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Influence of ground cover and herbicide treatments on *Tetranychus urticae* populations in peach orchards[1]

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ABSTRACT

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Two-spotted spider mites, *Tetranychus urticae* Koch, were sampled in peach orchards to quantify abundance in trees over different types of ground cover to document the dispersal of mites from orchard-floor plants to trees. Mite populations developed more quickly and with higher densities in trees over ground cover compared to bare ground, and specifically over covers of predominantly narrowleaf vetch, *Vicia angustifolia* Reichard. Orchard floor plants such as *Vicia, Geranium, Lamium,* and *Lepidium* contained relatively high densities of mites during early spring, and may have formed the source for later peach-tree infestation.

INTRODUCTION

Two-spotted spider mites, *Tetranychus urticae* Koch, may infest peach trees [*Prunus persica* (L.) Batsch] and cause damage to leaves and fruit yield. Kovach and Gorsuch (1985) found that high mite population levels accelerated leaf-drop and increased peach bloom density with no reduction in fruit weight or size, but Bailey (1979) found that high mite populations reduced peach yield during the final fruit-growth phase and also promoted early leaf-drop.

During the 1988 season, only a few acaricides were available for use on peaches in North Carolina, and the future for current or new acaricides is not promising. Our knowledge of spider-mite ecology in peach orchards is limited, and the effects of ground cover on mite population densities unclear.

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This study in 1987 and 1988 was undertaken to study the habits of spider mites in the peach/ground-cover ecosystem. Specific objectives were to quantify abundance of mites in trees under different types of ground-cover management, to document the dispersal and migration of mites from orchard-floor plants to the trees, and to determine the effect of herbicide applications on mite dispersal.

MATERIALS AND METHODS

Orchard-floor management experiment

This experiment was done in a 4.5-ha peach orchard (planted 1981) located on the Sandhills Research Station, Montgomery Co., NC. It contained blocks of the cultivars Biscoe, Norman, Pekin, and Winblo, and was used for ground-cover research by previous workers.

In May 1987, spider mites were discovered infesting narrowleaf vetch, *Vicia angustifolia* Reichard, in an area at the edge of the orchard. Five orchard-floor management treatments were applied to six trees each (either Norman or Biscoe) to document the importance of vetch to the resulting infestation of the trees. The treatments consisted of orchard floors of bare ground, bare ground with infested vetch (removed from another plot), a 1-m circle of bare ground surrounded by ground cover, ground cover with vetch not touching tree limbs or trunks (vetch knocked down), and an unmanaged control.

The method of mite migration into trees and the resulting within-tree dispersal was studied by banding trunks, and by stratified sampling. Three trees of each treatment were banded with duct tape and Tangle-Trap® (Tanglefoot Co., Grand Rapids, Mich.) to inhibit mite crawling into the trees. Mite population density was assessed by sampling 20 leaves in each of three sections of the tree and recording the proportion of leaves with motile mites. The three sections were the periphery, high center (> 1.5 m), and low center of the trees. Samples taken during summer were from only two sections in the trees because the low-center areas were completely infested.

Spring (3 samples in June) and summer (2 in June, 1 in July) data were analyzed as a factorial (ANOVA, Anonymous, (1982)), with type of orchard floor (management treatment), tree section, and banding as the factors.

Ground-cover experiment

This experiment was done in a 0.8-ha orchard (planted in 1965) located in Nash Co., NC, primarily containing Norman and Pekin trees. To test the effect of bare ground versus sod cover in mite infestation, the ground cover was modified during late March by removing all cover within the 'drip line' of six trees. These bare ground areas were maintained by hoeing or by applying paraquat throughout the growing-season. Half of the sod and bare-ground trees were banded with duct tape and Tangle-Trap to determine cursorial dispersal.

Thus, there were three trees each with the treatments of sod/banded, sod/nonbanded, bare-ground/banded, and bare-ground/nonbanded (a total of 12 trees).

Mites were sampled by selecting 20 leaves around the periphery of the tree and placing them in 'Berlese' (modified Tullgren) funnels until the leaves were dry (Farrier et al., 1980). Motile mites fell into vials of alcohol, were counted, and the dry peach leaves were weighed to calculate the number of mites per g of peach leaf. Sampling began in early April and was continued weekly until mid-July. Data were analyzed as a factorial (ANOVA; Anonymous, 1982), with cover and banding as the factors.

Ground-cover surveys were conducted in spring and early summer to determine the vegetation content in the orchard. Ten samples were taken using a 1-m^2 grid divided evenly into 25 sections. Frequency was defined as the number of times (as a percentage) a plant species appeared in the grid, while density was the number of plants per m^2. Plant species were identified according to Radford et al. (1976), and plants with a frequency of over 40% (except for seedling peach, greenbrier (*Smilax* sp.), and horsenettle (*Solanum carolinense* L.) were sampled for mites during spring and summer by funnel extraction.

Herbicide experiment

This experiment was done in a 1.0-ha orchard of 'Biscoe' and 'Norman' peach trees (planted in 1984) located at the Central Crops Research Station in Clayton. This orchard was divided into three herbicide-treatment plots. The herbicides simazine (treatment 1) and paraquat (treatment 2) were applied at recommended rates (4.5 kg a.i. ha^{-1} and 1.1 kg a.i. ha^{-1}, respectively) during February to the tree rows and row alleyways; the 3rd treatment consisted of ground cover with no herbicide application.

Within each herbicide plot, the ground cover was additionally modified to some trees during late March by removing all ground cover within the 'drip line' by hoeing. These bare-ground areas were maintained by hoeing throughout the season. Half of the sod and bare-ground trees were banded with duct tape and Tangle-Trap. Thus, there were three trees each with the treatments of sod/banded, sod/nonbanded, bare-ground/banded, and bare-ground/nonbanded within each herbicide plot (a total of 36 trees).

Mites were sampled weekly from April to July in each treatment by selecting 20 leaves around the periphery of the tree and placing them in modified Tullgren funnels. Data were analyzed as a factorial (ANOVA; Anonymous, 1982), with herbicide treatment, cover, and banding as the factors. Orchard-floor surveys were conducted to determine the frequency of ground-cover plant species, and plants in each treatment plot were sampled for mites from early March to late May by funnel extraction.

RESULTS

Orchard-floor management experiment

Spring and summer analyses suggested differences in mite-infested leaves among the main factors of management treatments, tree sections, and banding (spring only) (Table 1). Trees with vetch under them yielded higher proportions of infested leaves than trees within bare-ground treatments (Table 2), and had 70% of their leaves already infested by late May. These trees quickly became almost totally infested by July (Fig. 1). Trees with a bare ground cover started at lower mite densities, but by July were over 75% infested. Ground-cover plants other than vetch that were common were chickweed [*Stellaria media* (L.) Cyrillo], Carolina geranium (*Geranium carolinianum* L.), henbit (*Lamium amplexicaule* L.), and camphorweed (*Pluchea* sp.).

TABLE 1

Factorial analysis of the orchard floor management experiment from spring and summer sampling of peach leaves for *T. urticae*, Montgomery Co., NC, 1987

Source of variation	Spring			Summer		
	DF	*F*-value	$P_r > F$	DF	*F*-value	$P_r > F$
Treatment	4	23.2	0.0001	4	13.0	0.0001
Section	2	174.6	0.0001	1	38.9	0.0001
Banding	1	21.7	0.0001	1	2.2	0.1453
Treatment × section	8	3.0	0.0067	4	4.4	0.0055
Treatment × banding	3	1.4	0.2551	3	1.6	0.2135
Section × banding	2	0.9	0.4036	1	0.3	0.5999
Treatment × section × banding	6	0.5	0.8449	3	0.5	0.6998

TABLE 2

Proportion of *T. urticae*-infested peach leaves (mean ± SE)[1] in five orchard floor-management treatment plots during spring and summer sampling. Montgomery Co., NC, 1987

Treatment[2]	Spring	Summer
Control	0.83 ± 0.05a	0.99 ± 0.01a
Vetch knocked down	0.72 ± 0.04b	0.96 ± 0.02a
Vetch removed	0.58 ± 0.06c	0.91 ± 0.03ab
Bare ground w/vetch	0.54 ± 0.07c	0.82 ± 0.04bc
Bare ground	0.49 ± 0.08c	0.75 ± 0.05c

[1]Means followed by the same letter are not significantly different ($P > 0.05$, REGWF test, SAS Institute (Anonymous, 1982)).
[2]Orchard-floor treatments described in text.

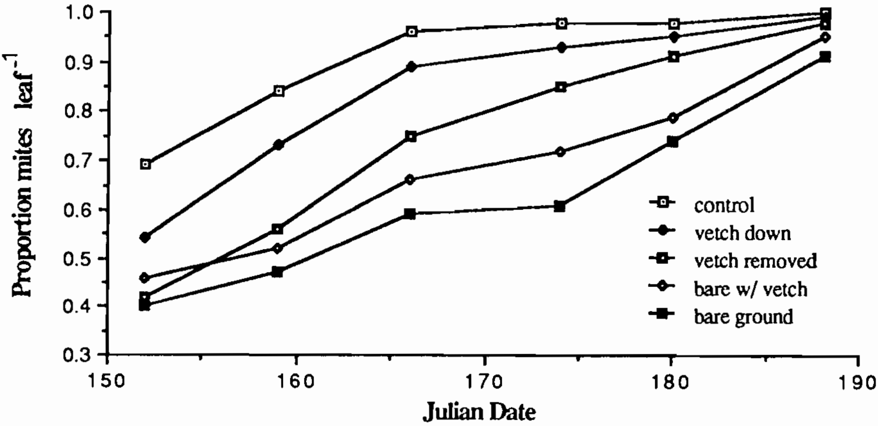

Fig. 1. Proportion of *T. urticae*-infested peach leaves in five orchard-floor management treatment plots during June and July sampling, Montgomery Co., NC 1987.

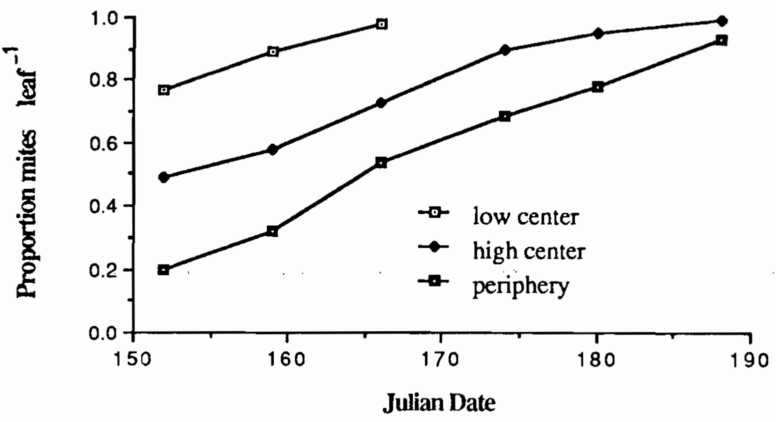

Fig. 2. Proportion of *T. urticae*-infested peach leaves in three tree sections during spring sampling and two sections during summer sampling, Montgomery Co., NC, 1987.

Tree colonization by *T. urticae* progressed from the low center to high center to peripheral sections (Fig. 2). Spring sampling showed the low-center sections with large proportions of infested leaves compared to the high center and periphery (0.88 ± 0.02; 0.60 ± 0.04; 0.35 ± 0.04, respectively). By the summer sampling, the center sections of the trees contained more infested leaves than the peripheral areas (0.95 ± 0.1; 0.80 ± 0.03), although the peripheral sections were quickly becoming infested.

Statistical interactions between factors can be described as differences in magnitude (large changes in the magnitudes of the differences between treatment means), or differences in direction (changes in the rank of any treatment means; Steel and Torrie, 1980). The management-treatment × tree-section interaction during the spring sampling was due to a change in the rank of management treatments in the peripheral section compared to the other tree sections; during the summer sampling the interaction was a result of a magnitude difference between tree-section means.

Spring sampling suggested that tree banding slows terrestrial migration, because nonbanded trees had a higher proportion of infested leaves than banded trees (0.68 ± 0.04 and 0.52 ± 0.04, respectively), but by the summer sampling there was no difference in leaf infestation between nonbanded and banded trees (Table 1).

Ground-cover experiment

Mite densities (mites g^{-1}) between covers were not significantly different (bare ground, 2.6 ± 0.7; sod, 2.4 ± 0.5; $P = 0.728$), but mite populations developed more quickly (Fig. 3) and reached higher densities in nonbanded (3.4 ± 0.6) compared to banded trees (1.6 ± 0.2; $P = 0.028$). Mite numbers were low in this orchard compared to the other orchards.

Samples taken in March and April from ground-cover plants showed low numbers of mites present. Mites were recovered from vetch, Carolina geranium, henbit, and chickweed, but with densities lower than 1.0 mite g^{-1}. High densities of mites were recovered in summer sampling from seedling peach (31.9), greenbrier (16.3), and horsenettle (13.8). These plants were present

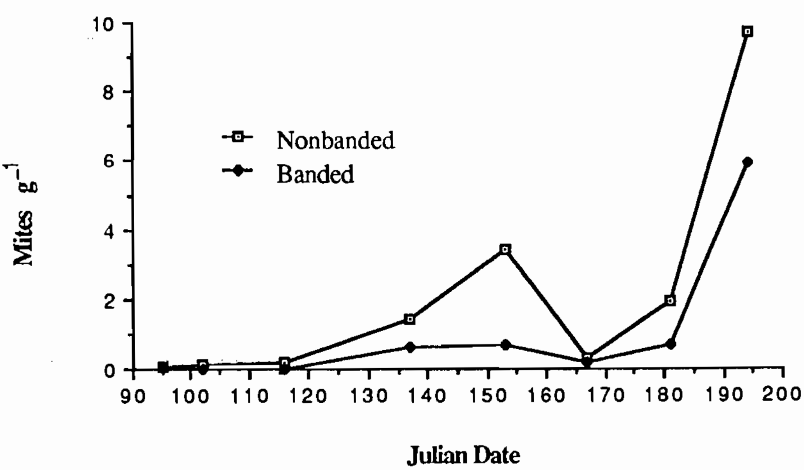

Fig. 3. *T. urticae* population density (mites g^{-1} peach leaves) sampled during early April to mid July, from nonbanded and banded trees, Nash Co., 1988.

in very low frequencies (< 1%), but were sampled because they appeared to have high mite infestations. Additionally, mites were found in lower numbers (from 2.8 to 0.3 mites g^{-1}) on cutleaf evening primrose (*Oenothera laciniata* Hill), white clover (*Trifolium repens* L.), Virginia pepperweed (*Lepidium virginicum* L.), and ragweed (*Ambrosia* sp.).

Herbicide experiment

Spring samples suggested differences among herbicide treatments, and between covers and banding, while summer samples suggested no factor differences (Table 3). Early samples showed that trees from the simazine plot contained more mites (11.6 ± 3.4 g^{-1}) than either the untreated (6.6 ± 1.0) or paraquat (3.3 ± 0.5) plots, but samples taken later in the season had statistically similar mite densities (simazine, 8.9 ± 3.4; untreated, 7.1 ± 1.2; paraquat, 6.4 ± 0.8; Fig. 4). Trees over plots with sod contained more mites (9.5 ± 2.4) than trees over bare ground (4.8 ± 0.6) in spring sampling, but the densities were similar during summer sampling (bare ground, 7.8 ± 0.9; sod, 7.1 ± 1.0). Nonbanded trees contained more mites (10.4 ± 2.2) than banded trees (3.9 ± 0.9) during spring sampling but had comparable numbers during the summer (nonbanded, 8.2 ± 0.9; banded, 6.7 ± 1.0). The spring sampling analysis produced significant herbicide × cover and herbicide × banding interactions due to the comparatively high numbers of mites found in the simazine/nonbanded trees.

Several common orchard plants contained relatively high densities of mites, including narrowleaf vetch, Carolina geranium, henbit, and Virginia pepperweed (Table 4). Vetch, which contained the highest densities of mites, was located in all three treatment plots. Two species of grass, bermuda [*Cynodon*

TABLE 3

Factorial analysis of the herbicide experiment from spring and summer sampling of peach leaves for *T. urticae*, Clayton, NC, 1988

Source of variation	Spring			Summer		
	DF	F-value	$P_r > F$	DF	F-value	$P_r > F$
Treatment	2	11.4	0.0003	2	1.2	0.3060
Cover	1	10.5	0.0035	1	0.3	0.6037
Banding	1	20.2	0.0002	1	1.1	0.2996
Treatment × cover	2	10.4	0.0006	2	0.3	0.7704
Treatment × banding	2	4.3	0.0249	2	2.2	0.1362
Cover × banding	1	2.6	0.1195	1	0.3	0.5759
Treatment × cover × banding	2	2.3	0.1216	2	0.5	0.6025

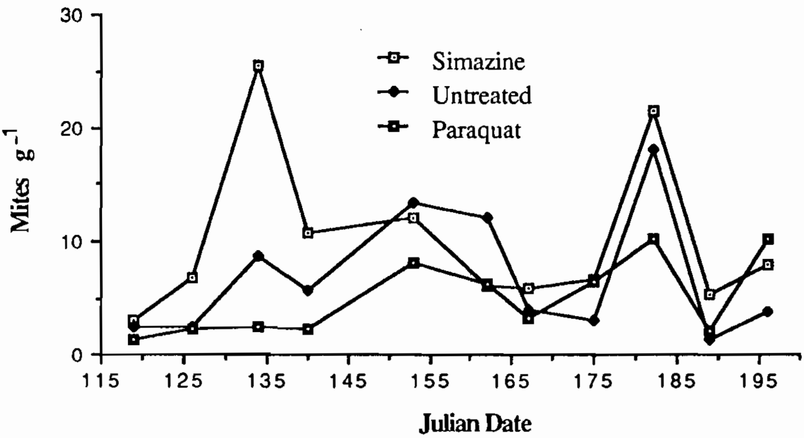

Fig. 4. *T. urticae* population density (mites g^{-1} peach leaves) from three herbicide treatment plots sampled during early March to late May, Clayton, NC, 1988.

TABLE 4

Tetranychus urticae population density (mites $g^{-1} \pm$ SE) from selected ground-cover plants, sampled from early March to late May, in three herbicide treatments plots, Clayton, NC, 1988

Genus	Simazine	Untreated	Paraquat
Vicia	18.4±8.0	27.6±11.5	52.2±11.8
Lamium	3.7±0.7	8.7±2.1	13.0±5.0
Geranium		15.3±3.7	
Lepidium		3.2±1.8	

dactylon (L.) Persoon] and crab [*Digitaria sanguinalis* (L.) Scopoli] contained very low densities of mites (0.2 g^{-1}).

DISCUSSION

Results indicated the importance of orchard-floor vegetation as a base for tree infestation. Tedders et al. (1984) discovered large numbers of mites infesting pecan trees in Georgia by migrating up the trunks from arrowleaf clover. Vetch, another legume, appeared to be a major host for *T. urticae* because orchards or plots that contained high densities eventually had heavy mite infestations. The plots in the Sandhills orchard where vetch grew nearby or as a cover under the trees consistently had the highest infestations. Vetch was also the dominant broadleaf in the simazine plots in Clayton, apparently a common problem with this pre-emergence herbicide (Heeney et al., 1981). Although the other plots also contained vetch, there were other plants available for feeding for a longer period of time, thus delaying migration into the trees. Samples taken in late spring and summer showed no treatment differences, thus once trees in the untreated and paraquat plots became infested, mite populations grew to similar levels.

Data from all three orchards suggest that, during the early season, mites moved into the trees from vetch and other vegetation and populations increased. Brandenburg and Kennedy (1981) found *T. urticae* overwintering on several feral hosts on field edges, including henbit, *Rubus, Trifolium*, and *Viola*, and our data suggests other plants serve as winter and early-spring hosts for *T. urticae*. Trees over bare ground generally contained fewer mites during the early part of the season than trees over a sod cover, due either to lack of a host source, or difficulties in migration. Dispersal into trees may be a result of the negatively geotactic response of nondiapausing females (Hussey and Parr, 1963; Foott, 1965) and the lack of a food source on the orchard floor.

The migration habits of mites have been studied in several crops, but little work has been done in tree fruits. Fleschner et al. (1956), working with citrus, indicated that *T. urticae* migration did not involve ballooning from leaves or aerial drift, as was found with other spider-mite species. Boyle (1957) clarified this further by showing laboratory and field evidence that *T. urticae* was normally disseminated by wind. Recent findings by Brandenburg and Kennedy (1982) and Margolies and Kennedy (1985) describe the cyclic dispersal of *T. urticae* in a corn/peanut agroecosystem. Early dispersal was by crawling from noncultivated hosts to corn in the spring, aerial dispersal from corn to peanut in the summer, and migration terrestrially from peanut to border vegetation in the fall.

From our data, we infer both terrestrial and aerial dispersal of mites from certain ground-cover plants to the peach trees. Low populations of overwintering mites were already on the trees and have been found on twigs and flowers in the early spring (Meagher, unpublished data, 1988). The effect of this population on late-season densities is not known. Banding slowed migration into the trees, but eventually populations reached levels comparable to those in nonbanded trees. Thus aerial dispersal into trees must be a component in *T. urticae* migration, and may be more likely when airblast spayers are used. Once mites get into the trees, the data from the orchard-floor management experiment indicate that they colonize trees by infesting the low-center areas first, and then move vertically up the trunk and eventually into the peripheral areas.

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