Mite Control and Integrated Pest Management: Treenut, Pome, Grape, and Strawberry Crops

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I. Introduction and Definitions

Mites are small arthropods in the class *Arachnida* and the subclass *Acari*. Although they are related to insects, mites are in the arachnid class and are closely related to spiders and ticks. They are common pests in agriculture, landscapes, and gardens.

Webspinning mites, belonging to the Tetranychid family of mites, are the most common of the mite pests found in agricultural habitats. They feed on fruit and nut trees, cotton, vines, berries, and vegetables, as well as field crops and ornamentals. Webspinning spider mites are named for the silk webbing they produce on leaves.

Mite species are estimated to number nearly 50,000. They live in diverse habitats; in soil, water or plant matter. They eat living and dead plant material as well as fungi, lichens, and even carrion. Some are parasites on animals and others feed on mold. Mites can aid in the decomposition and mixing of organic matter.

Primary plant pests are the webspinning spider mites, thread-footed mites, and gall mites.
This course will focus on the mites that threaten nut trees, pome fruit, grape, strawberry, tomato, and citrus crops.

**Identification**

Without magnification, spider mites appear to be tiny, moving dots. The largest mites, adult females, are less than 1/20\textsuperscript{th} inch long. A 10X hand lens makes seeing them much easier.

Adults have an oval body with two red eyespots near the head end and are eight-legged. Females often have large, dark spots on each side of their body and their legs and bodies are covered with bristles. Immature specimens are smaller than adults but similar in appearance. Larvae have six legs when newly hatched. When laid, eggs are translucent spheres and look like tiny droplets. They darken in color to a creamy shade before they hatch.

Hundreds of individual mites form colonies, often found on the undersurface of leaves. The characteristic webbing produced by webspinning spider mites helps distinguish them from other mite species and small insects such as aphids and thrips which also invade leaf undersides.

The Pacific spider mite, the twospotted spider mite, and strawberry spider mite are the most common of the webspinning spider mites.

**Life Cycle**

Spider mites may feed and reproduce all year on plants that remain green all winter in temperate climates. On deciduous trees and in colder habitats, webspinning spider mites overwinter under rough bark scales and in ground litter and debris. The overwintering mites are red or orange, mated females that begin feeding and laying their eggs when temperatures warm up again in the spring.
Webspinning spider mites prefer hot and dusty conditions. Plants under water stress are particularly vulnerable. Mites are most easily first discovered on plants and trees near roadways or the edges of orchards and gardens.

They reproduce rapidly in warm to hot temperatures and are at their peak populations June through September. Under the right conditions (food supply and temperature) a generation can complete its lifecycle in a week.

As the mite feeding decreases plant foliage quantity and quality, the females scatter to other plants via wind currents. In extreme defoliation conditions, they will go into hibernating phase and move off the plant.

In late summer, as temperatures cool and host plant conditions become inhospitable, the mite population may decline rapidly. Rain and predators are also factors in this decrease.

**Damage**

Mite damage is exacerbated by water stress. A small mite population may not warrant action, but large numbers of mites can cause damage warranting control measures. Mites suck cell content from leaves which first exhibits as a light stippling of dots. The leaves may appear
bronze in color. As mites continue to feed, the leaves turn yellowish or reddish and fall off. Webbing that covers the leaves, twigs, and fruit is visible.

Some mite damage—loss of leaves—may not affect crop yield during the year they infest (unless infestation and damage occurs in spring and/or early summer), but may affect the following year’s yield, although losses have not been fully documented. Leaf loss can lead to sunburned fruit. Other damage, particularly from webspinning spider mites, may more directly affect fruit.
II. General IPM Guidelines

Integrated Pest Management (IPM) is a complex process but it forms the very foundation of pest management. IPM protects the environment and society, reduces pest resistance to pesticides, and provides economically viable crop protection.

When synthetic pesticides became widely available after World War II, California entomologists developed a concept they called supervised insect control. Instead of calendar-based pesticide application, supervised control was based on regularly monitoring pests and their natural enemy populations. Then the best mix of chemical and biological controls is used for pest management. Chemicals are to be applied in a manner and with the methods that are least disruptive to biological control.

IPM was formalized in the 1970s and became public policy in the United States in February 1972. In 1979, an interagency IPM Coordinating Committee was formed to oversee the development and implementation of IPM practices.

The Federal Definition of IPM includes:

- Selection, integration, and implementation of pest control based on predicted economic, ecological, and sociological consequences.
- A comprehensive approach to pest control that uses combined means to reduce the status of pests to tolerable levels while maintaining a quality environment.
- The optimization of pest control in an economically and ecologically sound manner, accomplished by the coordinated use of multiple tactics to assure stable crop production and to maintain pest damage below the economic injury level while minimizing risks to man and the environment.
- A sustainable approach to manage pests by combining biological, cultural, physical and chemical tools in a way that minimizes economic, health and environmental risks. (From the National Coalition on IPM.)

IPM programs have grown from being purely insect management strategies to encompass disease and weed control. IPM incorporates principles and practices of heedful environmental conservation.

IPM Goals

Increased farm profitability is the primary goal of IPM. This is achieved by:

- Preventing and/or avoiding pest problems before economic loss occurs
• Reducing expenses by eliminating unnecessary management practices
• Improving efficiency by adopting better chemical application practices
• Minimizing risk to surface and ground water and air quality
• Minimizing the development of pesticide resistance

Implementing IPM

These principles and practices include:

**Plant resistance**: Plant varieties with intrinsic resistance to pests are the best option.

**Cultural Practices**: Many cultural practices will reduce environmental stresses that may lead to disease and pest issues. These include plant selection and placement, watering practices, nutrient management (fertilizers), soil, and region adaptability.

**Scouting and Monitoring**: This single principle may be the most important in implementing a successful IPM program. Regularly walking the field for scouting and monitoring purposes aids in detecting pests and diseases as early as possible and helps determine the extent of an infestation. Chemical and biological controls are more difficult to implement if the insect issues have been intensifying.

**Biological Control**: This basic practice of IPM is often underestimated in importance. When considering the best IPM program, attention should be paid to the natural enemy and predator of the targeted pest. This includes organisms such as parasites, pathogens (nematodes, fungi, bacteria, viruses, and other microbes), and predators.

**Knowing the Economic Injury Level (EIL) and Economic Threshold (ET) or Action Threshold (AT)**: The EIL is the pest population level that will cause economic damage to the infested crop or the critical population density where the loss caused by the pest is equal, monetarily, to the cost of management. The ET is the point at which management action should be taken in order to prevent an increasing pest population from exceeding the economic injury level. The ET will always represent a pest density (or level of pest damage) that is lower than the EIL.

**Water Management**: Intermittent irrigation, runoff recapture, and other water management practices are important considerations of Best Management Practices (BMPs). The goal is to minimize the risk of surface or groundwater contamination.

**Physical/Mechanical Practices**: Physically hoeing and cultivating are excellent and economical alternatives to applying pesticides as are tillage and mulching.
**Regulatory:** Keeping pests out of commercial nurseries is vital. New plant material should be inspected often and thoroughly. This is the simplest and easiest way to prevent pest infestation within a landscape system.

**Pesticides:** In IPM, pesticides are recommended to prevent significant economic damage to the crop. Pesticides should be used in combination with other management tools.

**The best IPM strategy** includes planned preventative measures. IPM is not practiced in isolation of other management practices. It is one component along with physical, biological, and nutritional practices.

Evaluation of the IPM program is critical. In evaluating the efficacy of the IPM program, consider the following:

- Did the measures provide adequate pest control?
- Were there unforeseen side effects?
- What can be done differently in the future to combat this pest?
- Does the IPM program need to be altered to provide better pest suppression?
- Were the suppression measures implemented in a timely and legal manner?
- Were good notes taken to reference in future years?

Knowing the steps taken and the results helps the manager to determine if the IPM program needs to be altered before the action threshold is reached again.
III. Mite Control in Nut Orchards

Almonds

Several mite species infest almond orchards but the trees can tolerate moderate mite populations without significant economic impact. Be sure to consider predator populations before choosing and applying treatments. Orchards with a high ratio of predator to pest may not require treatment.

Brown Mite (*Bryobia rubrioculus*)

Description

The brown mite is the largest of the almond pest mites. Its eggs are laid singly. They are red and without a stalk. They overwinter as eggs on twigs, in masses, most often found at the junction of wood growth from the two preceding seasons. Brown mites are the first of the pest mites to hatch in the spring, concurrently with leaf and bud opening.
Newly hatched brown mites are actually red and have six legs. At first they feed on buds, later on leaves. After the first molt, they become brown and have eight legs, and then resemble the adult which is flattened with long front legs. The first set of legs is longer than the other three pairs.

Mites feed only during the morning and evening, the cool parts of the day. They then migrate off the leaf during the warm midday. Brown mites are inactive during the hotter parts of the summer season. They reproduce from February to June, two to three generations during those months. Females lay up to about 30 eggs during their life span.

**Damage**

Brown mites are not considered major pests in almonds. In fact, a low to moderate brown mite population is considered beneficial by providing a food source for mite predators.

The biggest threat posed by brown mites is chlorosis, although infestations are usually confined to a few trees and the leaves rarely drop.

**Management**

Annual spur samples (spurs are the short shoots which contain the flower buds) should be taken to decide if there is a need to treat the orchard for brown mites.

**Sampling:**

- Sample between mid-November and mid-January, during the dormant season.
- Select 35 to 50 trees at random from each orchard or plot.
- Randomly choose two to three spurs from the inside of each tree’s canopy near the main scaffold.
- Clip off at the base, being sure to include some old spur wood along with the past season’s growth.
- Select a total of 100 random samples of spurs from 50 trees.
- Use a hand lens or binocular microscope to examine 20 spurs. Note the presence of mite eggs. Counting the number of eggs is not needed.

**Treatment Thresholds**

If no mites were found in the first twenty examined spurs, there is no treatment needed and you may stop examining the samples. If mites were found in the first twenty samples, continue checking the other samples. If mites are found on 20% or more of the samples, treatment is needed.
**Treatment Decisions**

Brown mites are best controlled by delayed-dormant or spring applications of narrow-range oil sprays.

Narrow range oils kill on contact with smothering and barrier effects so complete coverage is necessary. Oil alone controls moderate infestations. Be sure to cover all parts of the tree, but do not apply to water-stressed trees to avoid phytotoxicity.

During a cool spring, it is possible to have an early infestation, indicating the dormant treatments were possibly applied too early in the fall. It is also possible that the rate of oil was either inadequate or coverage was poor.

*Nealta* ® miticide supplies residual mite control at all life stages with a unique mode of action not found in other miticides. Cyflumetofen is the active ingredient and has proven highly effective against mites that have developed resistance to other acaricides. Cyflumetofen is also compatible with predatory mites and beneficial insects. It offers a short pre-harvest interval, application flexibility, and tank-mix compatibility.

Additionally, Abamectin is a popular pesticide that mites ingest while feeding. Abamectin is applied to the leaves prior to leaf hardening. In the lower San Joaquin Valley, this occurs around the first of June, and is slightly later in the season as you move north.

**Biological Control**

It is essential to avoid using insecticides that are also toxic to brown mite predators. Certain pesticides, chiefly pyrethroids used during the dormant season, leave residues that negatively affect predators. The western predatory mite and brown lacewing are considered effective predators so care should be exercised that any chemical control be non-toxic to them.

**European Red Mite (*Panonychus ulmi*)**

European red mite (*Panonychus ulmi*) eggs are red and have a slender stalk that rises from the center. The mites overwinter as eggs at the base of buds and small branch spurs, or in wounds, or bark cracks. The newly hatched mites are green, but turn red with feeding. They have white spots at the base of large hairs on the back. European Red Mites have five to ten generations each year.

**Damage**

The European red mite can be beneficial at low levels of infestation because they serve as a food source for mite predators. They usually do not increase to a harmful level and their population declines in the hotter summer months.
European Red Mites feeding causes leaf stippling. If allowed to continue, the feeding causes leaves to become pale and appear bronzed and burns at the tips and margins. If the trees are not stressed for water, they can withstand a fairly high infestation level for a prolonged period of time. High infestation is considered more than 50 mites per leaf.

However, if the trees are stressed for water, moderate to high infestation can cause defoliation.

Management

As noted above, natural predators usually keep the European red mite population below injurious levels and in fact, the European red mites are an important food source for predators, particularly in the early season.

Management programs should include monitoring for European red mite throughout the growing season. After taking a dormant spur sample, if it is determined that treatment is needed, the best option is a dormant application of oil spray.

Biological Control

Both the western predatory mite and the brown lacewing (*Hemerobius* sp.) feed on European red mites. The western predatory mite feeds on both immature- and adult-stage mites, but isn’t highly effective because it is unable to break through the European red mite’s egg shell. The brown lacewing is a more effective predator, but its presence in orchards is not to be relied on.

Monitoring and Treatment Decisions

Annual spur samples during the dormant season should be taken to decide if there is a need to treat the orchard for European red mites.

Spurs are the short shoots which contain the flower buds.

Sampling:

- Sample between mid-November and mid-January, during the dormant season.
- Select 35 to 50 trees at random from each orchard or plot.
- Randomly choose two to three spurs from the inside of each tree’s canopy near the main scaffold.
- Clip off at the base, being sure to include some old spur wood along with the past season’s growth.
- Select a total of 100 random samples.
- Use a hand lens or binocular microscope to examine 20 spurs. Note the presence of mite eggs. Counting the number of eggs is not needed.
If 20% of the sampled spurs have mite eggs, a delayed dormant oil spray is recommended.

During the growing season, orchards should be monitored weekly for mites. Because European red mite populations rarely reach damaging levels, there are no treatment thresholds established.

Delayed dormant spray applications are more effective because the eggs are nearer to hatching. Be sure to cover all parts of the tree. Oil only will control low to moderate infestations. Do not use oil sprays on water-stressed trees.

For spring applications, do not apply on water-stressed trees. Narrow range oils should be applied to trees that have been well-watered to avoid phytotoxicity. The mode of action is contact (smothering and barrier effects), so good coverage is vital.

**Webspinning Spider Mites**

**Pacific Spider Mite** (*Tetranychus pacificus*)

**Two Spotted Spider Mite** (*Tetranychus urticae*)

**Strawberry Spider Mite** (*Tetranychus turkestani*)

Webspinning mites, also called spider mites, are the most common of the mite pests. Species include the Pacific spider mite, the twospotted spider mite, and the strawberry spider mite. There are several other species, but this course will focus on these three as the most pervasive mite pests in almonds. The other common species can’t be reliably identified and distinguished in the field. The damage they cause, their biology, and their management are all the same as the Pacific spider mite, the twospotted spider mite, and the strawberry spider mite.
Description

Webspinning spider mites get their names from the silk webbing most species produce on infested leaves. Spider mites live predominantly on the undersides of leaves, in colonies. Webbing present on the leaves is the easiest way to isolate spider mites as opposed to thrips and aphids which also infest leaf undersides.

Eggs are translucent spheres, turning a cream color before hatching. When newly hatched, the larvae have six legs only.

Twospotted spider mite eggs are laid on leaf undersides, and are tiny, about 0.14 mm (1/180 inch) in diameter. Like the eggs of other spider mites, twospotted mite eggs are clear and colorless when laid and become creamy or white prior to hatching. The adult males, reproductive adult females, and nymphs are usually yellow or greenish and are oval. They have one or more dark spots on each side of their body while the top of the abdomen is spot-free.

The adult female twospotted spider mites may cease reproduction when cold weather arrives. Diapause is indicated when their color changes to bright orange.
Without a 10X hand lens, spider mites appear to be tiny moving dots. They are easily seen with the lens though. Adults have an oval body with eight legs and two red eyespots near the head. Females are the largest forms and are less than 1/20th of an inch long. The female also has a large dark blotch on each side of the body and many bristles that cover the legs and body. Immature specimens are much smaller, but otherwise resemble the adult.

On deciduous trees and in colder climates, spider mites overwinter as red or orange mated females. The mites burrow under rough bark scales and in ground litter and debris. They begin feeding and laying eggs again when the weather warms up in the spring. In parts of California and warmer areas, the mites may feed and reproduce all year long on green leaves, including during the winter months.

Spider mites prefer hot and dusty conditions and usually infiltrate orchards beginning on trees or plants that are near or adjacent to dusty roadways or at the margins of the orchard. In hot weather, spider mites reproduce rapidly and are most numerous between June and September. A generation can be concluded in less than a week, given favorable temperatures and food supplies.
On heavily infected plants, as the leaf quality declines, females catch wind currents and scatter to other plants. Trees under water stress are particularly susceptible to infestations.

In the late summer, mite populations may decrease due to predator numbers surpassing them, host tree/plant conditions grow unfavorable, and cooler weather.

Damage

Mites suck the contents of cells from leaves. A low population of mites is not cause for concern, but high populations can greatly affect plants and trees. Water stressed trees are particularly susceptible to mite damage.

The damage first exhibits as a stippling of light dots on the leaves. The leaves may take on a bronze color. If the feeding continues, the leaves turn reddish or yellowish and fall off. Large amounts of webbing will often cover the leaves, twigs, and fruit.

Leaf loss won’t cause heavy yield losses in the first year of infestation, unless it happens in spring or very early summer. However, the following year’s crop will be greatly impacted.
Management

Water-stressed trees are most susceptible to spider mite damage, so be sure trees are well-watered.

Avoid the use of broad-spectrum insecticides that are used on other pests because they often cause mite outbreaks. Water, insecticidal oils, and/or soaps may be used for management purposes.

Spider mite populations are often limited by their natural predators.

Monitoring of mite levels is recommended before implementing treatment for spider mites.

Monitoring

Stippled or yellow leaves are often the signal that you have mites. The mites are extremely small and difficult to spot. The mites will sometimes be gone by the time their damage is noticeable.

The underside of leaves is the first place to check for a mite infestation. Their eggs or webbing will be the first noticeable symptom. Use a hand lens to examine the leaf, then shake off some of the mites from the leaf surface, onto a sheet of white paper. After they’ve been disturbed, the mites will move freely around the paper.

Be certain of the presence of mites before you begin treatment. Trees will often recover after the mites have been dealt with.

Biological Control

Predatory mites are one of the most important weapons in the biological control arsenal. Many natural enemies target spider mites, which limits their populations in many non-agricultural setting such as landscapes and gardens.
The predatory mites are approximately the same size as the tree-feeding mites, but the predatory mites have longer legs and are more active. Their form is also more teardrop in shape than most spider mites. These are most often found along the mid-vein on the leaf underside.

Purchasing and releasing predatory mites can be beneficial in establishing the presence of a natural enemy of the spider mite in an orchard. However, better results may be achieved by maintaining environmental conditions conducive to the naturally occurring predators. This may include such things as avoiding dusty conditions and broad spectrum insecticide sprays.

The western predatory mite (*Galendromus occidentalis*) and the predatory mite (*Phytoseiulus persimilis*) are the major predators that are available commercially. Neither predator feeds on foliage and do not become pests, therefore, if a pest mite population is not present when the predators are released, they may migrate somewhere else, or starve. The western predatory mite is favored by hot and dry conditions.
Cyflumetofen miticide is an effective option against spider mites. It offers excellent results and has long residual activity against all mite life stages. Trial results show it is practically non-toxic to beneficial arthropods.

You can also use cyflumetofen to lower the level of pest mites and then release the predatory mites. One predator for every 10 spider mites is the usual guideline.

Insecticidal soaps and oils may be considered also. They are least toxic to people, non-target organisms, and the environment, as well as often being effective against mites.

**Cultural Control**

Dust and dusty conditions may lead to mite infestations. Water applied to dusty areas (particularly roads) at regular intervals and sufficient irrigation will help the orchard tolerate some spider mite damage.

Washing trees with water at midseason may help prevent mite infestations later in the season. Be sure the leaf undersides are well covered with the water.
Pistachios

Webspinning spider mites

Twospotted spider mite (*Tetranychus urticae*)

Pacific spider mite (*Tetranychus pacificus*)

Description

Both the twospotted spider mite and the Pacific spider mite overwinter as reddish-orange mature females. They prefer protected places on the trees, in the soil, and in decomposing leaf litter on the ground. When the weather warms in the spring, the overwintered females begin feeding on pistachio leaves and orchard ground cover. When the adult twospotted spider mite is actively feeding, it has a dark spot on each side of its body. Pacific spider mites have another pair of dark spots near its posterior end. Unfortunately for identification purposes, the second spots are often barely visible or may merge to dark areas, making positive identification a challenge.
As in almonds, spider mite colonies develop on leaf undersides and then, as their numbers increase, they may be found on the upper sides of the leaves.

Eggs are translucent spheres when laid and become pearly white or opaque prior to hatching. Spider mites are very small, 1.3 mm long (less than 1/20 inch). The immature mite molts three times as it matures into an adult. First stage mites have six legs, adults have eight legs.

Given favorable temperatures and a food supply, a spider mite generation can be concluded in seven days. They reproduce in warm weather and their population numbers are quite high in June and July.

**Damage**

Damage caused by both the Pacific spider mite and the twospotted mite appears at first as a loss of foliage color. As the mites continue to feed, the leaves will develop small, necrotic spots with webbing.

The webbing will contain all life stages of the spider mites. In pistachio trees, mite levels as low as three or four per leaflet may cause defoliation. The first sign of an increased mite population is often clusters of brown leaves. Early season defoliation will reduce nut yield and quality. Later season defoliation means harvest will be hampered due to layers of leaves on the ground that slow the drying of the ground crop.

As in almond orchards, water stressed trees are more susceptible to spider mite damage. Pistachio orchards with more alkaline soils are more prone to spider mite issues. Severe infestations exhibit acute defoliation and a shriveled crop.

**Management**

Spider mites in pistachio orchards are usually managed by their predator species. When there are no to low levels of predators, perhaps due to the use of broad-spectrum pesticides, or in water-stressed trees, spider mite populations may grow to damaging levels. Maintaining healthy trees and judicious use of pesticides often controls spider mites sufficiently.

**Biological Control**

The most vital predators of spider mites in pistachios are sixspotted thrips (*Scolothrips sexmaculatus*). Given the slow growth of spider mite populations in pistachios, thrips alone often provide effective control. The spider mite destroyer (*Stethorus picipes*) and minute pirate bugs (*Orius* spp. and *Anthocoris* spp.) are other predators.

**Cultural Control**

Mite problems can be lessened by maintaining excellent orchard management practices.

- Keep dusty conditions to a minimum.
- Don’t allow your trees to become stressed for water.
Avoid pesticides that threaten the spider mite’s natural predators, such as pyrethroids, organophosphates, and carbamates, at least until later in the season.

**Monitoring and Treatment Decisions**

Pistachio orchards should be monitored from June through August. Check for the presence of both spider mites and their predators.

If mites are discovered, reexamine the leaves in a week and take another sample to ascertain if the population is growing, decreasing, or maintaining the same level.

Predators usually keep the spider mites in check, but if an infestation is severe enough to cause defoliation or leaf stippling, treatment decisions should be made.

Cyflumetofen is an excellent choice for spider mite control, since it is not harmful to the beneficials.
IV. Mite Control in Pome Orchards

Brown Mite (*Bryobia rubrioculus*)

**Description**

Brown mites were described in the almond section. Refer there for a detailed description of the adult brown mite as well as its egg and larval stages.

**Damage**

**Pears:** The brown mite is not a major pear pest but on unsprayed trees it may be the dominant mite. The mite feeds on pear tree foliage and damage manifests as a stippled appearance due to chlorophyll loss, similar to the damage caused by leafhopper feeding. Leaves do not usually turn brown and defoliation is not a result of brown mite damage. Damage is usually on leaves closest to spurs and twigs since brown mites spend most of the day on wood in those areas. Red mite damage does not usually affect the fruit.
**Apples:** Brown mite in apples has been all but extinguished in the last few decades. A few orchards in Washington state reported a few mite occurrences in the early 2000s. Although not a threat to apple orchards, brown mite continues to be a nuisance in pears.

**Management**

The first mites to appear in the spring are usually brown mites. A minimal brown mite population is considered beneficial as they provide a food source for mite predators, keeping the predators nearby so they will continue to feed later in the season as the more damaging mites emerge. Oil treatment during dormancy is usually all that’s needed to keep the brown mites below a damaging threshold.

**Biological Control**

Brown mite predators include brown lacewings, green lacewings, minute pirate bugs, sixspotted thrips, and the spider mite destroyer lady beetle. Biological control of brown mites is not as consistent as it is in other mite species.

**Monitoring and Treatment Decisions**

Brown mite monitoring guidelines have yet to be established in California. Entomologists in other geographic locations recommend monitoring the first generation, remembering that brown mites congregate on the twigs, so samples should include buds, leaves, and twigs. Later generations may be sampled on leaf undersides.

Dormant or very early foliage season treatments of narrow range oils are most effective.

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**European Red Mite**

**Description**

The European Red Mite was described in the Nut Section. Please refer there for a full description.

**Damage in Pome Orchards**

European red mite feeding causes mottling and stippling of the leaves and they become lighter in color. Prolonged feeding causes bronzing. Mite burn occurs in high temperatures, even after the pest has been controlled. Mite burn is characterized by the leaf blade, or portions of it, turning brown and dry.

**Management**

Dormant oil treatments and predators usually keep mite populations below damaging levels.

**Biological Control**
Oil treatments during the dormant season are usually effective. Predators are the preferred control measure during growing season. The major European red mite predators include green lacewings, brown lacewings, minute pirate bugs, and the predatory mite Zetella mali.

**Cultural Control**

Reduce dusty roads and conditions inside and alongside orchards.

**Monitoring and Treatment**

During dormancy, apply a dormant or delayed-dormant oil spray. To sample, collect 100 fruit spurs, one from eye level and one from the treetop, from 50 trees in a 20-acre block. Examine the bases of buds and spurs. If more than 10% of the spurs are infested, continue to monitor during the growing season. If infestation levels are below 10%, European red mite is not likely to be a threat.

Sample after egg hatch, from finger bud to petal fall, by examining 100 flower clusters, one from eye level and one from the treetop of 50 trees. If more than five clusters are infected, treat immediately with oil. If more than 10 are infested, add a miticide to the oil. If between 5 and 10 clusters are infested, adding oil to the first spray for coddling moth may be all that’s needed for European red mite control.

In late spring, infestations may begin in the tops or bottoms of the tree canopy. Sample 20 trees. Take two samples from each; a spur or shoot sample from the top and a shoot sample from eye level. Examine five leaves per shoot. If less than 10% of the samples are infected, treatment is not needed. If 10-50 mites are found, treat with oil. If more than 50 mites are present, treat with oil and miticide.

Continue to monitor during the summer when checking for twospotted spider mites and pear psylla. Examine five leaves from 20 top shoots. If only European red mite is present, the same thresholds apply as late spring treatments. If spider mites are also found, follow thresholds for the spider mites.

At harvest time and post-harvest, sample again. Treatment thresholds are 50 to 150 mites per 100 leaves from bottom or eye level samples, and 50 to 200 mites per 100 leaves from top samples.

**Webspinning Spider Mites**

Pacific Spider Mite (*Tetranychus pacificus*)

Twospotted Spider Mite (*Tetranychus urticae*)

Strawberry Spider Mite (*Tetranychus turkestani*)

McDaniel Spider Mite (*Tetranychus mcdanieli*)

**Description**
Webspinning spider mites were described in the almond section. Refer there for detailed descriptions of the Pacific spider mite, the twospotted spider mite, and the strawberry spider mite.

Another webspinning spider mite of concern to pear growers is the McDaniel spider mite. Adult females have a broad oval shape with multiple pairs of spots. Some of the spots are always in the posterior portion of the abdomen. This helps distinguish it from the twospotted spider mite which has only two spots.

**Damage in Pome Orchards**

Feeding spider mites cause pear leaves to blacken. Pear trees have a fairly low tolerance for mite damage. As few as two to three mites feeding near a leaf midrib produce black areas from the midrib to the margin. The blackening can continue to spread even after control measures have been applied, especially in warmer temperatures. High mite levels can defoliate a tree and severe defoliation can stunt fruit growth. Defoliation can also cause trees to bloom in the fall, and so reduce the following year’s crop.

**Management**

Webspinning spider mites reach their highest population levels during summer. Dusty conditions and water-stressed trees are particularly susceptible. If the presence of predators is high enough, additional treatment may not be needed. Orchards using codling moth mating disruption may find that that manages their mite issues.

Gravenstein and Yellow Newtown apple varieties seem to tolerate low to moderate spider mite populations. Red Delicious, Golden Delicious, Rome Beauty, and Jonathans are more vulnerable to mite damage.

**Biological Control**

The primary webspinning spider mite predator is the western predatory mite (*Galendromus occidentalis*). For the predators to maintain control of the leaf-feeding mites, a ratio of one predator to 10 pests is necessary. The western predatory mite is best suited for biological control in orchards sprayed with oil added to codling moth sprays.

The western predatory mite feeds on other mites at all stages of growth, including eggs. They are available commercially.

With food sources available to the predacious mites, they will increase enough to control the webspinning mite population.

**Cultural Control**

Cover crops and sprinkler irrigation help reduce dusty conditions and are therefore appropriate for an IPM mite program. Maintain the cover crop’s irrigation to entice the webspinning mites to remain in the crop and off the fruit trees. Tall grasses and broadleaf weeds provide more
shelter for the mites than low-growing grasses. Clover is an excellent option for cover crops. Mowing or applying herbicides to the cover crop should be managed so that mites do not migrate to the trees, i.e. don’t mow too short or allow the crop to get too dry.

**Monitoring and Treatment**

When **pears** turn down, begin sampling for webspinning spider mites.

The recommended procedure:

- Collect 5 spur leaves from eye level from one scaffold branch from each of 20 marked trees that have been established as representative in a block.
- Examine 5 leaves from each shoot with a hand lens.
- Count webspinning spider mite nymphs and adults.

If no mites are found, wait three weeks and resample. If there is less than one mite per leaf, resample in two weeks. If there is one mite per leaf, resample in one week.

During the summer months, weekly checks are recommended. Check five leaves on 20 top shoots.

Bosc pears are more susceptible to mite damage and should have lower treatment thresholds than Bartlett pears. Asian pears and other varieties tolerate a higher mite population than French varieties.

The following treatment thresholds are for Bartlett pears. Adjust as necessary for your orchard.

Pears from turn down to harvest with 1-50 mites per 100 leaf samples should be treated with oil. If sampling reveals more than 50 mites per 100 leaf samples, add miticide to the spray.

Postharvest, check five leaves on 20 top shoots. If you find 51-100 mites per 100 leaves, an oil treatment may be needed, if no predatory species are present.

**Apples** should be monitored in July and August, or if you’ve already experienced high mite populations earlier in the growing season.

The recommended procedure:

- Collect 5 spur leaves at spaced intervals from one eye level lateral branch from each of 20 marked trees that have been established as representative in a block.
- Brush leaves in a mite-brushing machine. Count mites, not eggs.
- Count predatory mites as well as webspinning mites.
- Sample every 1-3 weeks.

When mite populations average 10 mites per leaf, begin treatments, however if you have one predatory mite per 10 webspinning mites, you may not need to treat. The predacious mite will likely be able to contain the infestation to non-damaging levels. Continue to monitor and if the pest mite population increases, then you may choose to treat.
Cyflumetofen miticide is an excellent choice for webspinning spider mites. It preserves beneficial mites and insects, can be mixed with other products, it is labeled for the entire pome fruit crop group, and it controls mites in all life stages—eggs to adults.

**Pear Rust Mites (*Epitrimerus pyri*)**

**Description**

Pear rust mites are found only in cultivated orchards and on quince. Rust mites are wedge-shaped, with the wider end at the head and extremely small. They do not look like webspinning spider mite and they do not form webbing. The eggs are clear when laid, becoming translucent prior to hatching. Nymphs are white, turning to tan before they molt. Adults are pale white to cream-colored during their growing season and have two pairs of legs near the front of their bodies. A hand lens (14 to 20X) is needed to see them. The females are a pale brown and overwinter in bark crevices or behind loose bud scales, most often on 2-4 year-old wood. As the buds open, the mites move to feed on developing clusters, leaves, and fruit. The females overwinter in crevices on twigs and under bud scales. They produce multiple generations during the summer months and can maintain a presence as long as it has new foliage as a food source.

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Pear rust mite
Jack Kelly Clark, courtesy UC Statewide IPM Program
**Damage**

The pear rust mite is common in the Pacific Northwest where it causes serious fruit damage.

Pear rust mites cause bronzing on the surface of fruit and foliage, where they feed. Injured leaves may stunt tree growth in young trees. Soon after petal fall, populations may increase to damaging levels on the fruit, around the calyx or stem end. Feeding and russetting may spread around the entire fruit if untreated.

Feeding damage later in the season is usually more scattered over the fruit surface. The level of russetting damage depends on the mite population and how long they've been feeding.

The pear rust mite invades opening fruit clusters to feed and lay eggs.

In pear varieties that are naturally russeted, such as Bosc and red-skinned varieties, the rust mite is not considered a pest, and is actually thought of as beneficial because it serves as a food source for predators. **Apple rust mites** are also a food source for predatory mites.

**Management**

The best pear rust mite control is achieved post-harvest. The pear rust mites are the most damaging in early spring, so treatment is advised pre-bloom. In-season treatment may be necessary when mite populations are high, as occurs when mites are allowed to overwinter.

A study on Bartlett pears and pear rust mite russet damage, revealed a damage threshold to be 1% damaged fruit, with 5% of the surface area russeted. That threshold is reached with as few as five mites per fruit.

**Biological Control**

Spraying is needed for complete pear rust mite control, though they can be suppressed in unsprayed orchards. The flip side of spraying is that spraying also curbs the mite’s predators. Predatory mites and brown and green lacewings are natural predators, but the fact that pear rust mites cause severe damage when left uncontrolled suggests that natural controls are not sufficient for control of pear rust mites.

**Monitoring and Treatment**

**At bud swell:** Sample fifty trees, two samples per tree, per 20 acres. Take one sample of a fruiting spur from the treetop and one from eye level, for a total of 100 samples.

Use a hand lens to examine under loose bark, in crevices of 2- to 4-year-old wood, and at the bud base. If at least two spurs are infested during the green tip to 1% bloom period, treatment is advised.

**At bloom:** Collect a flower cluster from both the treetop and eye level from 50 trees for 100 total clusters. If you observe any pear rust mites, treatment is advised.
During fruit development: Monitor weekly. Examine 40 fruit clusters for pests or pest damage. Use a hand lens to check the calyx area. After turn down, pear rust mites may be found anywhere on the fruit surface. If two or more pears have mites, or if any pear has more than 30 mites, treatment is advised.

At harvest: Monitor fruit in the bins for pear rust mite damage. Sample 200 pieces per bin from five bins per orchard or 20-acre area, for 1,000 pieces total.

Post-harvest: After harvest, inspect 20 top shoots, one each from 20 trees. With a hand lens, examine five leaves on each shoot for the presence of pear rust mites. If at least two shoots are infested, treatment is advised. You may also examine fruit left on the trees post-harvest, for mites.

Sulfur compounds applied post-harvest or pre-bloom are effective. Do not apply lime sulfur and oil spray before November 1 and only on trees not water stressed. Cyflumetofen miticide is an excellent option since it controls the mite in all life stages and does not affect the pear rust mite’s natural predators.

**Pearleaf Blister Mite (Eriophyes [=Phytoptus] pyri)**

Both the pearleaf blister mite and the appleleaf blister mite are pests in fruit growing areas of the United States and around the world. They are now relatively rare in commercial orchards in the Pacific Northwest.

**Description**

Adult pearleaf blister mites are about the same size as the pear rust mite. Instead of the wedge-shape, pearleaf blister mites have a long and slender white body that is striated and has a few long hairs. The immature forms are smaller, but otherwise resemble the adults. A 14 to 20X hand lens is needed to see the pests.

Eggs are oval and pearly white and about 0.04 mm long. Females overwinter at the base of the buds or under outer bud scales.

**Damage**

During the winter, the pearleaf blister mite feeds under the bud scales and may cause buds to dry and not develop in the spring. When the buds begin to grow, the mites feed on new leaves from green tip through bloom. They also feed on developing fruit which produces oval russet spots. The spots are often depressed with a surrounding “halo” of clear tissue. The spots often run together, but singly are 0.25 to 0.50 inch in diameter.

When the damaged fruit matures, it is misshapen and deformed.
Leaf feeding causes blisters, 0.125 to 0.25 inch across (3 mm to 6mm). The blisters are red at first and then turn black.

Eggs are laid in the blisters and the immature mites feed inside the blister so they are difficult to see and identify.

**Management**

Blister mites often proliferate on abandoned or neglected orchards. Monitoring and treatment are done in fall or during dormancy. The mites migrate from the leaf blisters to terminal and fruit buds at that time.

Check the leaf blisters for surviving mites.

Varieties with russeted skin surfaces do not exhibit blister mite damage. These resistant varieties include Bosc, Hardy, and Winter Nelis.

**Monitoring and Treatment**

The presence of any mites indicates a need for treatment.

During dormancy, the overwintering females can be found under the outer bud scales and are controlled with a fall spray. As the season continues, control is more difficult.

Examine terminal buds on 100 shoots (two each from 50 trees, one sample from the treetop, the other at eye level). A 14 to 20X hand lens will be needed to see the mites. Check the first several scales on each bud for mites.

The best predictor of a damaging mite population is sampling top shoots collected before, during, or after harvest. When three or more top shoots exhibit damage, damaged fruit can be expected the following spring, if left untreated during postharvest or dormancy.

At harvest, examine fruit in the bins for blister mite damage. Sample 200 fruit from 5 bins per orchard.

For best results, apply a narrow range oil during warm, sunny weather, from leaf fall to when the mites lay their eggs. If applying oil during dormancy, do not apply if the root zone is wet. Apply oil in late morning when moisture has dried from the bark.

Cyflumetofen miticide is another option. It offers control of the mite at all life stages and does not harm the natural predators.
V. Mite Control in Grapes

Webspinning Spider Mites

Pacific spider mite (*Tetranychus pacificus*)
Willamette spider mite (*Eotetranychus willamettei*)
Twospotted spider mite (*Tetranychus urticae*)

The Pacific, twospotted, and Willamette spider mites are the most common pests in grapes in the western United States. The twospotted and the European Red Mite are more damaging in the eastern areas of the country. In California, the Willamette spider mite is a problem in North Coast areas, the Salinas Valley, and the Sierra Nevada foothill range.

Description

Unless the Pacific and Willamette spider mites are side-by-side, it is very difficult to distinguish between them because their appearances are similar.
The Pacific spider mite is larger than the Willamette. The Pacific mite’s forelegs are reddish and the Willamette’s forelegs are translucent to pale yellow.

Pacific spider mite adult females are slightly amber to greenish in color. Later in the season, the adult female can turn orange to reddish. Depending on their life stage, they may have two large diffuse spots forward and two smaller spots on the rear part of the abdomen. Pacific spider mites do their most damage in the hotter and dryer months. They prefer the warm, upper canopy of the vine.

The Willamette spider mite is pale yellow and is an early-season pest. It prefers the cooler months and the cooler, shady parts of the vine.

The twospotted spider mite closely resembles the Pacific spider mite, except its spots are on the front of the body, rarely on the rear. It is rarely found on grapes.

**Damage**

The damage caused by each species is different and can be a tool in identifying each pest.

Pacific spider mite damage is yellow spots initially. As the damage spreads, necrotic areas appear on the leaves. Large populations of Pacific spider mites can burn the leaves bronze and fill them with webbing. The worst damage is along the shoulders and tops of the vine canopies.

In mid- to late-season, the Willamette spider mite feeding damage causes the foliage to turn yellowish-bronze, or in red grape varieties, leaves may turn reddish.

**Management**

Webspinning spider mites in vineyards require a variety of biological, cultural, and chemical controls.

**Biological Control**

The western predatory mite is very effective at controlling spite mite populations, if allowed to maintain or increase its population through the season. So avoid using disruptive sprays in order to preserve the predatory mites. Predator mites are available commercially.

Releases yield the best results when host plants (green beans) are placed directly on the vines. The recommended minimum is 1,000 predators per acre.

**Cultural Control**

Keep dust to a minimum. Maintain cover crops or resident vegetation to reduce dust. Avoid both water-stressing and overwatering the vines.
**Monitoring and Treatment**

Cyflumetofen is an excellent treatment option. It is effective on mite pests at all life stages and does not harm the predator mites, making it an excellent weapon in the battle against mites. It can be mixed with other products.

Carbaryl provides broad control against mites, although it also has a long duration impact on the predatory mite species.

The monitoring guidelines are the same for both wine and raisin grapes and table grapes.

Check under loose bark on the spur tip for the orange overwintering Pacific or Willamette spider mite. Maintain a monitoring form and make note of areas of concern and watch those areas during bloom.

When rapid shoot growth is taking place, monitor for both spider mites and predatory mites weekly.

- Early in the season, choose one leaf between the 2nd and 4th nodes on each of 20 vines. Later in the season, choose the 4th expanded leaf from the growing tip.
- Use a 10–14X hand lens and look for mites and mite predators.
- On your monitoring form, note if mites and mite predators are present (+) or absent (-).
- Determine if treatment is needed. (See the following chart.) Thompson Seedless vines are very vigorous and will tolerate more mite feeding. Consequently, injury levels would be lower for other varieties, but predator-prey ratios and comments are applicable to all varieties.
<table>
<thead>
<tr>
<th>Pacific mite injury levels (percent leaves infested)</th>
<th>Predator-prey distribution ratios for Pacific spider mites in Thompson Seedless raisin vineyards¹</th>
<th>Rare (less than 1:30)</th>
<th>Occasional (1:30 to 1:10)</th>
<th>Frequent (1:10 to 1:2)</th>
<th>Numerous (greater than 1:2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>light (less than 50%)</td>
<td>delay treatment to increase predators</td>
<td>delay treatment</td>
<td>treatment not likely necessary</td>
<td>treatment not necessary</td>
<td></td>
</tr>
<tr>
<td>moderate (50-65%)</td>
<td>treat if population is increasing rapidly</td>
<td>may delay treatment to increase predation</td>
<td>treatment may not be needed if the predator-prey distribution ratio is increasing rapidly</td>
<td>treatment not needed</td>
<td></td>
</tr>
<tr>
<td>heavy (65-75%)</td>
<td>treat immediately</td>
<td>may delay treatment a few days to take advantage of increasing predation</td>
<td>treatment may not be needed if predators are becoming numerous</td>
<td>treatment not needed, damage not increasing</td>
<td></td>
</tr>
<tr>
<td>very heavy (greater than 75%)</td>
<td>treat immediately</td>
<td>treat immediately unless predator-prey distribution ratio increasing very rapidly; carefully evaluate damage</td>
<td>treatment may not be necessary if population is dropping because of very high (greater than 1:1) predator-prey distribution ratios; carefully evaluate damage</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

¹ Thompson Seedless vines are very vigorous and will tolerate more mite feeding than less vigorous varieties. Consequently, injury levels would be lower for other varieties, but predator-prey ratios and comments are applicable to all varieties.

For up to date information on Pacific mite injury levels consult: [http://www.ipm.ucdavis.edu/PMG/r302400111.html](http://www.ipm.ucdavis.edu/PMG/r302400111.html)
VI. Mite Control in Strawberries

Spider Mites

Twospotted spider mite (*Tetranychus urticae*)

Carmine spider mite (*Tetranychus cinnabarinus*)

Strawberry spider mite (*Tetranychus turkestani*)

Lewis spider mite (*Eotetranychus lewisi*)

Along California’s Central Coast, the twospotted spider mite is the primary pest in strawberries. The strawberry spider mite is also found in those areas, especially in the warmer weeks of the production season.

The Lewis spider mite has been particularly invasive in Ventura County strawberries. It is reported in several Oxnard area fields. Since Lewis spider mite is also found on caneberries, strawberry fields near caneberries may also be infected.

The carmine spider mite is found in low densities in Southern California, the Central Coast, and the San Joaquin Valley regions. The Carmine spider mite is closely related to the twospotted spider mite.
Description

The twospotted spider mite may be brown to an orange-red, but is most often green to greenish-yellow or translucent. It has been described in detail in the Treenut section under Almonds.

In growing areas along the coast, temperatures rarely fall low enough so that a significant portion of the population undergoes diapause. Mating and egg-laying are year-round in coastal areas growing strawberries.

In in-land growing areas, during the coldest winter months, adult female strawberry spider mites may stop reproduction. Diapause is indicated by a change in color from red to bright orange.

The twospotted spider mite and the strawberry spider mite are similar in appearance. They are only differentiated by the morphological types of male genitalia.

The Carmine spider mite is bright red. Its population numbers generally decrease as spring temperatures increase.
The **Lewis spider mite** is similar in appearance to the twospotted spider mite, except that the Lewis spider mite females are smaller than the twospotted spider mite females. Lewis spider mites also have several small spots compared to the two spots which give the twospotted mite its name.

It is important to correctly identify the mites in the field, especially in winter. Diapausing carmine spider mites can be mistaken for predaceous mites. The predaceous mites move much faster and have a shiny, teardrop shape.

**Damage**

Mite infestation that exceeds one mite per leaflet is enough to affect crop yield.

Twospotted spider mite and carmine spider mite damage to strawberries appears as stippling, scarring, and bronzing of the leaves and calyx.

The damage caused by twospotted spider mite feeding is more severe during the first two to five months after transplanting in the late summer or fall. Mite feeding at this critical time decreases berry numbers per plant and overall plantation yield.

Berry plants are less susceptible to mite feeding following initial berry set. After berry set, yield losses result from 15-20 mites per mid-tier leaflet. Plants with infestations of more than 75 mites per leaflet may be very weak, they may appear stunted, and/or turn red.

**Management**

The twospotted mite population often reaches its peak after the spring fruit harvest. The peak is then followed by a natural and rapid decline in mites as the plant enters its vegetative growth cycle. The twospotted mite numbers may rise again later in summer as fruit production by day-neutral cultivars increases again.

Keys to minimizing spider mite damage:

- Cultural practices that favor vigorous plants.
- Protecting natural enemies by choosing miticides and insecticides that are least harmful to beneficials.
- If needed, supplement the natural enemy population by releasing predatory mites.
- Choose the most selective miticide available and alternate it with a miticide of a different chemistry in order to avoid resistance development.

**Biological Control**

There are several varieties of predator mites available commercially. They include:
- *Phytoseiulus persimilis*
- *Neoseiulus (Amblyseius) californicus*
- *Neoseiulus fallacis*
- *Galendromus occidentalis*

The first three listed are the most commonly used. *Phytoseiulus persimilis* feeds aggressively, multiplies and spreads rapidly, and feed exclusively on pest mites. However, if the pest mite population is too low, they feed on their own species, and their own population decreases.

*Phytoseiulus persimilis* is established in most strawberry-growing regions and will move naturally into spider mite-infested fields.

*Neoseiulus (Amblyseius) californicus* will also naturally inhabit strawberry fields and can contain pest mites to below economically damaging levels.

Other natural enemies of spider mites include:

- Minute pirate bug (*Orius* spp., *Anthocoris* spp.)
- Bigeyed bugs (*Geocoris* spp.)
- Damsel bugs (*Nabis* spp.)
- A rove beetle (*Oligota oviformis*)
- A lady beetle (*Stethorus* spp.)
- Brown lacewings (*Hemerobius* spp.)
- A predaceous midge larva (*Feltiella acarivora*)

Insecticides, miticides, and fungicides that are not selective will kill the predators. Release the predators only after residue levels have decreased to below lethal levels, following any pesticide application.

The *Lewis spider mite* does not respond to treatment of many miticides, but the predatory mites *Neoseiulus californicus*, *N. fallacis*, and *Amblyseius andersoni* provide effective control of Lewis mites in preliminary bioassays.

**Guidelines for predatory mite releases:**

- Monitor fields regularly to determine spider mite populations.
- A short-residual miticide before a predator release may improve biological control.
- Predatory mite releases should be early in the season, before pest populations increase. (On the Central Coast, spider mites are typically first observed in January or February. Further south, the infestations may begin in the fall.)
After the predator release, continue to monitor spider mite populations to evaluate efficacy of the release.

If you have a localized area of infestation, a limited release of *Phytoseiulus persimilis* may yield satisfactory results. Suggested release rates are an average of two to three predators per plant for low pest populations. Five predators per plant is recommended when the pest mite population has grown to threshold levels.

For a widespread infestation early in the season, releases can be about 1.5 predatory mites per plant, or about 30,000 per acre. This can be one large release, or up to three smaller releases of 10,000 predatory mites per acre, depending on weather conditions and the severity of the infestation.

**Cultural Control**

Preplant chilling (vernalization) is directly correlated to plant vigor. Fall transplant, nursery location, preharvest chilling, nursery harvest date, and length of pretransplant cold storage can all affect a plant’s vernalization. Plants with low chilling will be less vigorous and they often develop severe mite infestations. So be sure transplants receive proper chilling and adequate irrigation and fertilization.

Other cultural control factors include soil preparation and fumigation, the use of polyethylene plastic mulch, dust control, and adequate irrigation to avoid water stress.

**Monitoring and Treatment**

The key factor to successful strawberry production is vigorous plant growth in the first four months following fall transplant. It is critical to monitor the mid-tier leaves at this time, as mite feeding would be very damaging.

Monitoring guidelines:

- Select at random 10 leaflets per acre in small fields and 5 leaflets per acre in large fields.
- Examine the undersurface of mid-tier leaflets with a hand lens and count the number of mites.
- Record your findings on a sampling form.

The economic threshold established for strawberries in those months following transplantation is an average of five mites per mid-tier leaflet.

The threshold for summer transplants is ten mites per mid-tier leaflet, during that same time period following transplantation.

At harvest time, strawberries become more tolerant of mite feeding and treatment thresholds increase to an average of 15 to 20 mites per mid-tier leaflet.
These are general guidelines and treatment thresholds may vary depending on location, season, cultivar, plant vigor, and availability of an effective miticide.

Some new miticides have shown good results against twospotted spider mites, including Nealta®, a miticide with the active ingredient of cyflumetofen, which is very effective against most spider mites and not harmful to the predatory species. Nealta® is not effective against the Lewis spider mite.

Balancing microbial and botanical treatment options are an excellent approach.

**Cyclamen Mites (Phytonemus pallidus)**

**Description**

Cyclamen mites are typically found along the midvein of young, unfolded leaves and under the calyx of new flower buds. As the population increases, mites may be found anywhere on non-expanded plant tissue. A hand lens is necessary to see them. Adults measure 2.5 mm (about 0.01 inch). Mature adults are a shiny pinkish-orange. The female has thread- or whip-like hind legs while the male’s hind legs are more pincer-like.

Eggs are large for a mite, and translucent. Adult females lay about 90 eggs and about 80% of those develop into females. In the summer months, newly hatched mites mature within two weeks and their populations increase rapidly.

The cyclamen mite overwinters as adult females in the strawberry crown and may be present on transplants.
Cyclamen mites and eggs
Jack Kelly Clark, courtesy UC Statewide IPM Program

Magnification is needed to distinguish the cyclamen mite from the non-damaging tarsonemid mites. The only difference is a distinct bulge on the 4th femur of the adult male cyclamen mite.

**Damage**
The cyclamen mite is a pest primarily in fall-planted plants and second-year plantings. However, they can be moved into first-year fields with transplants and the damage becomes apparent as the season progresses.

Plant leaves become stunted and crinkled, which results in a compact leaf mass in the plant’s center. The mites also feed on the flowers, causing them to wither and die. Infested plants produce dwarfed fruit with prominent seeds on the berry flesh. If left unchecked, the cyclamen mite may prevent fruit production.
Cyclamen mite damage
Jack Kelly Clark, courtesy UC Statewide IPM Program

Management

The cyclamen mite requires carefully timed miticide sprays that do no harm to its natural predators. Because it is so difficult to distinguish the cyclamen mite from the non-harmful tarsonemid species, limit control measures to fields exhibiting damage symptoms.

Biological Control

The cyclamen mite has two natural predators, the *Typhlodromus bellinus* and *T. reticulatus*. Unfortunately, their populations increase too slowly to be effective as an economic control measure. Early season releases of the predatory mite *Amblyseius californicus* may provide some control.

If the cyclamen mite population has become large, the sixspotted thrips, minute pirate bugs, and the western predatory mite all feed on cyclamen mites.
Cultural Control

Transference of the cyclamen mite is easily accomplished by pickers, bees, birds, and equipment, including strawberry freezer trays. Be sure to use uninfected nursery stock.

Dipping trays of long-term cold storage transplants into a seven-minute 120°F hot water bath before planting may help prevent infestation. Wash the plants thoroughly before this treatment. After the water bath, submerge them in very cold water, and then plant.

Monitoring and Treatment

If damage is observed, inspect the rest of the field to determine the extent of the infestation. Monitor new leaves as they unfold and treat the infested area when one cyclamen mite in ten leaves is found.

Effective control requires a high rate of kill because the mite increases so quickly. A high rate of water per acre (300-500 gallons) is needed to soak the folded leaves and the immature flower buds in the crowns.

If damage is contained to a small area, treatment with a hand sprayer may be useful.

Abamectin is toxic to predatory mites and relatively toxic to parasites, but is considered safe for general predators. It is the chemical most compatible with an IPM program.
VII. Mite Control in Tomatoes

Tomato Russet Mite (Aculops lycopersici)

Description
A hand lens (14X) is needed to see the tomato russet mite due to its small size. Since they are so difficult to see, they are usually found once damage is noticeable. By that time, hundreds of yellowish, conical mites may be found on the green leaves immediately above the damaged bronzed leaves.

Damage
The russet mites remove cell contents from leaves, stems, and fruit cells. The mite usually starts near the ground and moves up the plant as the lower leaves dry out. This gives the plant an unhealthy appearance. The stems and leaves often become a greasy bronze or russet color. The mite will destroy the plant if not managed. Damage develops as summer temperatures rise.

Management
Once damage is observed, begin treatment and continue to monitor. If infestations occur in the same field, several years in a row, consider removing alternate hosts such as nightshades and morningglory.
**Monitoring and Treatment**

If bronzing on lower leaves and stems is observed, then check for mites on the leaves, both damaged and green, right above the bronzed leaves.

Damage is often observed first when the green fruit has reached one inch.

Examine infested areas of the field for bronzing leaves and stems to determine the extent of the infection. Mark the boundaries of the area and recheck in two to three days to see if the damage has increased. If so, immediate treatment is needed.

Sulfur dust or wettable sulfur needs thorough coverage. Ground application is preferred. Avoid drift. Do not use if an oil was applied recently or will be applied in the near future.

Abamectin is also effective against leafminers, psyllids, and tomato pinworm while it does not harm the russet mite’s natural enemies.
VIII. Mite Control in Citrus

Citrus Red Mite (*Panonychus citri*)

Description

The adult female citrus red mite is oval and globular while the male is smaller with a tapered abdomen. Each female lays two to three eggs a day on both sides of the leaf. They may lay up to 50 eggs in their lifetime. During warm weather, the red mite life cycle may be as short as 12 days.

Damage

The citrus red mite likes to feed on fully expanded young leaves, but they will also infect fruit. On the leaves, feeding produces a pale stippling that is visible on the upper leaf surface. In severe infestations, the stippling grows to dry necrotic areas. The leaves may drop and twigs dieback. Stippling or silvering affects green fruit but often disappears as the fruit ripens and changes color. If feeding continues on mature fruit, the silvering may continue to appear. High mite populations can cause sunburn on the fruit during hot weather. In Southern California orchards, during the Santa Ana winds, even low populations of citrus red mite may cause burning or blasting of foliage, as well as leaf drop.

Management
Citrus red mite is mostly a problem in hot and dry conditions when trees are water stressed. Research has shown that citrus can tolerate a higher red mite population than thought previously. Treatment may not be required in a healthy orchard with a well-planned IPM program. Monitor orchards and, when possible, use narrow range selective miticides.

**Biological Control**

The citrus red mite’s most important natural enemy is the predaceous mite who feeds on alternate food sources as well as the red mite. The predaceous mites mainly attack immature citrus red mites.

Other red citrus mite predators include a small black lady beetle, a predaceous dustywing, and the sixspotted thrips. Also red citrus mites are vulnerable to a virus that spreads rapidly in warm and moderately dry conditions. The infected mites move slowly, their legs curl under their body and they disintegrate.

Hot temperatures and low humidity also reduce the mite population.

**Cultural Control**

Water-stressed trees are vulnerable to red citrus mite infestations. Good irrigation practices reduce outbreaks.

Limit dust buildup on nearby roads.

**Monitoring**

*In the San Joaquin Valley:*

In February, survey orchards to determine if mites are present. Examine several leaves per tree at various sites, and check for eggs and immature mites with a hand lens.

In March (or as soon as mites have been detected), collect a total of 100 fully expanded leaves from throughout the orchard. Select leaves from just inside the shady region of the tree. Then:

- Determine the average number of mites per leaf.
- Count the number of predatory mites and figure their average per leaf.
- Note any virus-infected citrus red mites.
- Repeat every two weeks until red mite numbers decline to below one per leaf and petal fall has occurred.

In San Joaquin Valley navel oranges, if citrus red mite populations do not exceed eight mature females per leaf, by two to four weeks after petal fall, there should not be an economic loss. Healthy, well-irrigated trees can tolerate some degree of infestation. High temperatures and the virus reduce the mite population sufficiently in June and July so that treatment is not needed in the summer months.

In orchards treated with disruptive pesticides, treatments may be required in the spring.
In Southern California and coastal areas:

Depending on your local circumstances, monitoring may begin in late summer. Fall mite infestations can be quite damaging, in conjunction with the seasonal Santa Ana winds. About every two weeks, in late summer, monitor orchards as described above. Consider treating before Santa Ana conditions exist if there are more than eight to ten citrus red mites per leaf.

Treatment

In bearing orchards only, miticides available for controlling citrus red mite include acequinocyl (Kanemite), dicofol (Dicofol), fenbutatin oxide (Vendex), hexythiazox (Onager), oil, propargite (Omite), pyridaben (Nexter), and spirodiclofen (Envidor).

For nonbearing orchards only, bifenazate (Acramite) and etoxazole (Zeal) can be used.

Acequinocyl, bifenazate, fenbutatin oxide, and oil have the least effects on natural enemies, including predatory mites, but they also provide a shorter period of control of pest mites. Dicofol, etoxazole, hexythiazox, propargite, pyridaben, and spirodiclofen are of intermediate selectivity because they impact both pest mites and predatory mites for up to six weeks but have a nominal effect on beneficial insects such as lacewings, lady beetles, and *Aphytis melinus,*
which help control caterpillars, scale, thrips, and other pests.

Use of Oils

Extensive research on the use of oil sprays against various mite and scale insects has resulted in the development of recommendations that use specific rates and timing of treatments on different varieties of citrus in different regions of California in order to achieve expected pest control and limit the potential for leaf or fruit drop or fruit damage as a result of phytotoxicity. The narrow range 415, 440, and 455 oils were specifically developed for use in California to limit these concerns. Precautions for using petroleum spray oils are listed at the beginning of this guideline. Because mites are on the outside of the tree and sprayed with outside coverage, risks of phytotoxicity from oil are less than with a scale application. For additional information, see Managing Insects and Mites with Spray Oils.

<table>
<thead>
<tr>
<th>Type of oil (coverage)**</th>
<th>Varieties</th>
<th>Application times to avoid tree injury</th>
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<td></td>
<td>Navels</td>
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<td>Valencias</td>
<td>July–Sept.</td>
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<td>NR 415 (LV)</td>
<td>Grapefruit</td>
<td>Mar.–Nov.2</td>
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<td>Lemons</td>
<td>Mar.–Nov. or 21 days before picking?</td>
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<td></td>
<td>Navels</td>
<td>Aug. 15–Sept. and as needed before bloom1</td>
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<td>Valencias</td>
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<td>Navels</td>
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<td>Valencias</td>
<td>July–Aug.1</td>
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**LV – Low volume uses 20 to 100 gal water per acre. Do not use when temperatures will exceed 95°F (85°F to 90°F on coast).
OC – Thorough coverage uses 100 to 250 gal water per acre, depending on tree size.
IC – Intermediate coverage uses 250 to 600 gal water per acre.

1 Treatment can also be made from Feb. 15 - 50% bloom, but to avoid tree injury at this time, use only the low concentration (1.2%).
2 Do not apply Dec.–Feb. following subfreezing temperatures during the previous week or when subfreezing temperatures are anticipated during the following 2 weeks.

For up to date guidelines on the use of oils on citrus, please see [http://www.ipm.ucdavis.edu/PMG/r107400111.html](http://www.ipm.ucdavis.edu/PMG/r107400111.html)

Yuma Spider Mite (Eotetranychus yumensis)

Description

Yuma spider mite is found in California’s inland valleys. Its shape is similar to the citrus red mite, but its color is light straw to dark pink and it is much shinier. It lays spherical, peach-colored eggs within substantial amounts of webbing on leaf undersides and sometimes on fruit.
In the Coachella and Imperial valleys, Yuma spider mite infects grapefruit and lemons and their population peaks in winter and late spring. In the southern San Joaquin Valley, Yuma spider mite is found mostly on mandarins in the summer months.

**Damage**

The Yuma spider mite feeds by using its mouthparts to pierce and drink the fluids from the plant cells. Leaf feeding results in discolored foliage and sometimes in defoliation. Feeding on the surface of green fruit causes stippling and a bleached appearance, though often the fruit colors up normally as it matures.

**Management**

Yuma spider mite damage does not generally warrant treatment except in severe cases when it can be treated with sulfur, oil or other miticides. Be sure the oil and sulfur are not in combination or applications followed too closely.

**Biological Control**

The best predator of Yuma spider mite include sixspotted thrips. Other effective predators include spider mite destroyer, minute pirate bugs, and a predatory mite, *Euseius tularensis*.

**Cultural Control**

Dust control and adequate irrigation are key in reducing the Yuma spider mite’s impact on citrus groves.

**Monitoring and Treatment**

In the **San Joaquin Valley**, mandarins should be checked for Yuma spider mite in July and August. Check for leaf stippling and fruit with large amounts of webbing. On bearing trees, treatment is necessary if the stippling inhibits proper fruit coloring and if beneficial predatory species are not able to keep the Yuma spider mite population in check. On young trees, treat if leaf drop seems to be pending.

In the **Coachella and Imperial valleys**, treat as needed to prevent leaf drop. Between October and March 15, Yuma spider mite can be controlled with sulfur. Miticides provide control the rest of the year.

In non-bearing trees, Bifenazate or Etoxazole can be applied once a year.

Trees bearing orange, grapefruit, and lemons may be treated with Acequinocyl as well as other miticides and sulfurs.

Confer with your local county Agricultural Commissioner to determine your best treatment options.

**Texas Citrus Mite (*Eutetranychus banksi*)**

**Description**
In California’s inland valleys, the Texas citrus mite is a sporadic pest. Adults are tan- to brownish-green with dark green to black spots on the body’s upper side. Males are slender, and have longer legs than the females. The females are round-to-oval in shape and somewhat flatter than the citrus red or Yuma spider mites.

All stages of the mite, including eggs, are usually found along the midrib and lateral veins of the leaves. Eggs are flattish and disklike, and range in color from yellow when newly laid to reddish-brown prior to hatching.

In the San Joaquin Valley, Texas citrus mites are sometimes found in low numbers during the spring months, especially if insecticides that disrupt biological control have been used, such as formetanate hydrochloride (Carzol) or methidathion (Supracide).
Texas citrus mite populations decrease in summer but increase in the fall and early winter. When the weather becomes cold and wet (i.e. foggy in the Central Valley), population numbers fall again.

**Damage**

The Texas citrus mite feeds mainly on leaves. They can cause quite a bit of stippling and leaf drop. If the leaf drop continues, it can lead to fruit drop. In the San Joaquin Valley, damage is often limited to early harvested navels. Warm fall temperatures combined with decreased irrigation permit mites to increase.

Damage often begins in tree tops and progresses downward. Leaf drop caused by Texas citrus mite is distinctive because the leaf blade falls while the petiole remains in the tree. Leaf drop can lead to sunburned fruit, dropped fruit and decreased photosynthesis.

**Management**

In the San Joaquin Valley, watch for Texas citrus mite on early harvested navels in the fall or in the spring after treatments of broad-spectrum insecticides.

Treat if defoliation begins to occur in the outer canopy in tree tops and if cold, wet weather is not expected for at least several weeks.

**Biological Control**

Predators such as the sixspotted thrips, the spider mite destroyer, minute pirate bugs and predatory mites all help naturally control the Texas citrus mite.

**Cultural Control**

Dust control and adequate irrigation are the best cultural control measures against Texas citrus mite.

**Monitoring and Treatment**

Official treatment thresholds have not been established for this pest.

Miticides are quite effective in controlling Texas citrus mite. Cyflumetofen is an excellent option because it does not harm the predator species.

In the San Joaquin Valley, check for Texas citrus mite during spring months if insecticides that disrupt biological control have been used, such as formetanate hydrochloride (Carzol) or methidathion (Supracide). Treatment is necessary if leaf drop occurs in a significant amount.

In the fall months, (September through December) look for the pest on trees that bear early harvested fruit, especially navels. If leaves in the outer canopy at the tree tops are beginning to defoliate, treatment is needed, if cold weather is not expected for several weeks. Treatment is
not necessary if the defoliation is limited to leaves on the extremities of the fall flush. These will naturally fall or be pruned off during the winter.
IX. Beneficial Arthropods

Common Lacewings (Green) (*Chrysopa* spp., *Chrysoperla* spp.)

Green lacewings are soft-bodied insects with four membranous wings, golden eyes, and green bodies. They are commonly found in agricultural, landscape, and garden habitats. Larvae are also predaceous, preying on mealybugs, psyllids, thrips, mites, whiteflies, aphids, leafhoppers, small caterpillars, and insect eggs. They are available commercially and are among the most commonly released predators.

Green lacewing
Jack Kelly Clark, courtesy UC Statewide IPM Program

Insidious Flower Bug and Minute Pirate Bug (*Orius* spp., *Anthocoris* spp.)

These two insects are cousins and resemble each other both in size and appetite for mites and other small insects. They are about 1/5 inch long, oval to triangular in shape, black with whitish markings on their flattish backs. They are present all summer. They are particularly useful in decreasing the populations of the European red mite, the twospotted spider mite, and many aphids.
**Western Predatory Mite (Galendromus occidentalis)**

Western predatory mites do not have antennae, segmented bodies, or wings. They are more active than pest mites and stop only to feed. They prefer to feast on mites of all stages, but they also feed on pollen and other food. The western predatory mite is available commercially for release against spider mites. The western predatory mite tolerates hot climates with relative humidity above 50 percent.

**Seven-spotted Lady Beetle (Coccinella septempunctata)**

Lady beetles are easily recognized by their shiny, convex, half-dome shape and red color. Most lady beetles are predaceous as both larvae and adults. Older larvae and adults consume their entire prey. Larvae are active, elongate, have long legs and resemble tiny alligators.

**Sixspotted Thrips (Scolothrips sexmaculatus)**

Thrips are 2-3 mm long. They are slender insects with long fringes on their wing margins. They have three dark spots on each wing and are mostly pale-yellow as an adult. Both the larvae and the adult are predaceous, feeding on the European red mite, cyclamen mite, and spider mites. Sixspotted thrips can rapidly reduce pest mite populations.
Spider Mite Destroyer Lady Beetle (*Stethorus picipes*)
The shiny black spider mite destroyer is about 1/16 inch long and is covered with pale, tiny hairs. Adults and larvae both consume about six mites per day. At warmer temperatures, the spider mite destroyer can complete one generation from egg to adult in about three weeks. Females lay about 100 to 200 eggs in their one- to three-month lifespan.
Predatory Mite (*Phytoseiulus persimilus*)

Predatory mites are orange, shiny, and pear-shaped. They feed exclusively on spider mites and eat two or three adult females a day, or up to several dozen eggs a day. They are quite active, only stopping to feed. This mite is available commercially and is commonly released against spider mites. They tolerate hot temperatures as long as the relative humidity is between 60 and 90 percent.
X.  Miticide Resistance

The twospotted spider mite and Pacific mite have rapidly developed resistance to a miticide when that miticide is repeatedly applied to the same population. Therefore, it’s important to alternate miticides with differing modes of action and to avoid unnecessary spraying. Treat only infested portions of a field.

Organophosphate, carbamate, and pyrethroid insecticide applications have been known to induce twospotted spider mite and Pacific mite outbreaks. To avoid that, avoid early season applications or use insecticides that are less disruptive to the beneficials. Balancing microbial and botanical treatment options are an excellent approach.

Growers are advised to rotate chemicals with a different mode-of-action Group number. Do not use products with the same mode-of-action group number more than twice per season to help prevent resistance from developing.

Mode of action group numbers are assigned by the Insecticide Resistance Action Committee (IRAC). For more information, see their web site at http://www.irac-online.org

Dr. Raymond A. Cloyd, Kansas State University Professor of Entomology, offers these strategies to minimize insecticide/miticide resistance:

1. Use a variety of management strategies:
   - Cultural -- maintain proper watering and fertility practices. Avoid stressing plants.
   - Sanitation -- remove weeds, old plant, and growing medium debris.
   - Biological -- parasitoids, predators, entomopathogenic fungi/bacteria, and beneficial nematodes.
   - Plant Resistance -- grow (if available) insect tolerant plants.
   - Scouting -- evaluate effectiveness of management strategies and determine population dynamics of pests.

2. Rotate chemical classes with different modes of activity.

3. Minimize use of persistent materials, which can increase insect/mite exposure time.

4. Minimize the use of tanks mixes. Pests may develop resistance to multiple insecticides.

5. Use materials with non-specific modes of activity: soaps, oils, neem compounds, insect growth regulators, and entomopathogenic fungi and bacteria.
6. Spot spray. This avoids exposing entire pest population to pesticide.

7. Time applications to kill most vulnerable stages. May result in the use of reduced rates and/or less frequent pesticide applications.

Chemical Control

Many insecticides kill the spider mite’s natural predators, leading to an increase in spider mite populations. Some insecticides have also been proven to stimulate mite reproduction. During hot weather, insecticide use has triggered dramatic spider mite outbreaks within a few days.

Some chemical control measures may harm the trees, so check labels and apply them to a selected area of foliage to test for tolerance. Oils and soaps must contact the mites in order to kill them.

As always, read and follow all label directions. Be sure the product selected is the right one for your concern and that you are using it responsibly.

The University of California, Davis IPM website has many guidelines and can be consulted for up to date chemical controls. [http://www.ipm.ucdavis.edu/index.html](http://www.ipm.ucdavis.edu/index.html)

You have now completed the instructional portion of this Continuing Education course and may proceed to the quiz.