Conventional and Organic Mite Management in Winegrape Vineyards

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Spider Mites

Willamette Spider Mite

Pacific Mite Injury

Pacific Spider Mite
Spider Mites

Pacific Spider Mite

Tetranychus pacificus McGregor

- Broad host range
- Usually thought of as the greater problem in warm growing areas

Eggs - spherical and may be laid in webbing

Newly hatched larva (6 legs) - food spots on dorsum

Adults vary in color from slightly amber to greenish or reddish; usually 2 larger spots forward, 2 rear
Spider Mites

Pacific Spider Mite

*Tetranychus pacificus* McGregor

- Prefers the warmer upper canopy (sunny areas)
- Generally does better during the hotter, drier part of the season
- Produces more webbing and tends to aggregate

Damage begins as yellow spots, then dead (necrotic) areas appear on the leaves. High populations can render the leaves nonfunctional with leaf burning and heavy webbing.
Spider Mites

Willamette Spider Mite

*Eotetranychus willamettei* (McGregor)

- Cultivated and wild grapes are the main hosts
- Typically the species of concern in the coastal valleys and the Sierra Nevada foothills

Eggs spherical, slightly smaller than Pacific mite, and has a fine papilla (hair) that tapers at the top

Newly hatched larva (6 legs) - food spots on sides

Adults tend to be yellow with food spots on sides
Spider Mites

Willamette Spider Mite

*Eotetranychus willamettei* (McGregor)

- Considered an early-season mite
- Prefers the cooler (shady) parts of the plant
- More dispersed over leaf surfaces

Feeding in mid or late season causes foliage to turn yellowish bronze, and can open canopies. High densities (> 30-50 per leaf) reduces brix.
Distribution and abundance of Pacific and Willamette mite seems to be changing (there is increased pest status of Pacific mite in a number of areas):

- Pacific mites present earlier season
- Pacific mites becoming a problem in coastal valleys and into September
- Willamette mites remaining at damaging levels into August
Distribution and abundance of Pacific and Willamette mite seem to be changing. Why?

- pesticide use
- irrigation practices that promote water stress
- large-scale planting of wine varieties in new areas
- changes in insecticide and fungicide use patterns

*What about newer products?*
Distribution and abundance of Pacific and Willamette mite seem to be changing. Why?

- pesticide use
- irrigation practices that promote water stress
- large-scale planting of wine varieties in new areas
- changes in insecticide and fungicide use patterns
- *What about newer products?*

Do they effect six-spotted thrips, lacewings, hemipterans, predaceous beetles, or predator mites?

What about effects on spider mite development?
Acaricides - Status

• Older products had extended preharvest intervals or worker re-entry intervals that often dictated when they had to be applied, leading to preventative use
• Many new products representing an assortment of modes of action are registered
• These new products provide flexibility:
  - preharvest intervals
  - impacts upon beneficials
  - resistance management
<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>Agri-Mek</td>
<td>Abamectin</td>
<td>Chloride channel activators (GABA agonist)</td>
<td>6</td>
</tr>
<tr>
<td>Onager</td>
<td>Hexythiazox</td>
<td>Unknown mode of action (mite growth inhibitor)</td>
<td>10A</td>
</tr>
<tr>
<td>Zeal</td>
<td>Etoxazole</td>
<td>Unknown mode of action (mite growth inhibitor)</td>
<td>10B</td>
</tr>
<tr>
<td>Vendex</td>
<td>Fenbutatin oxide</td>
<td>Oxidative phosphorylation inhibitor/uncoupler</td>
<td>12B</td>
</tr>
<tr>
<td>Omite</td>
<td>Propargite</td>
<td>Inhibitor of oxidative phosphorylation; inhibitor of ATP synthase</td>
<td>12C</td>
</tr>
<tr>
<td>Kanemite</td>
<td>Acequinocyl</td>
<td>Mitochondrial complex III electron transport inhibitor</td>
<td>20B</td>
</tr>
<tr>
<td>Fujimite</td>
<td>Fenpyroximate</td>
<td>Mitochondrial complex I electron transport inhibitor</td>
<td>21</td>
</tr>
<tr>
<td>Nexter</td>
<td>Pyridaben</td>
<td>Mitochondrial complex I electron transport inhibitor</td>
<td>21</td>
</tr>
<tr>
<td>Envidor</td>
<td>Spirodiclofen</td>
<td>Inhibitor of lipid synthesis</td>
<td>23</td>
</tr>
<tr>
<td>Acramite</td>
<td>Bifenazate</td>
<td>Neuronal inhibitor (unknown mode of action)</td>
<td>25</td>
</tr>
<tr>
<td>Kelthane</td>
<td>Dicofol</td>
<td>Unknown</td>
<td>unc</td>
</tr>
</tbody>
</table>
## Grape Acaricide IRAC Classification

<table>
<thead>
<tr>
<th>Product</th>
<th>Active ingredient</th>
<th>IRAC #</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neem</td>
<td>Azadirachtin</td>
<td>18B</td>
</tr>
<tr>
<td>Organic JMS Stylet Oil</td>
<td>Paraffinic oil</td>
<td>na</td>
</tr>
<tr>
<td>M-pede</td>
<td>Potassium salts of fatty acids</td>
<td>na</td>
</tr>
<tr>
<td>Ecotrol</td>
<td>Rosemary &amp; peppermint oil</td>
<td>na</td>
</tr>
<tr>
<td>GC-Mite</td>
<td>Cottonseed, clove &amp; garlic oil</td>
<td>na</td>
</tr>
</tbody>
</table>
Location and design - 2006

- 96 acre commercial cabernet sauvignon vineyard
- East of Lodi, San Joaquin Co.
- vines drip irrigated
- 4 replicates for each treatment and untreated control
- each treatment replicate was 5 vines in size.
- treatments arranged in a completely randomized design

Special thanks to Steve Quashnick, Wilbur-Ellis Co. and Cliff Ohmart, Lodi-Woodbridge Winegrape Commission
Methods - (both 2006 and 2007)

- applications made with an Echo mister/duster air assist sprayer
- 72 gallons per acre volume - conventional treatments
- 150 gallons per acre volume - organic treatments
- water buffered to pH 6.5

Sampling -
- 5 leaves from center 3 vines of each plot
- mite-brushed and counted under microscope
Daily maximum and minimum temperatures (°F) during the period of the experiment.
Proportion of Willamette and Pacific spider mites among all spider mites present in untreated control plots

Spider Mite Species Composition, Grapes, Lodi, 2006

- Willamette mite
- Pacific mite

Date

<table>
<thead>
<tr>
<th>Date</th>
<th>Proportion of total mites</th>
</tr>
</thead>
<tbody>
<tr>
<td>7_24</td>
<td></td>
</tr>
<tr>
<td>7_31</td>
<td></td>
</tr>
<tr>
<td>8_7</td>
<td></td>
</tr>
<tr>
<td>8_14</td>
<td></td>
</tr>
<tr>
<td>8_21</td>
<td></td>
</tr>
<tr>
<td>8_28</td>
<td></td>
</tr>
</tbody>
</table>
Conventional acaricide study - treatments applied on July 20, 2006, to cabernet sauvignon grape vines

<table>
<thead>
<tr>
<th>Product</th>
<th>Active ingredient</th>
<th>Rate per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agri-Mek 0.83EC</td>
<td>Abamectin</td>
<td>16 oz</td>
</tr>
<tr>
<td>Zeal</td>
<td>Etoxazole</td>
<td>3 oz.</td>
</tr>
<tr>
<td>Zeal + Danitol (V-10141)</td>
<td>Etoxazole + Fenpropathrin</td>
<td>18 oz</td>
</tr>
<tr>
<td>Fujimite 5EC</td>
<td>Fenpyroximate</td>
<td>2 pts.</td>
</tr>
<tr>
<td>Nexter</td>
<td>Pyridaben</td>
<td>10.67 oz.</td>
</tr>
<tr>
<td>Envidor 2SC</td>
<td>Spirodiclofen</td>
<td>18 oz.</td>
</tr>
<tr>
<td>Acramite 50WS</td>
<td>Bifenazate</td>
<td>1 lb.</td>
</tr>
<tr>
<td>Omite 30WP</td>
<td>Propargite</td>
<td>8 lb.</td>
</tr>
<tr>
<td>Untreated</td>
<td>Untreated</td>
<td>--</td>
</tr>
</tbody>
</table>
Comparison of acaricides applied on July 20 to cabernet sauvignon grape vines

Treatments are significantly \( (P<0.05) \) different from untreated except for those indicated by 'ns'.

### Acaricide Comparison, Grapes, Lodi, 2006

- **Control**
- **Agri-Mek**
- **Zeal**
- **Zeal + Danitol**
- **Fujinite**
- **Nexter**
- **Envidor**
- **Acramite**
- **Omite**

Motile mites per leaf

- 0
- 5
- 10
- 15
- 20
- 25
- 30
- 35

Legend:
- **7_24**
- **7_31**
- **8_7**
- **8_14**
- **8_21**
- **8_28**

ns
Organic acaricide study - treatments applied on August 19, 2006, to cabernet sauvignon grape vines near Lodi

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Active ingredient</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated Control</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>Organic JMS Stylet Oil</td>
<td>Paraffinic Oil</td>
<td>2% v/v</td>
</tr>
<tr>
<td>Organic JMS Stylet Oil</td>
<td>Paraffinic Oil</td>
<td>1% v/v</td>
</tr>
<tr>
<td>Ecotrol + Natural Wet</td>
<td>Rosemary Oil + Saponin</td>
<td>0.75 qts + 0.125% v/v</td>
</tr>
<tr>
<td>M-pede</td>
<td>Potassium salts of fatty acids</td>
<td>2% v/v</td>
</tr>
<tr>
<td>GC-Mite + Natural Wet</td>
<td>Cottonseed, Clove and Garlic oil</td>
<td>1% v/v</td>
</tr>
<tr>
<td></td>
<td>+ Saponin</td>
<td>+ 0.125% v/v</td>
</tr>
</tbody>
</table>
Comparison of organic acaricides applied on August 19 to cabernet sauvignon grape vines

Organic Acaricide Comparison, Grapes, Lodi, 2006

- Untreated Control
- Organic JMS Stylet Oil 2%
- Organic JMS Stylet Oil 1%
- Ecotrol + Natural Wet
- M-pede
- GC-Mite + Natural Wet

# Pacific Mites / Leaf

- 8/14 Pre-treatment
- 8/21
- 8/28
- 9/5

NS (Not Significant)
Location and design - 2007

• commercial merlot vineyard
• south of Pilot Hill, El Dorado Co.
• vines drip irrigated
• 4 replicates for each treatment and untreated control
• each treatment replicate was 5 vines in size
• treatments arranged in a randomized complete block design

Special thanks to Benjamin Falk of Safari Vineyards and Lynn Wunderlich, UCCE, El Dorado Co.
Daily maximum and minimum temperatures (°F) during the period of the experiment.
Proportion of Willamette and Pacific spider mites among all spider mites present in untreated control plots, 2007.

Pretreatment count (August 8) = 67.4 mites per leaf
Conventional acaricide study - treatments applied on August 9, 2007, to merlot grape vines

<table>
<thead>
<tr>
<th>Product</th>
<th>Active ingredient</th>
<th>Rate per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agri-mek + Dyne-amic</td>
<td>Abamectin + surfactant</td>
<td>12 oz + 0.25% v/v</td>
</tr>
<tr>
<td>Zeal</td>
<td>Etoxazole</td>
<td>3 oz.</td>
</tr>
<tr>
<td>Fujimite + summer oil</td>
<td>Fenpyroximate</td>
<td>2 pts. + 1% v/v</td>
</tr>
<tr>
<td>Onager</td>
<td>Hexythiazon</td>
<td>19.2 oz.</td>
</tr>
<tr>
<td>Envidor</td>
<td>Spirodiclofen</td>
<td>18 oz.</td>
</tr>
<tr>
<td>Envidor + Bond</td>
<td>Spirodiclofen + surfactant</td>
<td>18 oz. + 0.25% v/v</td>
</tr>
<tr>
<td>Acramite</td>
<td>Bifenazate</td>
<td>1 lb.</td>
</tr>
<tr>
<td>Omite</td>
<td>Propargite</td>
<td>8 lb.</td>
</tr>
<tr>
<td>Orchex 796</td>
<td>Summer oil</td>
<td>1% v/v</td>
</tr>
<tr>
<td>QRD-400</td>
<td>Chenopodium ambrosiodes</td>
<td>4 qts.</td>
</tr>
<tr>
<td>Untreated</td>
<td>Untreated</td>
<td>--</td>
</tr>
</tbody>
</table>
Comparison of acaricides applied on August 9 to merlot grape vines

Treatments are significantly ($P<0.05$) different from untreated except for August 22 sampling date, $F=1.9719$, df = 10,42, $P=0.0710$. 

Acaricide Comparison, Grapes, El Dorado Co., 2007

Treatments:
- Control
- Envidor + NIS
- Envidor
- Fujimate + oil
- Agri-Mek
- Acramide + NIS
- Omite
- Zeal
- Onager
- Summer oil
- QRD-400

Motile mites per leaf
### Organic acaricide study - treatments applied on August 13, 2007, to merlot grape vines

<table>
<thead>
<tr>
<th>Product</th>
<th>Active ingredient</th>
<th>Rate per acre</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>na</td>
<td>na</td>
</tr>
<tr>
<td>Organic JMS Stylet Oil 1%</td>
<td>Parafinic Oil</td>
<td>1% v/v</td>
</tr>
<tr>
<td>Organic JMS Stylet Oil 2%</td>
<td>Parafinic Oil</td>
<td>2% v/v</td>
</tr>
<tr>
<td>GC-Mite + Natural Wet</td>
<td>Cottonseed, Clove and Garlic Oil + Saponin</td>
<td>1% v/v + 0.125% v/v</td>
</tr>
<tr>
<td>Ecotrol + Natural Wet</td>
<td>Rosemary Oil + Saponin</td>
<td>4 pts/acre + 0.125% v/v</td>
</tr>
<tr>
<td>Organocide + Natural Wet</td>
<td>Sesame Oil + Saponin</td>
<td>2 oz./gal + 0.125% v/v</td>
</tr>
<tr>
<td>M-pede</td>
<td>Potassium salts of fatty acids</td>
<td>2% v/v</td>
</tr>
</tbody>
</table>
Comparison of organic acaricides applied on August 13 to merlot grape vines

Treatments are significantly ($P<0.05$) different from untreated except for September 5 sampling date and those labeled ns.
Dual function products for organic production

Applied in the equivalent of 100 gpa

- Untreated
- Cosavet- micronized sulfur
- JMS Organic Stylet Oil – paraffinic oil
  – Sub-plot treatment Stylet oil > Cosavet
- Trilogy- neem oil
- Sporan- rosemary, clove and thyme oil
Methods

- Fantasy seedless organic table grapes
- 15-vine main-plots, 4 replicates
- 5-vine subplots
- Treatments applied every 10-14 days
- Leafhoppers: 12 leaf turns per plot
- Mites: 5 leaf samples per plot
- Powdery Mildew: 20 bunches examined per plot
Leafhopper nymph densities on fantasy seedless, 2006

Leafhopper Nymphs

Date


# leafhopper nymphs / leaf

Cosavet
Stylet Oil
Sporan
Trilogy
Oil/sulfur
Untreated

a
ab
b
c

0 5 10 15 20 25 30 35 40 45 50 55


Willamette Spider Mite densities on fantasy seedless, 2006

Spider Mites

- Cosavet
- Stylet Oil
- Sporan
- Trilogy
- Oil/sulfur
- Untreated

# spider mites / leaf

Date

Willamette Spider Mite densities on fantasy seedless, 2006
# Powdery mildew - results

Mean ± SEM powdery mildew incidence and severity in main plots, 2006

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Incidence $^a$ Mean ± SEM</th>
<th>Severity $^b$ Mean ± SEM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>0.99 ± 0.01 a</td>
<td>0.84 ± 0.05 a</td>
</tr>
<tr>
<td>Cosavet</td>
<td>0.96 ± 0.02 a</td>
<td>0.20 ± 0.02 bc</td>
</tr>
<tr>
<td>Stylet Oil</td>
<td>0.83 ± 0.01 b</td>
<td>0.10 ± 0.00 d</td>
</tr>
<tr>
<td>Sporan</td>
<td>0.99 ± 0.01 a</td>
<td>0.32 ± 0.02 b</td>
</tr>
<tr>
<td>Trilogy</td>
<td>0.94 ± 0.03 ab</td>
<td>0.16 ± 0.01 cd</td>
</tr>
</tbody>
</table>

$^a$ Proportion of grape bunches with powdery mildew infection

$^b$ Proportion of grape berries with powdery mildew infection

Means followed by the same letter are not significantly different (Tukey’s HSD, $p < 0.05$)

Means were arcsine transformed prior to analysis, means presented here are untransformed.
Powdery mildew - results

Mean ± SEM powdery mildew incidence and severity in stylet oil sub-plots, 2006

<table>
<thead>
<tr>
<th>Subplot Treatments</th>
<th>Incidence 0.83 ± 0.01 a</th>
<th>Mean ± SEM</th>
<th>Severity 0.10 ± 0.00 a</th>
</tr>
</thead>
<tbody>
<tr>
<td>Stylet Oil</td>
<td></td>
<td>0.10 ± 0.00 a</td>
<td></td>
</tr>
<tr>
<td>Stylet Oil then Cosavet c</td>
<td>0.85 ± 0.04 a</td>
<td>0.10 ± 0.01 a</td>
<td></td>
</tr>
</tbody>
</table>

\( ^a \) Proportion of grape bunches with powdery mildew infection
\( ^b \) Proportion of grape berries with powdery mildew infection
\( ^c \) Stylet Oil applied 5/17-6/26, Cosavet applied 7/10-8/7

Means followed by the same letter are not significantly different (Tukey's HSD, \( p < 0.05 \))
Means were arcsine transformed prior to analysis, means presented here are untransformed.
Phytotoxicity -

- Untreated
- Sporan
- Trilogy
- Cosavet
- Stylet Oil
- Stylet Oil > Cosavet
Predaceous Mites on Winegrapes

Galendromus (Metaseiulus) occidentalis (Nesbitt)
Neoseiulus (Amblyseius) californicus (McGregor)

also

Neoseiulus fallacis (Garman) - Lodi
Typhlodromus pyri Scheuten - north coast
Amblyseius andersoni Chant- north coast
Typhlodromus caudiglans Schuster- north coast
Metaseiulus johnsoni (Mahr)- north coast
Euseius stipulatus (Athias-Henriot) - central coast
Metaseiulus mcgregori (Chant) - central valley
Predaceous mites on winegrapes

- Adult females are typically narrowly oval
- Most are shiny white to slightly yellow or reddish
- Tend to move much more quickly than do spider mites
- Eggs are elliptical and perhaps 3 to 4 times larger than the spherical eggs of spider mites
- Overwinter primarily under the buds of grapevines as mated, adult females

*Sampling and decision rules in "Grape Pest Management"*
Pesticide Toxicity Measurements

Acute toxicity - percent mortality
LD50 or LC50 - dose response
Sublethal effects - fecundity, fertility, immature development
Total effects -
Persistence -
Behavioral modification -
Predator mite bioassays - analysis

Mortality, fecundity and fertility analyzed by ANOVA with means separated by LSD ($p < 0.05$)

Total effects of pesticides - $E$

$$E (%) = 100\% - (100\% - M) \times R$$

Where

$M = \text{Abbott corrected mortality (Abbott, 1925)}$

$R = \text{reproduction per treated female (eggs/female x \% fertility) / reproduction per untreated female}$
**Predator mite bioassays - direct contact**

G. *occidentalis* survival, fecundity and fertility after treatment of adult females with label rates of five different acaricides.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>% Survival</th>
<th>Total eggs/ female</th>
<th>Fertility (% hatch)</th>
<th>E</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>100</td>
<td>12.4 0.8a</td>
<td>100 0a</td>
<td>-</td>
</tr>
<tr>
<td>Acequinocyl</td>
<td>100 0a</td>
<td>9.2 0.6b</td>
<td>96.0 4.9a</td>
<td>28.5</td>
</tr>
<tr>
<td>Bifenazate</td>
<td>100 0a</td>
<td>9.4 0.5b</td>
<td>92.3 3.4a</td>
<td>30.2</td>
</tr>
<tr>
<td>Etoxazole</td>
<td>98.3 2.2a</td>
<td>9.4 0.7b</td>
<td>0 0b</td>
<td>100</td>
</tr>
<tr>
<td>Spiromesifen</td>
<td>98.3 2.2a</td>
<td>8.6 0.5b</td>
<td>96.1 4.0a</td>
<td>34.0</td>
</tr>
<tr>
<td>Fenpyroximate</td>
<td>0 0b</td>
<td>0 0c</td>
<td>0 0b</td>
<td>100</td>
</tr>
</tbody>
</table>

Means followed by the same letter are significantly different at *p*<0.05 by LSD.
Predator mite bioassays - residues

*G. occidentalis* survival, fecundity and fertility after treatment of leaves with label rates of five different acaricides.

<table>
<thead>
<tr>
<th>Active ingredient</th>
<th>% Survival</th>
<th>Eggs laid</th>
<th>Fertility</th>
<th>$E$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>98.3</td>
<td>2.2</td>
<td>11.2</td>
<td>1.0a</td>
</tr>
<tr>
<td>Acequinocyl</td>
<td>93.4</td>
<td>3.0</td>
<td>9.6</td>
<td>0.5a</td>
</tr>
<tr>
<td>Bifenazate</td>
<td>95.1</td>
<td>2.7</td>
<td>9.6</td>
<td>0.9a</td>
</tr>
<tr>
<td>Etoxazole</td>
<td>93.4</td>
<td>3.0</td>
<td>9.0</td>
<td>0.5a</td>
</tr>
<tr>
<td>Spiromesifen</td>
<td>91.7</td>
<td>3.2</td>
<td>5.0</td>
<td>0.7b</td>
</tr>
<tr>
<td>Fenpyroximate</td>
<td>0</td>
<td>0b</td>
<td>0</td>
<td>0c</td>
</tr>
</tbody>
</table>

Means followed by the same letter are significantly different at $p<0.05$ by LSD.
Leaf surface residues

- Acequinocyl: Harmless (class 1)
- Bifenazate
- Spiromesifen: Slightly harmful (class 2)
- Etoxazole
- Fenpyroximate: Harmful (class 4)

Direct contact spray

- Acequinocyl: Harmless (class 1)
- Bifenazate
- Spiromesifen
- Etoxazole
- Fenpyroximate: Harmful (class 4)
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