b - 1)/(b - 2)\log n$$

where $D_o = \sqrt{s^2/n}/m$ = the precision level, a = the intercept of the $s^2 = a + m^b$ regression and b = the slope of this regression. When a graph is constructed with Tn and n on logarithmic axes, the precision levels form linear isoclines (Fig. 4). A person sampling mites in cotton would use Fig. 4 by plotting Tn and n after each sample unit is counted. When the plot falls above the isocline of the desired precision level, then sampling is stopped, and the mean density is calculated as $m = Tn/n$. The precision of this estimate will be approximately that of the isocline on the graph. As D_o increases, the precision of the estimate of population intensity decreases and less sampling is required to reach the stop line.

Although binomial and sequential sampling plans for spider mites have been developed for cotton grown in the San Joaquin Valley (Wilson et al. 1981, Wilson et al. 1983), the necessary economic thresholds for *T. cinnabarinus* on cotton have not yet been established, mainly because accurate sampling methods were not available. Using our sampling scheme, researchers can now determine the economic threshold required to develop a sequential sampling program for spider mites in the Imperial Valley. This technique will ultimately allow generation of treatment decisions for cotton growers and pest control advisors.

Acknowledgment

We thank R. Hannibal for his assistance in treating and maintaining the field plots, and S. Sagnia for assistance in sampling.

References Cited

Carey, J. R. 1982. Within-plant distribution of Tetranychid mites on cotton. Environ. Entomol. 11: 796–800.

Green, R. H. 1970. On fixed precision level sequential sampling. Res. Popul. Ecol. 12: 249–251.

Helwig, J. T., and K. A. Council [eds.]. 1979. SAS user's guide, 1979 edition. SAS Institute Inc., Cary, N.C.

Iwao, S. 1968. A new regression model for analyzing the aggregation pattern of animal populations. Res. Popul. Ecol. 10: 1–20.

Iwao, S., and E. Kuno. 1971. An approach to the analysis of aggregation pattern in biological populations, pp. 461–513. *In* G. Patil, E. Pielou, and E. Waters [eds.], Statistical ecology, vol. 1. The Pennsylvania State University Press, University Park.

Leigh, T. F., and V. E. Burton. 1976. Spider mite pests of cotton. Div. Agric. Sci. Univ. of Calif. Berkeley. Leafl. 2888.

Lloyd, M. 1967. Mean crowding. J. Anim. Ecol. 36: 1–30.

Marcano-Brito, R. 1980. Factors affecting the distribution and abundance of 3 species of *Tetranychus* spider mites on cotton and the effect of their damage on transpiration and photosynthesis. Ph.D. dissertation, University of California, Riverside.

Taylor, L. R. 1965. A natural law for the spatial dispersion of insects, pp. 396–397. Proceedings of the XII International Congress on Entomology.

Van Steenwyk, R. A., N. C. Toscano, G. R. Ballmer, K. Kido, and H. T. Reynolds. 1975. Increase of *Heliothis* spp. in cotton under various insecticide treatment regimes. Environ. Entomol. 4: 993–996.

Wilson, L. T., T. F. Leigh, and V. Maggi. 1981. Presence-absence sampling of spider mite densities on cotton. Calif. Agric. 35: 10.

Wilson, L. T., D. Gonzalez, T. F. Leigh, V. Maggi, C. Foristiere, and P. Goodell. 1983. Within-plant distribution on spider mites (Acari:Tetranychidae) on cotton: a developing implementable monitoring program. Environ. Entomol. 12: 128–134.

Received for publication 10 January 1984; accepted 10 April 1984.