Mite Management Strategy and Miticide Resistance

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Two spotted spider mite
*Tetranychus urticae*

What’s up?
Two-spot mite: seasonal observations

- Two-spotted mites live on a wide variety of crops and weeds and can be carried from place to place by the wind - new strawberry plantings can be invaded early
- Mites develop slowly when conditions are cool (lower developmental temperature is 53.1°F)
- Populations build up during spring when temperatures start to increase
Susceptibility depends on

• Variety
• Plant vigor
  - Chilling of day-neutral varieties
  - Nursery fumigation
  - Horticultural practices
• Irrigation (water stress promotes mites)
• Dust
• Time of season and plant growth cycle
Two-spot mite feeding results in

• Yield reduction (primarily fewer fruit, not fruit size)
• Greatest impact from early season mite feeding - February to May (bud differentiation?)
• Effect of early season feeding on yield continues throughout the season
High mite densities appear as

- Yellowing on upper leaf surfaces
- Red to purple leaves at high densities often beginning at leaf margins
- Webbing
High mite densities appear as

- Yellowing on upper leaf surfaces
- Red to purple leaves at high densities often beginning at leaf margins
- Webbing

By the time these symptoms are observed, yield loss has already occurred
Determining mites and predators per midtier leaflet.

**Fall plantings** - sample every other week starting when the first leaf is fully expanded, and begin weekly sampling when daytime temperatures reach 68° to 70°F consistently or when mites begin to increase.

**Second year plantings** - assume that mites ARE present; monitoring less important than treating early-season with ovicide or growth regulator to reduce overwintering mites.
Presence/absence sampling - examine leaves in the field to see if mites are present; count percent of leaf with mites NOT number of mites per leaf. This method is fast for early season, but not accurate when densities exceed 10 per leaflet or following an acaricide spray.

- Sample the oldest fully expanded leaves early in the season.
- Later in the season, select mature leaves from the middle tier of the plant.
### Monitoring

**Presence/absence sampling** -

<table>
<thead>
<tr>
<th>Number of leaflets infested in a 100 leaflet sample</th>
<th>Estimated number of active mites per leaflet</th>
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</thead>
<tbody>
<tr>
<td>40</td>
<td>1</td>
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<td>50</td>
<td>2</td>
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<tr>
<td>60</td>
<td>5</td>
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<td>10</td>
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<td>20</td>
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Sample at least 50 and preferably 100 midtier leaflets at random from each block of 5 to 10 acres
What is a 'midtier leaflet'?

A mature leaflet from the middle tier of the plant - leaves that are dull green, not bright and shiny, but not old or dirty.
Monitoring - mite brushing

• Place 10 randomly selected leaflets in individual bags and keep cool
• Brush leaflets onto glass plates in groups of 10
• Count under low power dissecting microscope
Thresholds

- Early season - < 5 mites / midtier leaflet
- Later season - 15 - 20 mites / midtier leaflet

Based on studies of 'Selva'


Validated on study of 'Diamante' in 2006
# Diamante Treatment Timing, 2006

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Feb 2-09</th>
<th>March 3-13</th>
<th>Total</th>
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<tbody>
<tr>
<td>Kanemite</td>
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Mite-days (= total mites) are important
Early season mites are important.
Varietal Susceptibility

Evaluated annually from 1989 to 2011 with Dr. Doug Shaw
Variety and advanced selection evaluation, Watsonville, 2011

**Untreated - Day Neutral Selections**

- Monterey
- 6.204-1
- 7.148-3
- 5.206-5
- 7.114-2
- 7.92-3
- Albion
- San Andreas

**Untreated - Short Day Selections**

- Mojave
- Camino Real
- 8.51-609
- Palomar
- 7.148-1
- 5.165-1
- 6.137-2
- Benicia

**Treated - Day Neutral Selections**

**Treated - Short Day Selections**
Variety and advanced selection evaluation, Watsonville, 2011

Mite suppression through first fruiting cycle makes a difference in yield
Acaricides
Two-spot mite - Acaricides

The two-spotted spider mite has been reported to be resistant to over 92 unique insecticide or miticide active ingredients in over 367 cases worldwide.

This is among the most of any arthropod studied.
Two-spot mite - Acaricides

- Older products like Omite, Vendex and Kelthane had extended preharvest intervals or worker re-entry intervals that often dictated when they had to be applied.
- Registrations for most of these were suspended during the 1990s.
- Some (Kelthane) became ineffective due to resistance in some areas.

Acaricides became a critical problem when strawberry growers lost use of Omite as only Agri-mek was available - Goal was to register alternatives to Agri-Mek.
Two-spot mite - Acaricides

• Newer products that have been registered represent an assortment of additional modes of action

Provide greater flexibility:

shorter preharvest intervals

*some* have fewer impacts on beneficials

opportunity for resistance management
Resistance Management

Principles -

• Spray only when necessary and treat only infested portions of the field.
• Avoid early-season insecticide applications that are disruptive to beneficial arthropods.
• Alternate acaricides that have different modes of action.
# Acaricide Classification

<table>
<thead>
<tr>
<th>Product</th>
<th>Active Ingredient</th>
<th>Primary Target Site of Action</th>
<th>IRAC #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kelthane</td>
<td>Dicofol</td>
<td>Unknown mode of action</td>
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<td>Oxidative phosphorylation inhibitor</td>
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<td>Oxidative phosphorylation inhibitor</td>
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<td>Chloride channel activator</td>
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<td>Unknown mode of action (mite growth regulator)</td>
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<td>Unknown mode of action (mite growth regulator)</td>
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<td>Neuronal inhibitor (unknown mode of action)</td>
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<td>Inhibitor of lipid synthesis</td>
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<td>Site III electron transport inhibitor</td>
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<td>Site I electron transport inhibitor</td>
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<td>METI II electron transport inhibitor</td>
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<td></td>
<td>Highly refined mineral oil</td>
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<td>Highly refined mineral oil</td>
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<td></td>
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<td>Botanicals, exempt from tolerance</td>
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</tbody>
</table>

1 Not registered for use on any crop in California
Two-spot mite resistance?

- Dip strawberry leaves in different concentrations
- Let leaves air dry
- Transfer 10 to 15 adult female mites to the leaves
- Evaluate for mortality after 72 hours
Two-spot mite resistance?

Source of adult females are collections from strawberry fields. Population colonies are established on strawberry plants until sufficient adult females are available to conduct miticide bioassays

Initial locations:

- Zalom susceptible colony (> 25 years without treatment)
- Irvine
- Santa Maria (West Stowell Rd.)
- Nipomo (Oso Flaco Lake Rd.)
## Two-spot mite resistance?

### Agri-mek

<table>
<thead>
<tr>
<th>Sampling site</th>
<th>n</th>
<th>Slope ± SE</th>
<th>LC50 ppm</th>
<th>LC90 ppm</th>
</tr>
</thead>
<tbody>
<tr>
<td>Zalom Lab Susceptible</td>
<td>329</td>
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<td>658</td>
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<td>167</td>
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Field rate -
16 oz./acre in 200 gal. = 11.25 ppm
Two-spot mite resistance?

### Acramite

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</thead>
<tbody>
<tr>
<td>Zalom Lab Susceptible</td>
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<td>770</td>
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Field rate -

1 lb./acre in 200 gal. = 300 ppm
Two-spot mite lab resistance selection

- Established a field population
- Challenged the field population with Agri-mek or Acramite weekly at LD50 rate for 8 weeks
Two-spotted spider mite field population exposed to Agri-mek by lab selection at original LD50 value.

Abamectin-exposed colony

LC 50 increased by 23X in 8 generations
Two-spotted spider mite field population exposed to Acramite by lab selection at original LD50 value.

Bifenazate-exposed colony

LC 50 increased by 4X in 8 generations
Integrating Pesticides and Biocontrol of Mites

Acaricide compatibility -

*Galendromus occidentalis*

*Phytoseiulus persimilis*
Predator bioassays -

Contact and residual bioassays
Up to 37 days after application
Direct and side effects of -
  Acaramite = Bifenazate
  Agri-mek = Abamectin
  Kanemite = Acequinocyl
  Oberon = Spiromesifen
  Zeal = Etoxazole
  Fujimite = Fenpyroximate

Total effects ($E$) of acaricide residues on *P. persimilis* recorded 72 h after exposure to strawberry leaflets treated with the labeled dose of formulated products.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Days after treatment t</th>
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<tr>
<td></td>
<td>3</td>
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<td></td>
<td>26</td>
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<td>0</td>
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</tbody>
</table>

IOBC categories: A = short lived (<5 d), B = slightly persistent (5-15 d), C = moderately persistent (16-30 d), D = persistent (>30 d)
Lewis mite

*Eotetranychus lewisi*

Two-spotted Mite  Lewis Mite

*Eotetranychus lewisi*

*Tetranychus urticae*
Average percent mortality of adult female Lewis mites exposed to registered acaricides in a laboratory bioassay

![Lewis mite mortality bar chart](chart.png)
Mite Management Strategy and Miticide Resistance

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