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2011 Florida Citrus Pest Management Guide: Rust Mites, Spider Mites, and Other Phytophagous Mites[1]

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There are four families of phytophagous mites with species that are of economic importance:

1. Eriophyidae: pink citrus rust mite *(Aculops pelekassi)* and the citrus rust mite (*Phyllocoptruta oleivora)*;

2. Tetranychidae: Texas citrus mite *(Eutetranychus banksi)*, citrus red mite *(Panonychus citri)* and the six-spotted mite *(Eotetranychus sexmaculatus);*

3. Tarsonemidae: broad mite *(Polyphagotarsonemus latus);*

4. Tenuipalpidae: false spider mites *(Brevipalpus californicus, B. obovatus,* and *B. phoenicis).* These three species are not currently considered economic pests on citrus. However, the false spider mites are vectors of citrus leprosis. This serious disease no longer occurs in Florida, but with its recent spread in Latin America there exists increasing risk of reestablishment in Florida.

Citrus Rust Mites

The citrus rust mite (CRM) and the pink citrus rust mite (PCRM) are found on all citrus varieties throughout Florida. Although they can co-exist on the same leaf or fruit, the CRM is usually the prevalent species. However, the PCRM develops to greater damaging populations early in the season (April-May). Both rust mites are important pests of fruit grown for the fresh market. On some specialty varieties (such as Sunburst tangerine), damage may be particularly severe on stems and foliage, causing leaf injury and possible abscission. Fruit damage is the main concern with other varieties. Both mites feed on green stems, leaves and fruit, with the PCRM being potentially more destructive. Both species have four developmental stages during their life cycles: egg, first instar (larva), second instar (nymph), and adult.

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Egg deposition begins within 2 days after the female reaches sexual maturity and continues throughout her life of 14 to 20 days. The female lays one to two spherical transparent eggs (CRM) or transparent flattened eggs (PCRM) per day and as many as 30 during her lifetime. Eggs hatch in about 3 days at 81°F. The newly hatched larva resembles the adult, changing in color from clear to lemon yellow (CRM) or pink (PCRM) after molting to the nymphal stage. After about 2 days at 81°F, molting occurs. The first nymphal stage resembles the larval and requires about 2 days to molt to an adult at the above temperature. The CRM adult has an elongated, wedge-shaped body about three times longer (0.15 mm) than wide. PCRM are narrower, rounded and are smaller than the CRM. CRM usually is straw to yellow in color, whereas the PCRM usually is pink. Color is not always an effective or accurate means of separating the two rust mites. Males and females have an average life span of 6 and 14 days, respectively, at 81°F. In the field, females can live nearly 30 days in the winter. The length of the life cycle from egg to adult is 6 days at 81°F.

PCRM populations can begin to increase in April to early May on new foliage, reaching a peak in mid-June to mid-July, although the time of peak density can vary by several weeks depending on geographical location and weather. PCRM are more abundant in drier weather conditions. CRM population densities increase in May-July and then decline in late August, but can increase again in late October or early November. Mite densities in the fall rarely approach those early in the summer. During the summer, CRM are more abundant on fruit and foliage on the outer margins of the tree canopy. Generally, the north bottom of the tree canopy is preferred and supports the highest mite populations. The least favorable conditions for CRM increase are found in the south top of the tree canopy.

Visible characteristics of injury differ according to variety and fruit maturity. When rust mite injury occurs on fruit during exponential growth, before fruit maturity (April to September), epidermal cells are destroyed resulting in smaller fruit. Early season rust mite injury is called "russeting." Rust mite injury to mature fruit (after September) differs significantly from early "russeting." Unlike "russeting" on fruit, fall damaged fruit will polish, since the natural cuticle and wax layer remain intact. This condition is known as "bronzing." While the primary effect of fruit damage caused by rust mites appears to be a reduction in grade, other conditions have been associated with severe fruit injury that include reduced size, increased water loss, and increased drop.

Leaf injury caused by feeding of CRM exhibits many symptoms on the upper or lower leaf epidermis. When injury is severe, the upper cuticle can lose its glossy character, taking on a dull, bronze-like color, and/or exhibit patchy yellowish cells in areas of "russeting" that have been degreened by ethylene release during the wounding process. Lower leaf surfaces often show "mesophyll collapse" appearing first as yellow degreened patches (collapsed spongy mesophyll cells) and later as necrotic spots. With the exception of upper leaf epidermal injury to some specialty varieties, such as Ambersweet, Fallglo, and Sunburst, defoliation caused by CRM is rarely severe.

Leaf injury caused by feeding of PCRM is dramatic at mite densities exceeding 200 or more per leaf. Both mature and developing leaves can be affected with varying degrees of leaf distortion, curling under of leaf margins, crinkling of leaf tissues, and ultimate burn and leaf dieback occurring. PCRM feeds on the lower leaf surfaces following its movement from overwintering sites on buds in the early spring. Later PCRM populations begin moving onto fruit and then back to leaves as the mite migrates or disperses and then declines.

The need for chemical treatments to control rust mites is dictated by numerous biological attributes of the mites, marketing objectives for the fruit, and horticultural practices. These key biological factors include: 1) inherent ability of mites to quickly increase to injurious densities on fruit and sustain the potential for reproductive increase over time; and 2) small size, which makes it difficult to monitor population densities in the field and detect injurious levels until visible injury has occurred on the fruit. The marketing objective for fruit is particularly important. Cosmetic appearance is a priority for fruit grown for the fresh market. Fruit growth and

abscission are not affected until 50 to 75% of the surface has been injured. Thus, there is reduced justification for chemical control of rust mites on fruit grown for processing. Citrus groves producing fruit designated for the fresh market may receive three or four miticides per year typically during April, June, August, and October. In contrast, groves producing fruit designated for processing receive zero to two treatments per year. Miticides applied for the control of rust mites on fresh fruit varieties are often combined with compatible fungicides in the spring and summer. An alternative approach is using FC 435-66, FC 455-88, or 470 petroleum oil as a fungicide for greasy spot control and to suppress pest mites.

From a horticultural perspective, canopy density has an effect on rust mite populations and their ability to increase over a short period of time. The denser the canopy, the less favorable conditions are for a rapid rust mite increase. Since most registered miticides have no ovicidal activity and short residual activity on fruit and foliage, residual control is generally better if the miticide is applied when rust mite adult and egg population densities are low for fresh market varieties.

Since external blemishes caused by rust mites, fungal diseases, and wind are less important when fruit are grown for processing, the chemical control strategy for rust mites can be modified significantly. A summer spray is often required for greasy spot control. Use of petroleum oil in place of copper will reduce the likelihood of requiring a subsequent miticide treatment. Further miticide treatment may be unnecessary. However, a second petroleum oil application may be required for greasy spot control on summer flush.

Many scientific methods for sampling or scouting rust mite populations have been described. Of these, three general approaches are in widespread use: 1) determining the percentage of fruit and/or leaves infested with rust mites; 2) qualitative rating scales; and 3) individual adult mite counts taken from fruit on randomly selected trees. These sampling approaches are similar in that they are designed to avoid bias by randomly selecting different representative areas within a grove for sampling, avoiding border rows, and selecting fruit and/or leaves within a tree randomly.

One sampling method based on rust mite density (rust mites/square centimeter - cm^2) is described.

Processed Fruit: Initiate rust mite monitoring for PCRM in early April on leaves and fruit through casual observations and continue every 2 to 3 weeks throughout the fruit season. CRM will tend to develop later in the spring or summer. Select trees at random and within uniformly distributed areas throughout a 10- to 40-acre block representing a single variety with uniform horticultural practices. Avoid sampling adjacent trees. Fruit should be sampled at random representing the four quadrants of the tree and taken midway in the canopy (between interior and exterior). One fruit surface area should be examined midway between the sun and shade areas. The number of rust mites per cm^2 should be recorded and averaged for the 10 acres, represented by 20 trees with four fruit per tree or 80 readings per 10 acres. Six rust mites/cm^2 would be a planning threshold where pesticide intervention may be required within 10 to 14 days. Ten rust mites/cm^2 would be an action threshold where treatment would be required as soon as possible.

Fresh Fruit: Similar to above except monitor every 10 to 14 days with an average of 2 CRM/cm^2 as an action threshold.

Spider Mites

There are three species of spider mites that are potential pests on Florida citrus: Texas citrus mite, citrus red mite, and six-spotted mite. The Texas citrus mite is the predominant species in most groves throughout the state. The citrus red mite is usually second in abundance, but in some grove and nursery operations it is the predominant species. The Texas citrus and citrus red mites occur on citrus throughout the year and usually are most abundant in groves between March and June. They are found most commonly on the upper leaf surface of recently mature flush, and all stages of the mites orient along the mid-vein. As populations increase, they move to leaf margins and fruit.

The six-spotted mite is a sporadic pest occurring in colonies on the lower leaf surface and tends to be more abundant following cold winters, especially during December. Usually localized populations of this mite can be recognized by characteristic yellow blistering on mature leaves between March and May. Populations decline rapidly in June and remain very low through the remainder of the year.

Spider mites feed primarily on mature leaves and differ from rust mites by feeding beneath the epidermal layer of cells. They are capable of removing cellular contents, causing cell destruction and reducing photosynthesis. Mesophyll collapse and leaf drop can result when trees are stressed by high spider mite infestations alone or in combination with sustained dry, windy conditions that may occur in the late fall, winter or early spring months. When populations of Texas citrus mite or citrus red mites are high, they will also feed on developing fruit. Spider mites prefer dry weather and low relative humidities in the range of 30 to 60% and generally do not pose a sustained problem in the higher humidity conditions that occur between June and September.

Populations of Texas citrus and citrus red mites aggregate among leaves within and between citrus trees. A sampling method has been developed that provides 25% or less error margins when motile mite densities (i.e. all stages except eggs) are above 2/leaf.

The sample unit is a mature leaf immediately behind flush leaves. Figure 1 shows the optimum number of sample areas within a 10-acre block of orange trees when using 1, 5, or 10 trees per area and collecting either 4 or 8 leaves per tree. For example, if you look at 1 tree/acre, then it is necessary to look at over 10 sample areas within a 10-acre block to achieve accuracy. If you examine 5 or 10 trees/area, then only 4 or 5 areas need to be examined. As mite densities increase above 2/leaf, the optimal number of sample areas declines below 5. Table 1 provides examples of different sample sizes at different control thresholds.

When the control threshold is increased from 5 to 10 mites/leaf, there are corresponding reductions in the amount of sampling required within a 1- or 10-acre block. At weekly or biweekly intervals during periods of spider mite activity, collect either one leaf

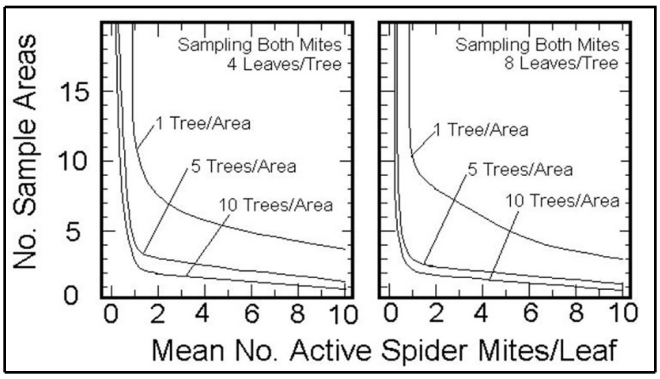

Figure 1. Optimum number of sample areas/10 acres.

per quadrant (i.e., N, S, E, W) (4 leaves/tree) on each tree per sample area or two leaves per quadrant (8 leaves/tree). Sampling consistency is important since spider mite numbers can increase on one quadrant of a tree. Place leaves from individual trees into labeled paper bags and then into a cold ice chest for examination under a stereomicroscope OR examine individual leaves in the field with a stereomicroscope or 10X hand lens. If one motile stage of a Texas citrus or citrus red mite is present on either the upper or lower leaf surface, then the leaf is infested. A good relationship was found between the average number of Texas citrus mites or citrus red mites and the percentage of leaves infested across 10-acre blocks of young orange trees. For example, an average of 5 motile spider mites/leaf equaled 70 to 80% infestation levels. This constitutes a treatment threshold for processing fruit.

Spider mites are suppressed to low densities by several species of predacious mites, insects, and entomopathogens in some groves. However, when populations averaging 5 to 10 motile spider mites per leaf develop between September and May, it would be reasonable to apply a miticide, especially if the trees are stressed. However, infestations comprised predominantly of adults, particularly males, are in decline and would not require control. Adult mites are recognized by their large size relative to immatures and females distinguished by their round shape and shorter legs compared to males.

Need for controlling spider mites is based on temperature and humidity conditions, spider mite population levels, tree vigor, and time of the year. Petroleum oil provides some ovicidal activity against spider mite eggs. None of the other miticides provide ovicidal activity, and their residual activity must be

sufficiently long-lasting to kill subsequently emerging larvae.

Broad Mites

The broad mite is an economic problem on citrus grown in green- or shade-house conditions and on lemons and limes grown in the field. The mite is whitish in color, very small, about 160 microns in length. The mite is found on the lower surfaces of young apical leaves where its eggs are deposited. The life cycle is modified with an emerging larval stage lasting about one day and then molting. Pharate females (developing nymphs) are picked up by the males and moved to newly developing flush and young citrus fruit. Mating occurs immediately after the female emerges. Males are very active and live for about one week.

The broad mite is only capable of feeding on very young, tender leaf or fruit tissues. The toxic saliva that is injected by this mite can result in significant damage. New leaf growth that is fed upon becomes distorted and feathered. A delayed terminal die-back can occur on infested citrus seedlings. Subsequent development of damaged buds can result in a rosette and formation of a witches' broom. Small fruit become silvered from intense feeding by the mite with subsequent reduced fruit growth.

Optimal environmental conditions include warm temperatures, high humidity, and low light intensity. Adults can survive through prolonged exposure to freezing temperatures, but are sensitive to temperatures greater than 90°F.

Application of Miticides

Selection of a miticide should be based on the target pests to be controlled, avoiding risks of phytotoxicity, products that will be tank mixed, the time of year, treatment to harvest interval, and prior use of a product. All miticides except petroleum oil should be used only once a year to minimize resistance development. Selection of those time intervals are provided in Table 2. For example, dicofol can be effectively used for spider mite or rust mite control during the supplemental early spring or postbloom intervals. The product is most effective when applied at **ONE** of these times. Conversely, Comite would be recommended in the fall **or** supplemental late fall intervals. Vendex is effective in one of the following four periods: supplemental spring, postbloom, fall, **or** supplemental fall periods. Petroleum oil spray applications can be effectively applied during the postbloom, summer, or fall intervals. Sulfur is included since it has a short treatment to harvest interval and provides a highly effective means of cleaning up rust mite infestations prior to harvest when needed. Use of sulfur should be minimized given its toxic effects on several beneficial arthropods.

Recommended Chemical Controls

READ THE LABEL.

See Table 3.

Rates for pesticides are given as the maximum amount required to treat mature citrus trees unless otherwise noted. To treat smaller trees with commercial application equipment including handguns, mix the per acre rate for mature trees in 250 gallons of water. Calibrate and arrange nozzles to deliver thorough distribution and treat as many acres as this volume of spray allows.

TO MINIMIZE RISK OF RESISTANCE, DO NOT APPLY A SPECIFIC MITICIDE MORE THAN ONCE PER ACRE PER SEASON OTHER THAN PETROLEUM OIL.

Table 1. Control Thresholds and Appropriate Sample Sizes for 10 Acres

If the control threshold is:	**Sample size** (Sample trees should be uniformly scattered across a 10-acre block. Do not sample adjacent trees.)
5 mites/leaf	Examine 4 leaves/tree from 6 trees/area from 4 areas/10 acres = 96 leaves on 24 trees/10 acres
8 mites/leaf	Examine 4 leaves/tree from 6 trees/area from 3 areas/10 acres = 72 leaves on 18 trees/10 acres
10 mites/leaf	Examine 4 leaves/tree from 5 trees/area from 2 areas/10 acres = 40 leaves on 10 trees/10 acres
15 mites/leaf	Examine 4 leaves/tree from 4 trees/area from 2 areas/10 acres = 32 leaves on 8 trees/10 acres

Table 2. Citrus Miticide Selection[1]

Supplemental (early Spring)	Post Bloom	Summer	Fall	Supplemental Fall
--	--	Agri-mek + oil	--	--
--	--	--	Comite	Comite
Dicofol	Dicofol	--	--	--
Envidor	Envidor	Envidor	Envidor	Envidor
--	Petroleum oil	Petroleum oil	Petroleum oil	--
--	--	--	Sulfur	Sulfur
--	--	Micromite	Micromite	--
--	--	--	Nexter	Nexter
Temik	--	--	--	--
Vendex	Vendex	--	Vendex	Vendex

[1]Except for petroleum oil, do not use the same miticide chemistry more than once a year.

Table 3. Recommended Chemical Controls for Mites

Pesticide	IRAC MOA[1]	Mature Trees Rate/Acre[2]	Comments	Pests Controlled
Agri-Mek 0.15 EC + Petroleum Oil 97+% (FC 435-66, FC 455-88 or 470 oil)	6	5 to 10 fl oz + min of 3 gal	Restricted use pesticide. Do not apply any petroleum oil products when temperatures exceed 94°F. Do not apply Agri-mek or any other abamectin containing product within 30 days of last treatment. Do not apply more than 40 fl oz/A of Agri-mek or any other abamectin containing product in any growing season. Do not make more than 3 applications of Agri-mek or any other abamectin containing product in any growing season.	Rust mites Broad mites Citrus leafminer

Table 3. Recommended Chemical Controls for Mites

Pesticide	IRAC MOA[1]	Mature Trees Rate/Acre[2]	Comments	Pests Controlled
Comite 6.55 EC	12C	3 pt	Leaf distortion and/or fruit spotting may occur when used in the spring or if tank mixed with oil or applied within 2 weeks prior to or following an oil application. Do not use in spray solution above pH 10.	Rust mites Spider mites
Envidor 2 SC	23	13 to 20 oz	Limit to one application per season. Use 20 oz rate if tank mixing with oil. Tank mixing with oil results in reduced residual activity.	Rust mites Spider mites
Kelthane MF	UN	6 pt	Applicators must be in an approved cab or cockpit. Citrus rust mites are tolerant to Kelthane in some groves following repeated applications. Do not use in spray solutions above pH 7.	Rust mites Spider mites
Micromite 80WGS	15	6.25 oz	Restricted use pesticide. See restriction on the label.	Rust mites Root weevils Citrus leafminer
Movento 240 SC + Petroleum Oil 97+% (FC 435-66, FC 455-88 or 470 oil)	23	10 oz/A + 3% V/V	Limit of 20 oz of product (0.32 lb ai) per acre per season. Do not apply within 10 days prior to bloom, during bloom, or until petal fall is complete. Movento has a similar mode of action as Envidor; do not make back-to-back applications of these two products.	Asian citrus psyllid Some scale insects
Nexter 75 WP	21	6.6 oz	Tank mixing with oil or copper results in reduced residual activity.	Spider mites False spider mites Rust mites
Petroleum Oil 97+% (FC 435-66, FC 455-88 or 470 oil)	NR[3]	2% v/v	Do not apply when temperatures exceed 94°F. 470 weight oil has not been evaluated for effects on fruit coloring or ripening. These oils are more likely to be phytotoxic than lighter oils.	Rust mites Scales Whiteflies Spider mites Greasy spot Sooty mold
Sulfur Kumulus 80 DF Microthiol 80 DF Thiolux 80 DF Wettable powder or dust	NR[3]	 15 lb 15 lb 15 lb 50 lb	Limit to one application per season where supplemental rust mite control is needed between main sprays. Do not combine with oil or apply within 3 weeks of oil as fruit burn may result. May cause eye irritation to applicators and fruit harvesters.	Rust mites Broad mites (Kumulus, Thiolux and Microthiol only)
Temik 15 G	1A	33 lb	Restricted use pesticide. Notification of intent to apply is required. Application permitted only between Nov. 15 and Apr. 30. See label for application restrictions. When psyllid control is required, apply at least 30 days prior to anticipated flush.	Rust mites Citrus nematode Aphids Whiteflies Psyllids
Vendex 50 WP	12B	2 lb	Restricted use pesticide. Tank mixing with oil or copper results in reduced residual activity. Do not apply at rates greater than 20 oz/500 gal to fruit less than one inch in diameter within 10 days of an oil spray.	Rust mites Spider mites

Table 3. Recommended Chemical Controls for Mites

Pesticide	IRAC MOA[1]	Mature Trees Rate/Acre[2]	Comments	Pests Controlled
[1]Mode of action class for citrus pesticides from the Insecticide Resistance Action Committee (IRAC) mode of action classification V4.2.1 (2005). Refer to ENY-624, Pesticide Resistance and Resistance Management, in the 2011 Citrus Pest Management Guide for more details. [2]Lower rates may be used on smaller trees. Do not use less than minimum label rate. [3]No resistance potential exists for these products.				