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Phytophagous mite populations on Tahiti lime, *Citrus latifolia*, under induced drought conditions

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Abstract. In the north-western region of Venezuela, *Phyllocoptruta oleivora, Tetranychus mexicanus* and *Brevipalpus phoenicis* are common plant-feeding mites on leaves, fruits and branches of Tahiti lime, *Citrus latifolia*. The population dynamics of these herbivores are affected by many factors, such as weekly treatments with wettable sulphur, particularly during the wet season, maintenance pruning of plants, irrigation with microsprinklers, induction of water stress by withholding irrigation and biotic and abiotic environmental factors. During October 1994–January 1995, 31 trees in a commercial orchard were sampled weekly in order to describe population fluctuations of plant-feeding mites (mean number of mites per leaf or fruit), before (4 weeks) and after (4 weeks) a period of 6 weeks of drought stress (no irrigation). The population density of *P. oleivora* increased progressively during the last 3 weeks of the irrigation period and reached a maximum of 24 mites per fruit. In contrast, the populations of the other two species, *T. mexicanus* and *B. phoenicis*, remained at the same low density as before the withholding-irrigation period. After 6 weeks without irrigation, only *T. mexicanus* increased, to a high mean value of 11 mites per leaf. The withholding-irrigation practice appears to affect the population size of *P. oleivora* towards the end of this period and that of *T. mexicanus* at the beginning of the re-establishment of the water supply. The highest proportion of trees (32%) was infested by *T. mexicanus* after the withholding-irrigation period, when irrigation was resumed, whereas the highest levels of infestation of trees by *P. oleivora* and *B. phoenicis* were 16 and 10%, respectively, during the last week of the water-stress period. Although factors affecting the dynamics of the mites in the orchard are likely to be complex, irrigation management apparently plays an important role.

Key words: plant-feeding mites, population fluctuation, withholding irrigation, wettable sulphur, *Citrus latifolia*.

Introduction

Phyllocoptruta oleivora is regarded as the most serious pest on fruits, mature leaves and branches of Tahiti lime in Mara Co., Zulia State, Venezuela (Mora and Aragon, 1987; Quiros-Gonzalez, 1996). According to Yothers (1918), Muma (1965), McCoy and Albrigo (1975), Allen (1976, 1978, 1979) and Keifer *et al*. (1982), this species is a key pest of citrus in Florida and in other citrus-growing areas around the world, causing fruit rind russetting resulting in loss in yield and fruit quality. In addition,

Allen (1978), Huan *et al*. (1992) and Yang *et al*. (1994) showed that infestations of *P. oleivora* also affect fruit growth (diameter, weight and nutrient contents) and cause premature fruit drop. The importance of *P. oleivora* is such that efficient lime production in Florida hinges on the rational management of this species, along with that of *Polyphagotarsonemus latus* (Wolfenbarger, 1974; Campbell, 1979; Peña and Baranowski; 1990).

Tetranychus mexicanus mainly causes damage to the undersides of lower, old leaves, although it may also attack young leaves that emerge after pruning when irrigation is resumed. Damaged leaves yellow where the mites have been feeding. *Tetranychus mexicanus* has been reported to feed on *Citrus* species, causing damage to both sides of the leaves (Ochoa *et al*., 1991), but *Brevipalpus phoenicis* prefers the fruits and the undersides of old leaves. The damage is observed as a dark brown coloration on leaf tops and where they feed on the fruit. The latter species is considered important on different citrus species, causing damage in association with other plant-feeding mites, fungi, viruses and insects (Ochoa *et al*., 1991). *Tetranychus mexicanus* and *B. phoenicis* are less important pests in Venezuela. *Tetranychus mexicanus* does not damage fruits and *B. phoenicis* densities on the fruits usually do not reach levels that are sufficiently high to cause economic damage. However, both should be considered in integrated pest management (IPM) programmes in this region as potential pests of Tahiti lime. In some lime groves, *P. oleivora* is currently being controlled with weekly treatments of wettable sulphur (Kumulus®), but no IPM programme has yet been developed that includes all three mite species.

The biotic and abiotic factors that influence the ecology of plant-feeding mites on citrus have received considerable attention (Muma, 1955; Mora, 1987; Mora and Cepero, 1987; Abou-Setta and Childers, 1989; Li *et al*., 1989; Beattie *et al*., 1991). However, some horticultural practices affect the plant phenology and also, indirectly, the biotic components of the citrus system. One such practice, used in *Citrus latifolia* in the north-western region of Venezuela, is to withhold irrigation for a period of 6 weeks during the dry season, after which period irrigation is resumed. This is done to promote new leaf flushes and flowering at the right time, in order to harvest fruits when prices are high on the market. However, the water stress practice may affect the population dynamics of the three phytophagous species.

In this study, preliminary investigations were made on the estimation and variation of the population density and infestation levels of *P. oleivora*, *T. mexicanus* and *B. phoenicis* on Tahiti lime before, during and after a period of withholding irrigation.

Materials and methods

The study was conducted in a 12 ha commercial Tahiti lime orchard, in La Cocuiza, Mara Co., Zulia State, in the north-western part of Venezuela. This is a very dry

tropical zone, with low precipitation, high temperatures and a low relative humidity (Ewel *et al*., 1979). The orchard was a 9-year-old plantation, planted at 4 m × 6 m and divided into 31 plots, each with 144 plants. Another crop grown at the farm is guava, *Psidium guajava*, on which *B. phoenicis* is a key species. As horticultural practices may affect fluctuations in population size of citrus mites, all events that occurred during this study were registered. It should be mentioned that the study was performed in a commercial orchard, where management decisions were made by the owner. The trees were subjected to the following regime: irrigation at the base of each tree with microsprinklers (4 h every 3 days), weekly maintenance pruning of old branches, mechanical (traction engine) cleaning and weeding twice during weeks 13 and 14 of this study and five sulphur (5 kg ha^{-1} each) treatments in the entire orchard as requested by the grower. The sampling period lasted from the last week of October 1994 to the last week of January 1995, in total 14 sampling weeks, with 4 weeks of irrigation, followed by 6 weeks of withholding irrigation and 4 weeks of irrigation again. Thirty-one randomly selected trees, one from each plot, were marked and sampled every week. Five leaves and five medium-sized fruits were taken from various parts of the tree. Young leaves were also sampled and studied for the presence of *T. mexicanus* as soon as new growth of leaves commenced after resumption of irrigation. The samples were placed inside paper and plastic bags and taken to the laboratory in a cool box. Every week, the total number of mobile mites of each species was counted on 155 leaves and 155 fruits under a Leica-Wild 3Z stereomicroscope. Mite species were easily identified, since they belong to different plant-feeding families. The mean number of mites per leaf (for *T. mexicanus* and *B. phoenicis*) and fruit (for *P. oleivora*) per plant were determined in order to record population fluctuations. The proportion (%) of infested plants by each species of mite was derived from the total number of weekly sampled plants.

Results

The population trends of *T. mexicanus, B. phoenicis* and *P. oleivora* are presented in Figure 1. The population density of *T. mexicanus* was very low before and during the withholding of irrigation. Once irrigation was resumed, the population density of this species started to increase and reached a highest density of 11 mites per leaf. The population of *B. phoenicis* remained at a density of approximately four mites per leaf before, during and after the withholding-irrigation period, but, after resumption of irrigation, the density increased to a mean of eight mites per leaf. The population density of *P. oleivora* varied from zero to 29 mites per leaf during and after the withholding-irrigation period. The highest peaks were reached at the end of the drought stress (a mean of almost 24 mites per leaf) and at the end of the 4-weeks period with resumed irrigation (a mean of 29 mites per leaf). It is important to note that after resumption of irrigation, the population of *P. oleivora* decreased to almost

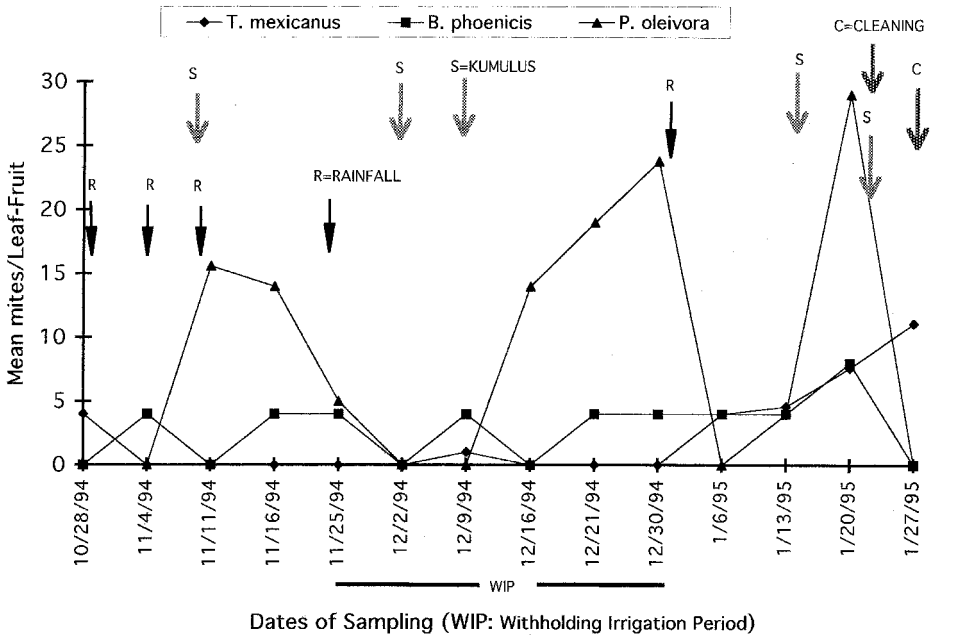

Figure 1. Population fluctuations of three species of mites feeding on Tahiti lime. The days of rainfall (R), the times of sulphur applications (S) and when orchard cleaning (C) (weeding) was carried out are shown.

zero and subsequently increased to a maximum. Figure 2 shows that *T. mexicanus* was found in 32% of the trees after resumption of the irrigation, whereas *B. phoenicis* and *P. oleivora* were found in approximately 10 and 16% of the plants, respectively, towards the last week of the withholding-irrigation period. *Phyllocoptruta oleivora* and *B. phoenicis* peaked before *T. mexicanus*. The sulphur (Kumulus®) applications, the occurrence of rainfall and the cleaning of the orchard are indicated with arrows in Figure 1.

Discussion

Populations of plant-feeding mites may be affected by a range of uncontrolled factors and by agricultural practices. Withholding irrigation is a practice that alters the phenology of the plants and may affect the dynamics of the mite populations. A direct relationship with this practice has not been found in any previous report on citrus. However, Hudson and Beirne (1970), McCoy (1977) and Knapp *et al*. (1982) studied the effect of different kinds of irrigation management on mite populations on apple and citrus. Knapp *et al*. (1982) observed that a higher population of *P. oleivora* consistently occurred in orchards with subcanopy irrigation than in orchards with

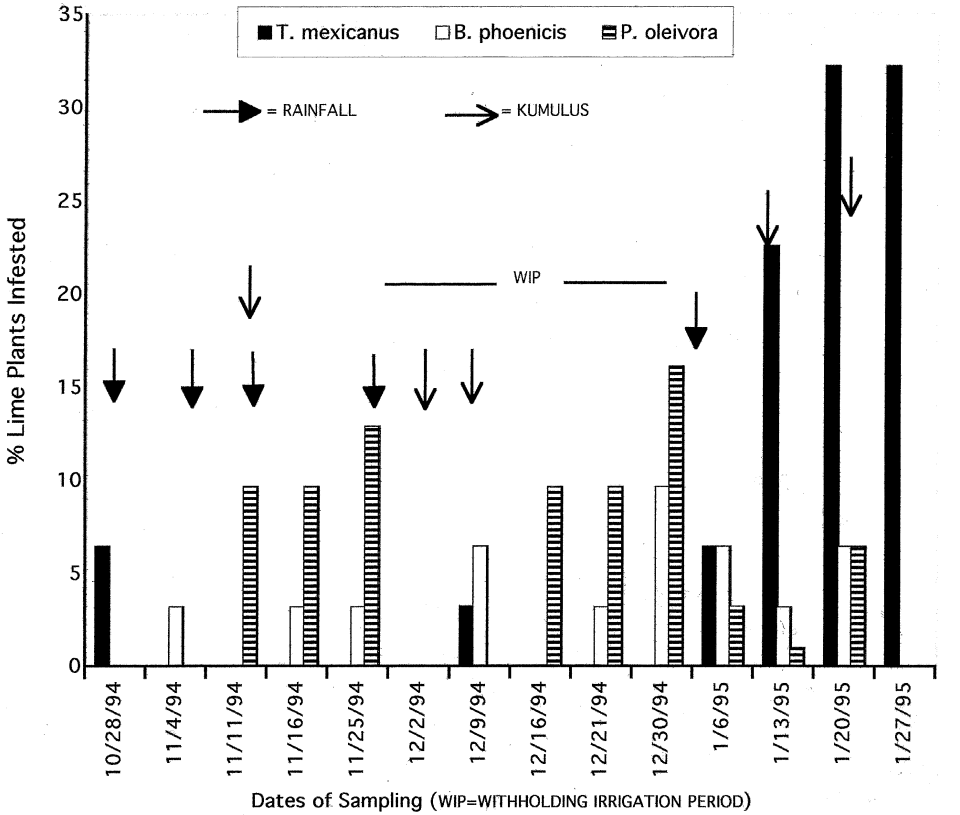

Figure 2. Proportion of lime trees infested by herbivorous mites before, during and after a period of induced drought stress.

overhead irrigation. This is an indication that irrigation management needs to be included in the analysis and management of mite populations. *Tetranychus mexicanus* colonies were observed on the leaves during the entire drought period. This species may increase its reproduction after the new leaves emerge due to the resumption of irrigation. Before this resumption, no young leaves were available for the spider mites. It was noted that the lower leaves were damaged by mites when the plant was exposed to water stress. New leaves formed after resumption of irrigation were immediately infested. *Brevipalpus phoenicis* also responded to the resumption of irrigation, but later than *T. mexicanus*. These data agree with observations by Mora (1987) on the shooting period of Valencia orange trees where a positive effect of the development of new leaves was found on the population growth of *P. oleivora*.

During the last 2 weeks (weeks 13 and 14) of this study the grower cleaned the grove of weeds and removed old and dry branches from the lime plants in order to prepare the trees for a new production peak. The populations of all three mite species

were high in week 13. However, in week 14, only the population density of *T. mexicanus* remained high (abundant new leaves were developing), whereas those of *B. phoenicis* and *P. oleivora* decreased to zero. Weed management and maintenance of green cover crops or weeds may also affect the abundance of phytophagous and predatory mites in citrus. Osburn and Mathis (1944) and Muma (1961) found no difference in citrus rust mite populations in trees in clean, cultivated plots and in trees grown in plots with ground cover plants. However, Gravena *et al*. (1993) observed lower incidences of *P. oleivora* and *B. phoenicis* and higher population densities of phytoseiids in trees with green ground cover than in trees without weeds. Knapp *et al*. (1982) documented the effects of complete and strip herbicide applications in a pineapple orange grove and found significantly higher populations of citrus rust mites on plants with complete herbicide treatment, suggesting that different horticultural practices influence the population dynamics of these plant-feeding mites.

The effect of sulphur applications on the mite populations was variable, even for the same mite species (Figure 1). For example, populations of *P. oleivora* decreased after the first sulphur application during the drought period (16 November 1994), but an increase in population size was noted after the sulphur application during the period when irrigation was practised again (20 January 1995). The grower expects good results from sulphur applications, but this does not always happen because of the complexity of conditions in the orchard.

The different population densities of the species observed during the study reflect the different responses of the species to phenological changes due to the horticultural management methods used. Withholding irrigation for a period followed by the resumption of water supply definitely induces the development of new vegetative and fructiferous shoots, thereby providing the mites with food of higher quality.

Conclusion

It is concluded that the populations of the three mite species studied react differently to the biotic and abiotic factors in the citrus plantation. *Phyllocoptruta oleivora* and *T. mexicanus* appear to respond to the physiological changes in the plants during water stress. The populations of *T. mexicanus* increased when new leaves developed after resumption of irrigation. *Brevipalpus phoenicis* showed a similar but later reaction. *Phyllocoptruta oleivora* showed three peaks in population size, one in each period before, during and after the withholding-irrigation period. The highest percentage of infestation was reached by *T. mexicanus* followed by *P. oleivora* and *B. phoenicis*. The maximum densities of *P. oleivora* and *B. phoenicis* occurred earlier than that of *T. mexicanus*. Further ecological studies are being conducted to reveal the life-history parameters of these mites species in relation to the phenology of the plants and the agronomic management used in the region.

Note

This article is a delayed contribution to the Proceedings of the Third International Symposium on Population Dynamics of Plant-inhabiting Mites (*Exp. Appl. Acarol.* 21(6/7) 1997). This symposium took place in Gilleleje, Denmark, 26–29 June 1995.

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