intermediate categories suggest an acceleration of the increase in drop rate as damage approaches 100%. That is, the categories 0, 1 to 50 and 51 to 75% are relatively close together as compared to 76 to 100% which tends to be considerably above the others (Figs. 24).

Discussion

The data show conclusively that rust mite damage does increase the fruit drop rate in the 3 varieties tested, and it is likely that other varieties would be similarly affected. But what is the economic importance of this phenomenon? Percent fruit drop can be calculated using a formula which has been fitted to the data (2). Using the formula is a cumbersome procedure, however, and probably gives an underestimate of rust mite impact since it is suspected that rust mite damage also reduces fruit size. Recent studies (3, 12) strongly suggest a causal relationship between damage and reduced size. A final analysis then must wait the completion of on-going studies relating fruit growth and drop to rust mite damage.

For the time being, over reaction to these results is unwarranted. The drop tests described in this paper were conducted on select fruit, many of which were heavily damaged and they are not representative of a total grove effect unless all the fruit in the grove is similarly damaged. Calculation of the total grove effect requires that we know what fraction of the fruit falls into each damage category (the frequency distribution). We must then sum the drop for each category to obtain the total effect for the grove. Studies which are currently underway will make such calculations possible. Then the total economic impact of the rust mite can be calculated for any given situation.

Literature Cited


MIGRATION AND DEVELOPMENT OF CITRUS RUST MITE ON THE SPRING FLUSH OF VALENCIA ORANGE*1

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Additional index words.

Abstract. The citrus rust mite, Phyllocoptruta oleivora (Ashmead) appears to migrate to newly formed stem growth and the under surface of leaves near the base of the spring flush in late-March mainly by crawling. Development on spring flush during April is generally slow but more rapid than corresponding development on old (previous year) flush. Initially, mites appear to infest all new flush leaves within a few days. However, most rapid population increase appears to take place on leaves that were first infested. Mites were always well-established on the new flush before they were detected on fruit. Natural enemies of the rust mite were virtually absent from the spring flush from March through May. Data suggest that mite control is not necessary during the dormant period but can be applied in early May to delay mite increase on fruit and foliage.

The citrus rust mite, Phyllocoptruta oleivora (Ashmead) has been an important pest of citrus since the inception of commercial production in Florida (4). The injury caused by the mite is the result of intra-epidermal feeding on fruit and foliage (1, 6). Leaf and stem injury appear as small brownish blots resembling the "russet" condition

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common to immature fruit and will, on occasion, cause premature defoliation (5). Fruit injury appears as different forms of surface discoloration and can affect external fruit quality (1, 8), internal fruit quality (3, 9), fruit growth (8), and rate of fruit drop (2).

The seasonal abundance of the citrus rust mite has been discussed by numerous researchers. Yothers and Mason (11) reported that the most rapid increase in rust mite infestations occurred in May and June with the maximum being reached in late-June or early July. Pratt (10) found that the maximum may extend into late-July or early August and can be correlated with humid weather. Pratt (10) also reported a secondary maximum for November and early January. McCoy et al. (7) found similar results under unsprayed conditions, however, peak densities varied in time and intensity under sprayed conditions.

Although the seasonal abundance of citrus rust mite appears to follow a distinct cycle with 2 peaks; weather, natural enemies, and particularly horticultural practices will cause atypical population fluctuations to the extent that damage may occur any time of the year (7). During February and March, however, mite populations are generally at their lowest seasonal density before migration to the spring flush begins. Virtually no information is available on the migration of citrus rust mite to the spring flush and new fruit nor on subsequent rate of development on old and new flush. Information of this type has practical importance, since production managers must make a decision at this time as to whether to include an acaricide with any fungicides being applied during the dormant and/or postbloom periods. Our purpose in this study was to measure the migration pattern and determine the rate of increase of citrus rust mite and its natural enemies on old and new flush and fruit in the spring in 1978 and 1979.

**Materials and Methods**

Experiments were conducted in a 20-tree plot in 2 mature commercial groves of 'Valencia' orange on rough lemon rootstock near Lake Alfred and Lakeland, Florida. The Lake Alfred grove had a hedgerow tree spacing pattern (15 ft x 30 ft) whereas the Lakeland grove had a wider spacing (25 ft x 30 ft). The Lake Alfred grove received no pest control in 1977-1979 while the Lakeland grove received the conventional 3 sprays per year for pest control.

During the 2nd week in March, migration studies were begun. Two hundred fifty new shoots representing spring flush were selected randomly and flagged among trees in each grove. Each week, 20 of these shoots were randomly selected from 5 trees, clipped at the most recent terminal bud scale scar, and transferred to the laboratory. Immature and adult rust mites were counted on each leaf, each stem segment (stem segment defined as stem between 2 leaf junctions), and fruit beginning with the oldest leaf (base of shoot). Leaves of the new flush were also rated to maturity.

In the Lakeland grove, 50 additional shoots were flagged in early March 1979 before rust mites were present. “Tangle foot” (manufactured by Tanglefoot Co., Grand Rapids, Michigan) was applied at the terminal bud scale scar to serve as a barrier to prevent movement of mites onto new flush. An additional 50 flushes were identified which received no “tangle foot.” Each week, a 50 leaf sample was collected randomly from each treatment and the number of mites per leaf counted in the laboratory using a stereomicroscope.

An estimate of population density of citrus rust mite on new (spring) and old (previous year) flush was determined by counting the number of immature and adult mites on the upper and lower surface of 100 leaves collected weekly on 10 randomly selected trees within each plot. All developmental stages of the mite, recognizable mite cadavers with the fungal pathogen, Hirsutella thompsonii Fisher and predators of the rust mite were identified with a stereomicroscope in the laboratory.

The graph showing rust mite population densities on flushes in time are expressed as “mite days.” These mite-time units were calculated for each data set by taking the sum of the means for 2 consecutive sample dates, dividing by 2, and multiplying by the time in days between the sample dates. Each value was added to a subsequent value thereby producing a cumulative area under the mite population growth curve.

**Results**

Citrus rust mites were observed initially on newly formed stem growth and/or on the undersurface of the leaf near the petiole end of newly expanded leaves. As shown in Figs. 1-4, mites were generally detected on the leaves nearest the base of the new flush in late-March. When mites were prevented from moving to the new flush via the “tangle foot” barrier, detectable populations were delayed by almost 2 weeks indicating that the major means of mite migration is by crawling from the old flush (Table 1). Once established on the new flush, the rust mite appeared to develop slowly on all leaves of the new shoots, however most rapid increase appeared to take place on leaves that were initially infested.

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Fig. 3. Frequency distribution for citrus rust mite population on leaves of new flush from the Lake Alfred grove in the spring, 1978. (Leaf position 1 represents the oldest leaf and asterisk represents date mites first detected on new fruit.)

Fig. 4. Frequency distribution for citrus rust mite population on leaves of new flush from the Lakeland grove in the spring, 1979. (Leaf position 1 represents the oldest leaf and asterisk represents date mites first detected on new fruit.)

Table 1. Comparison of the mean number of citrus rust mites per leaf on shoots with and without "Tangle foot" barrier.

<table>
<thead>
<tr>
<th></th>
<th>4/10</th>
<th>4/19</th>
<th>4/29</th>
<th>5/1</th>
<th>5/11</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tangle foot</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With</td>
<td>0.0</td>
<td>0.0</td>
<td>0.1</td>
<td>0.1</td>
<td>1.1</td>
</tr>
<tr>
<td>Without</td>
<td>0.7</td>
<td>0.5</td>
<td>0.7</td>
<td>18.9</td>
<td>5.0</td>
</tr>
</tbody>
</table>

*Values based on the total number of mites/leaf found on 50 leaves randomly selected from 50 shoots.

Table 2. Comparison of mite days per leaf on old and new flush of Valencia orange on May 1 for 2 groves in 1978 and 1979.

<table>
<thead>
<tr>
<th></th>
<th>Lake Alfred</th>
<th>Lakeland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1978</td>
<td>1979</td>
</tr>
<tr>
<td>Old</td>
<td>3.7</td>
<td>214.6</td>
</tr>
<tr>
<td>New</td>
<td>11.7</td>
<td>777.8</td>
</tr>
</tbody>
</table>

*Values based on 100 leaves randomly collected from 10 trees.

Fig. 5. Mean citrus rust mite population density on leaves of old and new flush expressed as mite days per leaf in 2 groves during the spring of 1978 and 1979.

Table 3. Number of citrus rust mite cadavers infected with Hirsutella thompsonii on old and new flush of Valencia orange for 2 groves in 1978 and 1979.

<table>
<thead>
<tr>
<th></th>
<th>Lake Alfred</th>
<th>Lakeland</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1978</td>
<td>1979</td>
</tr>
<tr>
<td>Old</td>
<td>3</td>
<td>9</td>
</tr>
<tr>
<td>New</td>
<td>0</td>
<td>2</td>
</tr>
</tbody>
</table>

*Totals based on 100 leaves per sample collected randomly each week from 10 trees.

Discussion

Practically speaking, these data suggest that chemical control of citrus rust mite from February thru mid-April is generally unnecessary since citrus rust mite populations develop slowly on all parts of the tree. However, the fact

that populations slowly increase on both old and new flush at this time and generally accelerate in May and June justify chemical control at the time fungicides are applied to fresh market fruit in late-April and early May. Chemical control of citrus rust mite in groves where fruit is to be processed is also justified in view of mite buildup and virtual absence of natural enemies in the spring. If mite populations remain constant in May as occurred in the Lake Alfred grove in 1978, chemical control can be delayed, however a monitoring program would have to be in operation to detect low mite population density. Naturally, justification for a mite monitoring program depends on the characteristics of the grower operation.

Literature Cited


RESULTS OF 5 YEARS' CONTINUED USE OF A B S C ISSION-INDUCING CHEM I CALS ON 'HAMLIN' ORANGES

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Additional index words. Acti-Aid, Pik-Off, Release, Sweep, citrus.

Abstract. Acti-Aid (cydoheximide), Acti-Aid plus Sweep (chlorothalonil), Pik-Off (glyoxal-dioxime), and Release (5-chloro-3-methyl-4-nitro-lH-pyrazole) were sprayed at several rates onto 'Hamlin' (Citrus sinensis (L.) Osb.) orange trees during December, January, and February for 5 years. Fruit quality (as indicated by total soluble solids and acidity), yield, and tree growth were not affected by the abscission-inducing chemicals. Up to 10% defoliation occasionally resulted from sprays, but leaf size and shoot growth were not affected. When applied in February, the chemicals delayed flowering about 1 week in 1976 and 1978. Sweep increased the effectiveness of Acti-Aid in 4 of 5 years when applied in December, but not at other application times. Acti-Aid and Release loosened fruit more consistently than Pik-Off in December. The three sprays were equally effective in January; and Release was the most effective spray in February.

Acti-Aid (cydoheximide), Pik-Off (glyoxal-dioxime), Release (5-chloro-3-methyl-4-nitro-lH-pyrazole) or certain combinations of these sprays are effective citrus fruit looseners and can be used to facilitate mechanical (2, 3, 4, 6, 7) hand harvest (1). Sweep (chlorothalonil) may delay flowering, reduce fruit size and fruit set, and can be used to facilitate mechanical harvest (2, 3, 4, 6) or hand harvest (1). Sweep (chlorothalonil) may be considered as an abscission chemical that is registered for use as an abscission chemical on oranges.

Data presented in most reports are from one season and show the efficiency of the chemicals in lowering the fruit removal force (FRF) or increasing ethylene production and cellulase activity. The only reported information on fruit quality after the applications of abscission chemicals is on 'Valencia' oranges during one season (5), and the effects on yield of 'Valencia' oranges have been reported after mechanical harvest (9). Some defoliation usually occurs after abscission chemical applications (4, 7). Effects of continued low levels of defoliation on fruit quality, yield, and tree growth have not been reported. Other effects of continued use of these abscission-inducing chemicals on fruit quality, yield, tree growth, and consistency of loosening during several seasons are not known. Abscission chemicals cause tissue damage, as shown by defoliation (4) and fruit rind damage (7). An application of these chemicals could be expected to influence flowering, particularly if they are applied close to the bloom period. Other probable effects are a reduction in acidity because of the ethylene produced, a reduction in ratio of soluble solids to acids in juice, and lower juice content because of increased maturation rate.

The objectives of our study were to determine the effects of continued use of Acti-Aid, Pik-Off, Release, and Acti-Aid plus Sweep on quality, yield, and tree growth of 'Hamlin' oranges, and to determine how consistently these chemicals loosen 'Hamlin' oranges during a 5-year period when applied in early, middle, and late periods of the usual harvest season.

Materials and Methods

For these tests, 'Hamlin' (Citrus sinensis (L.) Osb.) 10-year-old orange trees on Carrizo citrange (C. sinensis (L.) Osb. X Pomegranate trifoliata (L.) Raf.) rootstock growing near Lake Butler, Florida, were used. The grove was well irrigated, fertilized, and received adequate pest control measures. Two 2-tome replications were used for each treatment at each application date. Over a 5-year period, the chemicals were applied consistently in December, January,