2019–2020 Florida Citrus Production Guide: Rust Mites, Spider Mites, and Other Phytophagous Mites[1]

Jawwad Qureshi and Phil A. Stansly[2]

Mites from four families known to feed on plants commonly colonize citrus. These include 1) two citrus rust mite species in the family Eriophyidae: citrus rust mite *Phyllocoptruta oleivora* and the pink citrus rust mite *Aculops pelekassi*; 2) three species of spider mites in the family Tetranychidae: Texas citrus mite *Eutetranychus banksi*, citrus red mite *Panonychus citri* and the six-spotted mite *Eotetranychus sexmaculatus*; 3) one species in the family Tarsonemidae: broad mite *Polyphagotarsonemus latus*; and 4) three species of false spider mites in the family Tenuipalpidae: *Brevipalpus californicus*, *B. obovatus*, and *B. phoenicis*. These three species in the fourth group are associated with the spread of the disease called leprosis. This disease no longer occurs in Florida but increasing risk of reestablishment in Florida exists with its recent spread in Latin America. Currently, rust mites, spider mites, and broad mites are common and cause economic damage to commercially grown citrus in the state.

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 coexist 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.

Each of the two species go through four developmental stages during their life cycle: egg, first instar (larva), second instar (nymph), and adult. 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.

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2. Jawwad Qureshi, assistant professor, UF/IFAS Indian River Research and Education Center; and Phil A. Stansly, professor (deceased), Entomology and Nematology Department, UF/IFAS Southwest Florida REC; UF/IFAS Extension, Gainesville, FL 32611.

PCRM are narrower, smaller and rounded. CRM is usually straw to yellow in color, whereas the PCRM is usually pink, but 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 mite 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. These destroyed epidermal cells fracture as the fruit enlarges, causing a rough form of russeting known as sharkskin. Mature fruit maintains intact epidermal cells and a wax layer to take a polished look referred to as "bronzing." Fruit damage by rust mites affects the appearance and reduces grade initially but may also lead to reduced size, increased water loss, and increased drop under severe infestation.

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 patches of yellowish discoloration where wounded epidermal cells have released ethylene. Damage to lower leaf surfaces results in collapse of spongy mesophyll cells, appearing first as yellow degreened patches and later as necrotic spots. With the exception of upper leaf epidermal injury to some specialty varieties, such as Ambesweet, 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 ultimately burn and leaf dieback. PCRM feeds on the lower leaf surfaces following its movement from overwintering sites on buds in the early spring. Later populations move onto fruit and then back to leaves as the mites migrate or disperse, and then decline.

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.

The need for chemical treatments to control rust mites is dictated by numerous biological attributes of the mites, horticultural practices and marketing objectives for the fruit. 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 both 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.

Spider Mites

Three species of spider mites 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 are usually 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. Table 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 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 are 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 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 and very small—about 160 microns in length. It 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 dieback 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. With the current emphasis on Asian citrus psyllid and citrus leafminer control, it would be wise to choose a miticide that may also have some activity against one of these two pests, such as diflubenzuron (Micromite 80 WGS) or spirotetramat (Movento). Separate chapters of this production guide address Asian citrus psyllid and citrus leafminer management. With the exception of petroleum oil, no miticide should be applied more than once per year to avoid development of resistance. Time intervals for application of products to target mites are provided in Table 2. Some products are listed for more than one time interval to indicate that they can be effective in providing mite control during those times, but use is allowed only once per year. 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

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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.*

Supplemental (early Spring)	Post Bloom	Summer	Fall	Supplemental Fall
--	--	Agri-mek + oil	--	--
Apta	Apta	--	Apta	Apta
--	--	--	Comite	Comite
Envidor	Envidor	Envidor	Envidor	Envidor
--	Petroleum oil	Petroleum oil	Petroleum oil	--
--	--	--	Sulfur	Sulfur
--	--	Micromite	Micromite	--
--	--	--	Nexter	Nexter
Movento	Movento	Movento	--	--
Vendex	Vendex	--	Vendex	Vendex
*Except for petroleum oil, do not use the same miticide chemistry more than once a year.				

Table 3. Recommended chemical controls for mites.

IRAC MOA[1]	Pesticide Trade name	Rate/ Acre[2]	Comments	Pests controlled
6	**Abamectin**			
	Agri-Mek 0.15 EC + Petroleum Oil 97+% (FC 435-66, FC 455- 88 or 470 oil)	5 to 10 fl oz + min of 3 gal	Always apply with a minimum of 1 gal horticultural mineral oil 97+% (FC 435-66, FC 455- 88, or 470 oil). Do not apply any abamectin-containing product, (1) within 30 days of last treatment, (2) more than 3 times in any one growing season, or (3) more than 0/47 lb A.I./ac in a growing season. Do not apply in citrus nurseries.	**Rust mites, broad mites**, citrus leafminer, Asian citrus psyllids at higher rates.
12B	**Fenbutatin-oxide**			
	Vendex 50 WP	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**
12C	**Propargite**			
	Comite 6.55 EC	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**
15	**Diflubenzuron**			
	Micromite 80 WGS	6.25 oz	Do not apply more than 3 applications per season. See restrictions on label. Do not apply when temperatures exceed 94°F. Recommended to apply with 2% horticultural mineral oil.	**Rust mites**, citrus root weevils, Asian citrus psyllids
21	**Pyridaben**			
	Nexter 75 WP	6.6 oz	Tank-mixing with oil or copper results in reduced residual activity.	**Spider mites**, false spider mites, rust mites
21A	**Tolfenpyrad**			
	Apta	14–27 fl oz	Do not apply by air. Do not apply more than 27 oz/acre per growing season. Do not make more than 2 applications per year. Allow at least 14 days between applications.	**Citrus rust mite, spider mites (higher rates)**, Asian citrus psyllids
23	**Spirodiclofen**			
	Envidor 2 SC	13–20 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**
	Spirotetramat		Limit of 0.32 lb A.I./ac per 12 months. Minimum interval of 21 days between applications.	
	Movento 240	10 fl oz	Do not make more than one application during primary citrus bloom period. Recommended to be applied in 2% horticultural mineral oil.	**Citrus rust mites**, Asian citrus psyllid nymphs, aphids, mealy-bugs, scale insects, whiteflies
	Movento MPC	16 fl oz	Do not apply within 10 days prior to bloom, during bloom, or until petal fall is complete. Recommended to be applied in 2% horticultural mineral oil.	

IRAC MOA[1]	Pesticide Trade name	Rate/ Acre[2]	Comments	Pests controlled
Unk[3]	Petroleum Oil 97+% (FC 435-66, FC 455-88 or 470 oil)	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, spider mites**, scales, whiteflies, greasy spot, sooty mold
	Sulfur		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)
	Kumulus 80 DF	15 lb		
	Microthiol 80 DF	15 lb		
	Thiolux 80 DF	15 lb		
	Wettable powder or dust	50 lb		

[1] Mode of action class for citrus pesticides from the Insecticide Resistance Action Committee (IRAC) Mode of Action Classification V.8.4 (2018).
[2] Lower rates may be used on smaller trees. Do not use less than the minimum label rate.
[3] Mode of action unknown.