FEEDING INJURY TO 'ROBINSON' TANGERINE LEAVES BY *BREVIPALPUS* MITES (ACARI: TENUIPALPIDAE) IN FLORIDA AND EVALUATION OF CHEMICAL CONTROL ON CITRUS

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ABSTRACT

Larvae, nymphs and adults of the false spider mites *Brevipalpus phoenicis* (Geijskes) and *B. obovatus* Donnadieu (Acari: Tenuipalpidae) were found feeding on the ventral surface along the midrib of 'Robinson' tangerine leaves during December 1990. Resinous irregular areas were present in association with the chlorotic midvein areas of injured cells on the lower leaf surface. Similar injury was occasionally evident on some lateral veins in association with the mites. Yellowed, blistered areas were evident on the upper leaf surface opposite the injured areas on the lower leaf. Leaf drop was evident only on trees that were heavily infested with false spider mites. This type of leaf injury by *Brevipalpus* mites has not been previously reported on Florida citrus. Chemical control evaluations showed that AC 303,630 in combination with petroleum oil, pyridaben, fenbutatin-oxide, dicofol or high rates of sulfur provided at least 35 days control. Ethion was less effective and carbaryl failed to control these mites.

Key Words: Tenuipalpidae, injury, false-spider mites.

RESUMEN

En diciembre 1990, se encontraron larvas, ninfas y adultos del acaro falso *Brevipalpus phoenicis* (Geijskes) y *B. ovatus* Donnadieu (Acari: Tenuipalpidae) alimentandose en el envéz de las hojas de mandarina "Robinson". Se observaron areas resinosas irregulares conjuntamente con areas cloroticas en la nervadura central en el envéz. Un daño similar se encontró ocasionalmente en algunas nervaduras secundarias. En el haz se observó, amarillamiento y ampollamiento de las areas afectadas. Se observó defoliación unicamente en aquellos arboles con una gran infestación de acaros falsos. Este tipo de daño no ha sido reportado en cítricos en Florida. Las evaluaciones de control químico demostraron que AC 303,630 en combinación con aceite, pyridaben, fenbutatin-oxide, dicofol o altas dosis de azufre brindaban control por 35 días. Ethion fué menos efectivo y carbaryl no controló estos acaros.

Three species of false spider mites [*Brevipalpus californicus* (Banks), *B. obovatus* Donnadieu, and *B. phoenicis* (Geijskes) (Acari: Tenuipalpidae)] have been collected from citrus in Florida (Denmark 1984). All three species are cosmopolitan and occur on citrus in Asia, Africa, Australia, Europe, the Middle East, South America, and the United States (Jeppson et al. 1975). These mites feed on fruit, stems, branches, and leaves of citrus. On leaves, they are most commonly found on the lower surface near the midrib or veins.

False spider mites are reddish in color, slow moving, and not readily detected because of their small size and sluggish behavior. They are about 260 μm in length (Muma 1961). *Brevipalpus* mites are found on many perennial plants and have relatively long life cycles compared with other phytophagous mite pests, especially on

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citrus. Population levels of these mites tend to increase slowly due to their relatively long life cycle (i.e., 35 days at temperatures between 70 and 85°F) (Manglitz & Cory 1953).

The greatest concern with *Brevipalpus* species on citrus in Florida and elsewhere in the world has been their association with the viral disease, leprosis (Chiavegato et al. 1982). Leprosis and infestations of *B. californicus* very nearly destroyed the citrus industry in Florida before the late 1920's (Knorr et al. 1968). Leprosis was first observed in Florida in the 1860's and ultimately was found in 17 counties that essentially represented the total citrus growing area within Florida at that time. The problem disappeared from Florida citrus in the late 1920's apparently following the widespread usage of sulfur for mite control (Knorr et al. 1968).

Symptoms of leprosis have been reported to occur on fruit, leaves, shoots and large limbs. Chestnut-brown spots from pinhead size to 6 mm in diameter occur on oranges (Knorr 1973). In Florida, this malady has been referred to as nailhead rust (Knorr & Price 1958). Similar lesions occur on both upper and lower leaf surfaces, especially along the margins. Scaly lesions, called scaly bark, grow on the twigs (Knorr & Price 1958).

Chiavegato et al. (1982) conducted transmission studies with the virus causing leprosis and its vector *B. phoenicis*. The causal agent of leprosis is presumed to be a mite-vectored bacilliform virus (Garnsey et al. 1988). Leprosis has been transmitted by larvae of *B. phoenicis* after a 24 h acquisition period but nymphs and adults were less efficient (Chiavegato & Salibe 1984).

According to Knorr (1959), only *B. californicus* has been associated with this disease in Florida. *B. obovatus* has been associated with leprosis in Argentina and Venezuela (Garnsey et al. 1988). *B. phoenicis* is the vector in Brazil (Chiavegato et al. 1982).

Knorr et al. (1968) found foliar and fruit lesions on 'Valencia' orange that were similar in color, size and diameter to those caused by leprosis. However, corresponding lesions on shoots, twigs or branches were not evident. Large populations of *B. californicus* and *B. phoenicis* were associated with a rind spotting of grapefruit in Texas between June and October 1966. The injury was only on fruit and resembled leprosis-like spotting (Dean & Maxwell 1967).

Brevipalpus gall or nodal galling resulted from *B. phoenicis* feeding on citrus seedlings in Venezuela and Florida (Knorr & Denmark 1970). Plants subsequently died since they were unable to leaf out. They further reported leaf drop on sour orange seedlings where *B. phoenicis* occurred in association with the fungus *Elsinoe fawcetti* Bitancourt & Jenkins. Another foliar problem called phoenicis blotch has been reported in association with *B. phoenicis* on Florida citrus. Diffuse chlorotic spotting of foliage in sweet orange trees occurred which resembled early stages of leprosis. However, no gumming of the affected areas occurred (Knorr et al. 1960).

Because little attention has been given to *Brevipalpus* mites in recent years, it is appropriate to review chemical control of these potentially serious pests. These mites have been observed in many citrus groves throughout Florida in conjunction with other research activities (unpub. data). A serious leaf drop problem caused by high populations of *B. phoenicis* and *B. obovatus* was identified in 'Robinson' tangerine. Injury to leaves and subsequent chemical control evaluations are reported in this paper.

Materials and Methods

A 'Robinson' tangerine grove located in Haines City, Polk County, Florida was visited on 28 December 1990. The grower had complained about extensive leaf drop to his 3-year-old trees. Several trees were examined. Only *Brevipalpus* mites were found associated with leaf injury. They were removed for slide mounting in Hoyer's medium (Krantz 1978) and subsequent identification to species. No other arthropods were found on the leaves.

Chemical control of *Brevipalpus* mites was assessed during 1991 and 1992. Both experiments were established in a 'Hamlin' orange grove of 20+-year-old trees in Hardee County that were 2.4 to 3.7 m high with 3 to 4.6 m canopy diameters and infested with moderate numbers of *Brevipalpus* mites. Tree spacing was 3.7 by 8.5 m with 321 trees per hectare. Pesticide treatments were applied dilute in 5,574 liters of water per ha with a handgun using a truck-mounted sprayer at 350 psi on 3 July 1991. The 1992 field experiment was established in the same grove site. Treatments were applied dilute in 7,781 liters of water per ha with a handgun on 1 July 1992.

Experimental miticides included AC 303,630 [4-bromo-2-(4-chlorophenyl)-1-(ethoxymethyl)-5-(trifluoromethyl) pyrrole-3-carbonitrile] (American Cyanamid Corp., Princeton, NJ) formulated as a 24% emulsifiable concentrate (EC) and a 22.5 g per liter (3 lb per gallon) soluble concentrate (SC), pyridaben formulated as 20 and 75% wettable powders (WP) (BASF Corp., Research Triangle Park, NC), and Microthiol sulfur (ELF ATOCHEM Corp., Tifton, GA) was a micronized WP formulation containing 80% sulfur while the other sulfur compound was a 90% WP formulation. The remaining pesticides included FC435-66 petroleum oil (Orchex 796), fenbutatin oxide (= Vendex®), dicofol 4EC, ethion 4EC, and carbaryl 80S that are registered for use on citrus.

Treatments were assigned at random to single tree plots in 1991 and in a randomized complete block design in 1992 and replicated 5 times in both experiments. Each sample tree was a vigorous, healthy tree representative of the block, and each plot was separated from adjacent plots by at least one tree within and between rows.

Forty fruit were picked at random around the perimeter of each sample tree after 42 d post-treatment on 14 August 1991. Each fruit was agitated in a bucket containing 80% ethyl alcohol, detergent, and bleach that was modified by increasing alcohol concentration in a mixture developed by Gilstrap & Browning (1983). The solution from each sample tree was poured into a separate labeled jar, returned to the laboratory, and then poured into a gridded Petri dish and examined using a stereomicroscope. The number of motile *Brevipalpus* mites per sample was counted.

In 1992, 20 fruit per sample tree were washed individually in a bucket containing the alcohol-detergent-bleach solution and vigorously shaken immediately after picking. The solution from each sample tree was poured into a separate labeled jar and returned to the laboratory where the contents were counted as before. Preliminary sampling indicated that this method captured at least 95% of false spider mites on individual fruit. A subsample of 10 to 20 mites from each of 2 or 3 water-sprayed trees was slide-mounted and identified to species from sample dates during both years.

The mite count data in each treatment were subjected to Log_{10} (X + 1) transformations for statistical analysis using PROC ANOVA (SAS Institute 1991). Untransformed counts are presented for comparison in the tables. If the difference between treatments was significant ($P \leq 0.05$), Duncan's (1955) new multiple range test was used to separate treatment means.

RESULTS AND DISCUSSION

Brevipalpus phoenicis and *B. obovatus* were identified from larvae, nymphs and adults collected from the injured 'Robinson' tangerine leaves in Haines City (Fig. 1A and B). Yellow blistered areas on the upper leaf surface occurred along the lengths of most infested leaves. Resinous irregular injured areas were present in association with the chlorotic midvein areas of injured cells on the lower leaf surfaces. No indication of mesophyll collapse (Pratt 1958) was evident. Similar injury was occasion-

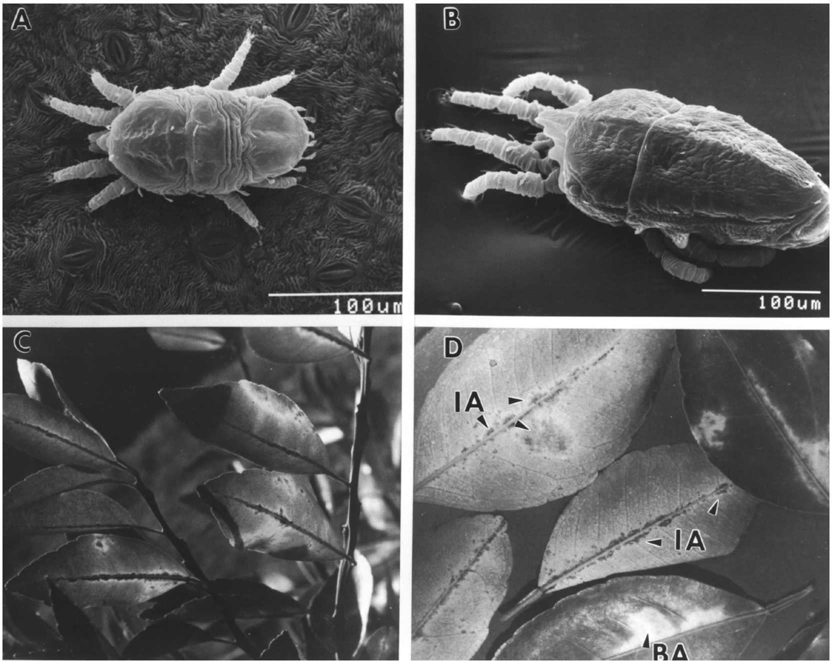

Fig. 1. (A) *Brevipalpus* sp. nymph. (B) *Brevipalpus* sp. adult. (C) Feeding injury caused by *B. phoenicis* and *B. obovatus*. (D) Lower leaf surface feeding injury primarily along the midvein with some lateral vein injured areas (IA) and yellow blistered area (BA) on the upper leaf surface.

ally evident on some lateral veins too. Considerable leaf drop of mite infested leaves was evident (Fig. 1C and D) while adjacent non-infested 'Robinson' trees did not have injured leaves or leaf drop. All of the mites were found on the ventral surface of each infested leaf, mostly along the midvein, with motile numbers often exceeding 50 per leaf. Occasionally, chlorotic or resinous areas between lateral veins on the lower leaf surface were found infested with these mites. Mite infestations were heavier along the four or five rows on the north edge of the grove during December 1990. Leaf drop was confined to these trees. This type of leaf injury by *Brevipalpus* mites has not been previously reported on Florida citrus. None of the types of injury previously described from other countries corresponded to foliar injury and leaf drop reported here.

Three adult *B. phoenicis* and 5 adult *B. obovatus* specimens were identified from a series of 20 prepared slides from the 'Robinson' tangerine trees in 1990. In the 1991 miticide experiment on 'Hamlin' orange, *B. phoenicis* and *B. obovatus* accounted for 68 and 32%, respectively, of the 34 specimen identifications. Slide-mounted specimens identified from subsamples collected between 9 July and 27 August 1992 were 86% (N = 139) *B. phoenicis* and 14% (N = 23) *B. obovatus*. According to Denmark (1984), *B. obovatus* has rarely been found on Florida citrus. *B. phoenicis* was the principal false spider mite observed during this study on both 'Robinson' tangerine and 'Hamlin' orange in Central Florida. *B. californicus* was not recorded during this study.

In 1991, AC 303,630 at both rates, pyridaben 75 WP and dicofol all provided significantly better control compared with the water sprayed trees and Microthiol sulfur after 42 days (Table 1).

TABLE 1. NUMBERS OF *BREVIPALPUS PHOENICIS* (GEIJSKES) AND *B. OBOVATUS* DONNADIEU ON 'HAMLIN' ORANGE FRUIT TREATED ON 3 JULY 1991.

Treatment and Formulation		Rate per 378 Liters	Post-treatment Means of Motile Mites per 40 Fruit[1] 14 Aug +42 d
AC 303,630	24% EC	100 ppm	3.6 c
AC 303,630	24% EC	200 ppm	2.6 c
Pyridaben	20 WP	181 g	8.2 bc
Pyridaben	75 WP	48 g	4.8 c
Dicofol	4 EC	355 ml	1.0 c
Microthiol sulfur	80% WP	1.8 kg	21.8 ab
Water spray	—	—	34.4 a
			F = 6.12, df = 6,28, P = 0.0003

[1]Means within a column followed by the same letter are not significantly different by ANOVA followed by Duncan's NMRT.

In 1992, both rates of AC 303,630 + petroleum oil, fenbutatin-oxide, and both rates of sulfur provided significantly better control of the mites through 35 days post-treatment compared with the other treatments (Table 2). Pyridaben and ethion provided significantly better control of *Brevipalpus* spp. compared with the water-sprayed check trees; carbaryl was ineffective.

The new miticides (i.e., AC 303,630 and pyridaben) were compared against established standards (i.e., sulfur, fenbutatin-oxide, dicofol) for control of *Brevipalpus* mites on Florida citrus.

B. phoenicis has been reported to be susceptible to sulfur, dicofol and chlorobenzilate while organophosphate and carbamate pesticides are ineffective (Jeppson et al. 1975). Results from these studies confirm that carbaryl was ineffective in controlling *Brevipalpus* mites. Ethion showed activity against these mites; however, it was not as effective as AC 303,630, sulfur or fenbutatin-oxide.

Miticide evaluations for control of *B. phoenicis* on tea in Kenya showed that flucythrinate, dicofol, omethoate, dimethoate, and permethrin were also effective. However, significant yield increases were obtained only in the flucythrinate and permethrin treatments (Sudoi 1990). In Brazil, dicofol at 37 g AI per 6 liters of water, clofentezine at 9.45 g AI per 6 liters of water and RU-1000 (an experimental pyrethroid) at 1.76 or 2 g AI per 6 liters of water were effective at least 35 days following treatment in controlling *B. phoenicis* on citrus (Mariconi et al. 1989). Cyhexatin at 20 g AI per 100 liters, binapacryl at 50 g AI per 100 liters and bifenthrin at 5.6 g AI per 100 liters were most effective in controlling *B. phoenicis* on citrus in Brazil (Arashiro et al. 1988).

ENDNOTE

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TABLE 2. NUMBERS OF *BREVIPALPUS PHOENICIS* (GEIJSKES) AND *B. OBOVATUS* DONNADIEU ON 'HAMLIN' ORANGE FRUIT TREATED ON 1 JULY 1992.

Treatment and Formulation		Rate per Hectare	Pre-treatment Means[1] 15 Jun -15 d	Post-treatment Means ± SE of Motile Mites per 20 Fruit[1] 8 Jul +7 d	16 Jul +15 d	24 Jul +23 d	5 Aug +35 d	27 Aug +57 d
AC 303,630	3 SC	100 ppm						
+ Orchex 796 oil	FC 435-66	0.5%	48 ± 12 a	0.8 ± 0.4 cd	0 b	0 c	1.4 ± 0.9 c	0 c
AC 303,630	3 SC	200 ppm						
+ Orchex 796 oil	FC 435-66	0.5%	51 ± 14 a	0.8 ± 0.8 cd	0 b	0 c	1.4 ± 0.9 c	0 c
Carbaryl	80 S	5.6 kg	49 ± 13 a	4.0 ± 0.4 ab	9.8 ± 1.7 a	48.8 ± 12.1 a	49.8 ± 8.2 a	26.8 ± 7.2 a
Fenbutatin-oxide	50 WP	2.2 kg	49 ± 12 a	0 d	0 b	0 c	1.2 ± 0.6 c	7.2 ± 4.4 abc
Pyridaben	75 WP	119 g	62 ± 25 a	3.0 ± 1.8 bc	0.2 ± 0.2 b	0.8 ± 0.8 c	11.4 ± 7.4 b	4.6 ± 4.1 bc
Ethion	4 EC	7 liters	66 ± 29 a	2.0 ± 0.9 bcd	0.8 ± 0.8 b	4.2 ± 2.0 b	4.6 ± 0.8 b	8.6 ± 3.6 ab
Sulfur	90 WP	28 kg	59 ± 24 a	1.4 ± 0.9 cd	0.4 ± 0.4 b	0 c	1.2 ± 0.6 c	1.8 ± 0.8 bc
Sulfur	90 WP	56 kg	45 ± 11 a	0.6 ± 0.4 cd	0 b	0.6 ± 0.6 c	0 c	1.4 ± 1.0 bc
Water spray (check)	—	—	50 ± 10 a	9.6 ± 2.5 a	17.0 ± 5.4 a	44.4 ± 5.6 a	40.8 ± 8.6 a	8.2 ± 4.2 ab
			$P = 0.9999$ $F = 0.05$, df = 8,36	$P = 0.0001$ $F = 5.81$, df = 8,36	$P = 0.0001$ $F = 22.15$, df = 8,36	$P = 0.0001$ $F = 15.71$, df = 8,36	$P = 0.0001$ $F = 11.50$, df = 8,36	$P = 0.0035$ $F = 17.93$, df = 8,36

[1]Means within a column followed by the same letter are not significantly different by ANOVA followed by Duncan's NMRT.

REFERENCES CITED

ARASHIRO, F. Y., A. J. RAIZER, C. A. SUGAHARA, R. MOTA, J. M. SILVA, AND F. A. M. MARICONI. 1988. New field tests for chemical control of the citrus leprosis mite *Brevipalpus phoenicis* (Geijskes, 1939) on orange trees. Anais da Escola Sup. Agric. Luiz de Queiroz 45: 67-78.

CHIAVEGATO, L. G., M. M. MISCHAN, AND M. A. SILVA. 1982. Prejuizos e transmissibilidade de sintomas de leprose pelo acaro *Brevipalpus phoenicis* (Geijskes, 1939) Sayed, 1946 (Acari, Tenuipalpidae) em citros. Cientifica 10: 265-271.

CHIAVEGATO, L. G., AND A. A. SALIBE. 1984. Transmissibility of leprosis symptoms by *Brevipalpus phoenicis* to young citrus plants under laboratory conditions, pp. 218-221 *in* S. M. Garnsey, L. W. Timmer, and J. A. Dodds [eds.] Compendium of citrus diseases. Proc. Conf. Int. Organ. Citrus Virol. 9th. IOCV, Riverside, California.

DEAN, H. A., AND N. P. MAXWELL. 1967. Spotting of grapefruit as associated with false spider mites. Proc. Rio Grande Valley Hort. Soc. 21: 35-45.

DENMARK, H. A. 1984. *Brevipalpus* mites found on Florida citrus (Acarina: Tenuipalpidae). Florida Dept. Agric. & Consumer Serv., Div. Plant Ind. Entomol. Circ. 69.

DUNCAN, D. B. 1955. Multiple range and multiple F test. Biometrics 11: 1-42.

GARNSEY, S. M., C. M. CHAGAS, AND L. G. CHIAVEGATO. 1988. Leprosis and zonate chlorosis, pp. 43-44 *in* J. O. Whiteside, S. M. Garnsey, and L. W. Timmer [eds.] Compendium of citrus diseases. APS Press, The American Phytopathological Society, St. Paul, Minn.

GILSTRAP, F. E., AND H. W. BROWNING. 1983. Sampling predaceous mites associated with citrus. Texas Agric. Exp. Sta. PR-4139. 5 p.

JEPPSON, L. R., H. H. KEIFER, AND E. W. BAKER. 1975. Mites injurious to economic plants. Univ. California Press, Berkeley. 614 p.

KNORR, L. C. 1959. Presenting *Brevipalpus* mites and some questions that they pose. Citrus Mag. 21: 8-12, 20, 22.

KNORR, L. C. 1973. Citrus diseases and disorders, an alphabetized compendium with particular reference to Florida. Univ. Presses of Florida, Gainesville. 163 p.

KNORR, L. C., AND H. A. DENMARK. 1970. Injury to citrus by the mite *Brevipalpus phoenicis*. J. Econ. Entomol. 63: 1996-1998.

KNORR, L. C., H. A. DENMARK, AND H. C. BURNETT. 1968. Occurrence of *Brevipalpus* mites, leprosis, and false leprosis on citrus in Florida. Florida Entomol. 51: 11-17.

KNORR, L. C., AND W. C. PRICE. 1958. Leprosis, pp. 112-114 *in* R. M. Pratt [ed.], Florida guide to citrus insects, diseases and nutritional disorders in color. Agric. Exp. Sta., Gainesville, FL.

KNORR, L. C., B. N. WEBSTER, AND G. MALAGUTI. 1960. Injuries to citrus attributed to *Brevipalpus* mites, including Brevipalpus gall, a newly reported disorder in sour-orange seedlings. FAO Plant Prot. Bull. 8: 141-148.

KRANTZ, G. W. 1978. A manual of acarology. 2nd ed. Oregon State Univ. Book Stores, Inc., Corvallis.

MANGLITZ, G. R., AND E. N. CORY. 1953. Biology of *Brevipalpus australis*. J. Econ. Entomol. 46: 116-119.

MARICONI, F. A. M., R. C. RANGEL, R. HAMAMURA, A. I. CLART, L. F. MESQUITA, M. A. C. CARDOSO, AND E. B. REGITANO. 1989. Citrus leprosis mite *Brevipalpus phoenicis* (Geijskes, 1939): Field test of chemical control. Anais da Escola Sup. Agric. Luiz de Queiroz 46: 473-483.

MUMA, M. H. 1961. Mites associated with citrus in Florida. Florida Agric. Exp. Sta. Bull. 640.

PRATT, R. M. 1958. Florida guide to citrus insects, diseases and nutritional disorders in color. Agric. Exp. Sta., Gainesville, FL.

SAS INSTITUTE. 1991. SAS language and procedures: Usage 2, Version 6, First ed. SAS Institute, Cary, NC.

SUDOI, V. 1990. Evaluation of different acaricides for control of red crevice mite *Brevipalpus phoenicis* Geijskes (Acari: Tenuipalpidae) infesting tea. Trop. Pest Management 36: 349-352.