Biology and control of Neofabraea leaf and twig lesions of oil olives in California

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Dr. Dani Lightle, UCCE
Dr. Brenna Aegerter, UCCE
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University of California
Agriculture and Natural Resources
Symptoms: severe defoliation (2016)

Arbosana

Koroneiki
Symptoms: Arbosana
Symptoms: Branch cankers (Arbosana)
Neofabraea diseases in olive:

- Fruits can also get infected in CA (Arbequina)
Surveys for Neofabraea diseases of olive: In Super-High-Density orchards
**Pathogen identification:** morphological and molecular studies
Neofabraea diseases in olive:

- Lepra Fruit Rot/Leprosis
  - Tuscany Italy in 1907 (Petri, 1915)
  - Spain (Roca et. al., 2007)


Photo credits: S. Rooney-Latham and Doug Gubler
Neofabraea diseases in olive:

- A problem increasing problem in Spain and Portugal

**Disease diagnosis:** An old disease, “Lepra”
Neofabraea diseases in apple and pear:

- **Bull’s eye rot and canker**

- "Bull's-eye rot" occurs on fruit at open lenticels or at breaks in the skin

- The rot spots may be only specks, but most of them are 0.5 to 1 inch

- Spots may occur singly or be numerous

- The fungus overwinters in cankers and infected fruits

- Oregon, Washington, and California
Neofabraea in apple orchards in CA:

- Not found, but likely to occur
Pathogenicity in apple:

- CA olive isolates are pathogenic to apple: source of inoculum?
Disease emergence: super-high-density oil olive

- Intensification of agricultural practices
- Mechanical harvest
- Changing weather conditions
Disease emergence: Infection occurs at wounds caused by mechanical harvesters
Disease emergence: Infection occurs at wounds caused by mechanical harvesters
Disease emergence: Infection occurs at wounds caused by mechanical harvesters
Disease emergence: super-high-density oil olive

- Pathogens not detected from harvester pads: not a source for disease spread
Pathogenicity in leaves:

Wounds are required for infection!
Pathogenicity in shoots:

Wounds are required for infection!
Pathogenicity in olive fruits:
Temperature study:

A

![Graph A: P. vagabunda KARE1288](#)

![Graph B: P. vagabunda KARE1943](#)

![Graph C: N. kienholzii KARE1281](#)

![Graph D: N. kienholzii KARE1065](#)

![Graph E: P. vagabunda KARE1944](#)

![Graph F: N. kienholzii KARE943](#)
Disease cycle:

**Fall:** Mechanical harvest

**Fall:** Infection of fresh wounds

**Rain:**

**Fall:** Infection of fresh wounds

**Inoculum reservoir:** Old olive leaves and fruits, possibly apples (November)

**May-June:** Defoliation

**Symptoms best visible in March/April**
Neofabraea diseases in olive:

- Premature leaf senescence
- Increased leaf drop
- Limited fruit set
- Poor tree and orchard performance
- Reduced yield
- Reduced profitability

Table 1. Yield data for two locations where Neofabrae diseases have been documented.

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>2012</td>
<td>2013</td>
<td>2014</td>
<td>2015</td>
</tr>
<tr>
<td>Orchard A - 203 acres</td>
<td>5.78</td>
<td>7.16</td>
<td><strong>3.37</strong></td>
<td>6.93</td>
</tr>
<tr>
<td>Orchard B - 38 acres</td>
<td>4.1</td>
<td>5.8</td>
<td><strong>2.8</strong></td>
<td>6.1</td>
</tr>
</tbody>
</table>

* TPA = tons per acre.
Disease control: fungicide trials

Copper fungicides?

- Arbosana trees
- Stihl SR 450 Backpack Sprayers
- Rating on March 8, 2018

- Single application at harvest
- Two applications, one at harvest, and a second 2 to 3 weeks after harvest

- Topsin M (thiophanate-methyl – group 1)
- Inspire Super (difenconazole/cyprodinil – group 3+9)
- Luna Experience (fluopyram/tebuconazole – group 3+7)
- Luna Sensation (fluopyram/trifloxystrobin – group 7+11)
- Mertect (thiabendazole – group 1)
- Kocide 3000 (Copper Hydroxide)
- Rhyme (flutriafol – group M3)
- Vangard WG (Cyprodinil 75% – group 9)
- Ziram (ziram – group M3)
- Bravo (Chlorothalonil – group M5)
**Fungicide trials:** Experimental unit = 2 Trees, 4 repetitions
Fungicide trials 2016-2017:

Leaf Spot Incidence

![Graph showing leaf spot incidence for different treatments: Water control, Luna Experience, Vangard, Ziram, Inspire Super, Luna Sensation, Topsin M. The graph highlights the differences in leaf spot incidence among the treatments.]

University of California
Agriculture and Natural Resources
Fungicide trials 2016-2017:

Twig Lesion Incidence
Fungicide trials 2017-2018:

Eight products were tested in the field during the fall and winter 2017-2018:

- Topsin M (thiophanate-methyl – group 1)
- Inspire Super (difenoconazole/cyprodinil – group 3+9)
- Kocide 3000 (copper hydroxide)
- Tebucon (tebuconazole – group 3)
- Rhyme (flutriafol – group M3)
- Vanguard WG (cyprodinil – group 9)
- Ziram (ziram – group M3)
- Bravo (chlorothalonil – group M5)
Fungicide trials 2017-2018: Trial 1

Trial 1, single spray application: Average number of leaf lesions per olive tree according to various fungicide treatments and compared to the water treatment and a copper treatment (Kocide 3000).
**Fungicide trials 2017-2018: Trial 2**

**Trial 2, two spray applications:** Average number of leaf lesions per olive tree according to various fungicide treatments and compared to the water treatment (Kocide 3000).
### Fungicide trials 2018-2019: Trial 1 & 2

<table>
<thead>
<tr>
<th>Company</th>
<th>Fungicide</th>
<th>Flag</th>
<th>Rec. Rate/A</th>
<th>My Calc (2.8gal)</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>UPI, United Phosphorus Inc</td>
<td>Ziram 76DF</td>
<td></td>
<td>6 pounds / acre</td>
<td>37.5</td>
<td>gr</td>
</tr>
<tr>
<td>Syngenta</td>
<td>Inspire Super</td>
<td></td>
<td>20 fl oz</td>
<td>8.2</td>
<td>mL</td>
</tr>
<tr>
<td>Certis</td>
<td>Kocide 3000</td>
<td></td>
<td>7 lb</td>
<td>43.7</td>
<td>gr</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>W</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Trt. #</th>
<th>Treatment</th>
<th>Assigned Flag</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Ziram T1</td>
<td>Black (B)</td>
</tr>
<tr>
<td>2</td>
<td>Inspire Super T1</td>
<td>Pink (P)</td>
</tr>
<tr>
<td>3</td>
<td>Kocide 3000 T1</td>
<td>Yellow (Y)</td>
</tr>
<tr>
<td>4</td>
<td>Inspire Super T1 + T2</td>
<td>Orange (O)</td>
</tr>
<tr>
<td>5</td>
<td>Ziram T1 + T2</td>
<td>White Red Dots (RD)</td>
</tr>
<tr>
<td>6</td>
<td>Inspire Super T1 + Ziram T2</td>
<td>White Blue Stripe (BS)</td>
</tr>
<tr>
<td>7</td>
<td>Ziram T1 + Inspire Super T2</td>
<td>Green (G)</td>
</tr>
<tr>
<td>8</td>
<td>Control</td>
<td>White (W)</td>
</tr>
</tbody>
</table>

First spray was on **11/20/2018** (T1) and the second spray on **12/3/2018**. Olive harvest was on 11/13/2018. Trial rating of leaf spots was on **4/24/2019**.
Fungicide trials 2018-2019: Trial 1

Field Trial 1 - 2019

- Control
- Kocide
- Inspire Super T1 + Ziram T2
- Ziram T1 + Inspire Super T2
- Inspire Super T1
- Ziram T1
- Ziram T1 + T2
- Inspire Super T1 + T2

Average total number of leaf spots

Control > Kocide > Inspire Super T1 + Ziram T2 > Ziram T1 + Inspire Super T2 > Inspire Super T1 > Ziram T1 > Ziram T1 + T2 > Inspire Super T1 + T2
Fungicide trials 2018-2019: Trial 2

Field Trial 2 - 2019

- Control
- Kocide
- Inspire Super T1 + Ziram T2
- Ziram T1 + Inspire Super T2
- Inspire Super T1
- Ziram T1
- Ziram T1 + T2
- Inspire Super T1 + T2

Averages total number of leaf spots

A - Best performance
B - Second best performance
Fungicide registration: IR4

- Two new fungicides for olive (Inspires Super and Ziram)
- Neofabraea, Phlyctema, Peacock, Cercosporiose foliar diseases
- Improve health, yield and profitability of orchards
- No residues in fruits or oil

<table>
<thead>
<tr>
<th>Client Sample</th>
<th>EMA Sample No</th>
<th>Sample</th>
<th>Date Analyzed</th>
<th>Method</th>
<th>Chemicals</th>
<th>Amount</th>
<th>RL</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-Pu</td>
<td>18071821-01</td>
<td>Olive Fruits</td>
<td>07/26/18</td>
<td>LC/MS/MS Extended</td>
<td>Cypreasonil, Difenoconazole</td>
<td>ND</td>
<td>0.01</td>
<td>ppm</td>
</tr>
<tr>
<td>T1-Pu</td>
<td>18071821-02</td>
<td>Olive Fruits</td>
<td>07/26/18</td>
<td>LC/MS/MS Extended</td>
<td>Cypreasonil, Difenoconazole</td>
<td>ND</td>
<td>0.01</td>
<td>ppm</td>
</tr>
<tr>
<td>T1-Pu</td>
<td>18071821-03</td>
<td>Olive Fruits</td>
<td>07/24/18</td>
<td>EBDC Screen</td>
<td>Ziram</td>
<td>ND</td>
<td>0.05</td>
<td>ppm</td>
</tr>
<tr>
<td>T1-Pu</td>
<td>18071821-04</td>
<td>Olive Fruits</td>
<td>07/27/18</td>
<td>LC/MS/MS Extended</td>
<td>Thiophanate Methyl</td>
<td>ND</td>
<td>0.01</td>
<td>ppm</td>
</tr>
</tbody>
</table>

P. O. No: OOCGRESIDUE2018  
Project: Neofabraea Olive

<table>
<thead>
<tr>
<th>Client Sample</th>
<th>EMA Sample No</th>
<th>Sample</th>
<th>Date Analyzed</th>
<th>Method</th>
<th>Chemicals</th>
<th>Amount</th>
<th>RL</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2-O</td>
<td>18071822-01</td>
<td>Olive Fruits</td>
<td>07/24/18</td>
<td>EBDC Screen</td>
<td>Ziram</td>
<td>ND</td>
<td>0.05</td>
<td>ppm</td>
</tr>
<tr>
<td>T2-P</td>
<td>18071822-02</td>
<td>Olive Fruits</td>
<td>07/27/18</td>
<td>LC/MS/MS Extended</td>
<td>Thiophanate Methyl</td>
<td>ND</td>
<td>0.01</td>
<td>ppm</td>
</tr>
</tbody>
</table>

ND = None Detected at the Reporting Limit (RL)
RL = Reporting Limit
Excess sample and extracts are stored for a minimum 30 of days from the date of analytical report. Special storage arrangements possible. Results relate only to items tested. Samples are analyzed as received. Reports should not be reproduced, except in full, without written consent by Environmental Micro Analysis, Inc. To see the scope of our ISO 17025 accreditation go to http://emalab.com/ISO17025.pdf.
## Duration of wound susceptibility: Leaves

- Optimizing the number and timing of fungicide applications
- Limit costs while improving performance of orchards

<table>
<thead>
<tr>
<th>Week</th>
<th>Flag color</th>
<th>Inoculation</th>
</tr>
</thead>
<tbody>
<tr>
<td>W 0</td>
<td>Orange</td>
<td>22-Nov</td>
</tr>
<tr>
<td>W 1</td>
<td>Blue</td>
<td>29-Nov</td>
</tr>
<tr>
<td>W 2</td>
<td>Green</td>
<td>6-Dec</td>
</tr>
<tr>
<td>W 3</td>
<td>Purple</td>
<td>13-Dec</td>
</tr>
<tr>
<td>W 4</td>
<td>Red</td>
<td>20-Dec</td>
</tr>
<tr>
<td>W 5</td>
<td>Yellow</td>
<td>27-Dec</td>
</tr>
</tbody>
</table>
Duration of wound susceptibility: Leaves

Neofabrae kienholzii - Leaf wound susceptibility over time
Lath-house data 2017-2018

Incidence leaf spots (%)

Week after harvest

Week 0
Week 1
Week 2
Week 3
Week 4
Week 5

y = -17.27 x + 111.96
R² = 0.88
Duration of wound susceptibility: Leaves

*Neofabrae kienholzii* - Leaf wound susceptibility over time
Field data 2017-2018

Week after harvest

Incidence leaf spots (%)

\[ y = -21.39 \times + 117.35 \]

\[ R^2 = 0.86 \]
Duration of wound susceptibility: Leaves

*Phlyctema vagabunda* - Leaf wound susceptibility over time
Field data 2017-2018

Incidences leaf spots (%) over time:
- Week 0: 100%
- Week 1: 10%
- Week 2: 10%
- Week 3: 10%
- Week 4: 10%
- Week 5: 10%
Duration of wound susceptibility 2018-2019:

**Neofabrae kienholzi - Leaf wound susceptibility over time**
Lath-house data 2018-2019

- Incidence leaf spots (%)
  - Week after inoculation

**Phlyctema vagabunda - Leaf wound susceptibility over time**
Lath-house data 2018-2019

- Incidence leaf spots (%)
  - Week after inoculation

**Neofabrae kienholzi - Leaf wound susceptibility over time**
Lath-house data 2018-2019

- Fungal recovery (%)
  - Week after inoculation

**Phlyctema vagabunda - Leaf wound susceptibility over time**
Lath-house data 2018-2019

- Fungal recovery (%)
  - Week after inoculation

**Neofabrae kienholzi - Twig wound susceptibility over time**
Lath-house data 2018-2019

- Incidence twig lesions (%)
  - Week after wounding

**Neofabrae kienholzi - Twig wound susceptibility over time**
Lath-house data 2018-2019

- Fungal recovery (%)
  - Week after wounding
Timing of fungicide applications:

T1 (after harvest)

T2 (2 to 3 weeks after harvest)
Fungicide trials 2018-2019: Trial 1 & 2

- Our research helped minimize the number of spray applications without increasing risks of disease incidence – IPM practices

First spray was on **11/20/2018** (T1) and the second spray on **12/3/2018** (T2). Olive harvest was on **11/13/2018**. Trial rating of leaf spots was on **4/24/2019**.
Conclusion:

- Neofabraea leaf spot is an emerging disease of oil olives in CA
- Limited to Super-High-Density orchards
- Two Neofabraea species are involved
- Aggressive pathogens of increasing concern in Spain, Italy and Portugal
- Associated with mechanical harvest
- Requires wounds (leafs and twigs) for infection
- Mainly Arbosana cultivar is susceptible
- We understand the disease cycle
- Duration of wound susceptibility: 4 weeks
- Ziram and Inspirer Super after harvest + 2-3 weeks after
- IR4 projects for product registration
Olive Anthracnose:
Olive Anthracnose:

Olive Oil Commission of California

RESEARCH GRANT PROPOSAL

Project Year: 2020

Anticipated Duration of Project: 2 years

Principal Investigator: Florent Trouillas, University of California, Davis, Department of Plant Pathology and Kearney Agricultural Research and Extension (KARE) Center, flotrouillas@ucanr.edu

Cooperating Personnel:
Mohamed Nouri, Farm advisor, UCCE San Joaquin County, mnouri@ucanr.edu
Rosa Jaime Frias, Laboratory Assistant, KARE, rejaimefrias@ucdavis.edu

Project Title: Investigating the occurrence and distribution of Olive Anthracnose in California

Commodity: Oil Olive

Objectives:

1- Determine the occurrence and distribution of olive Anthracnose in California.
2- Determine what *Colletotrichum* species are associated with olive Anthracnose in California.
3- Determine the pathogenicity of the identified *Colletotrichum* species to main oil olive cultivars in California.
Olive Anthracnose:

Photo credits: Juan Moral
Olive Anthracnose:


Fig. 8. Diagramatic representation of the disease cycle of olive anthracnose in the Mediterranean region.
Olive Anthracnose:

Olive Anthracnose worldwide:


Dr Vera Sergeeva
www.olivediseases.com
2019-20 Surveys for olive Anthracnose:

In Super-High-Density orchards

✓ November 2019
✓ December 2019
✓ January 2020

Conventional orchards
Field observation and disease diagnosis:

➢ Working with OOCC members

Olive Oil Commission of California Funds Research

The OOCC’s research projects for the new fiscal year will give the state’s producers insight into the control of olive knot and olive anthracnose.
Survey for olive Anthracnose:

- Olive trees near almond and walnut orchards
Survey for olive Anthracnose:

- Olive trees near orange and mandarin orchards
Survey for olive Anthracnose:

- Ornamental olive trees near commercial olive orchards
Field observation and disease diagnosis:

- Testing symptomatic fruits
Field observation and disease diagnosis:

- Testing mummies from commercial olive orchards
Field observation and disease diagnosis:

➢ Testing symptomatic leaves
Field observation and disease diagnosis:

- Testing symptomatic leaves
Field observation and disease diagnosis:

- Botryosphaeria
Disease diagnosis: morphological studies

Undescribed species…

Leptosphaeria species…
Leaf senescence and leaf drop:

- General neglect of the normal inputs
- Water stress
- Nitrogen on other nutrient deficiency

Photo credits: E. Fichtner
Field observation and disease diagnosis:

- Nitrogen or Potassium deficiency, water problem
Field observation and disease diagnosis:

- Nitrogen or Potassium deficiency, water problem
Field observation and disease diagnosis:

- Neofabraea?
Field observation and disease diagnosis:

- Neofabraea
Field observation and disease diagnosis:

- Herbicide drift
Field observation and disease diagnosis:

- Lygus or Stink bug
Field observation and disease diagnosis:

- Weevil damages
Field observation and disease diagnosis:

- Freeze injury
Field observation and disease diagnosis:

- Olive anthracnose was not found in commercial olive orchards in California!
Kearney Ag Center:

[Map of California showing various UC campuses and REC locations, including Kearney REC, UC Davis, UCD Vet Med, UC Berkeley, UC Riverside, etc.]
Kearney Ag Center: Olive
Olive Anthracnose:

Gordal Sevillana olives
Olive Anthracnose:

Gordal Sevillana olives
Olive Anthracnose:
Olive Anthracnose: *Colletotrichum fioriniae*
Olive Anthracnose: causal agent

➢ *Colletotrichum fiorinia*e (*Colletotrichum acutatum species complex*)

- *Colletotrichum fiorinia*e
- *Colletotrichum acutatum*
- *Colletotrichum karstii*
- *Colletotrichum gloeosporioides*
Is Anthracnose a threat to California oil olives?

Anthracnose; Is it a Threat to California Pistachios?

By Theos J. Michalides, Paul L. Lichti, and Juan Moral

Anthracnose of pistachios. In July 2016, putative diseased samples were collected from two pistachio (Pistacia vera) orchards in northern California (Glenn County) with black and sunken lesions on leaves and branches. Samples were of the Red Aleppo, Joly, and Kerman cultivars. Eventually, individual fruit were totally blighted. These lesions from the pistachio leaf and the margins of leaf lesions from multiple diseased samples revealed 100 percent Colletotrichum species recovery from the cultivars (cv.) Red Aleppo and 18 percent from samples of the cv. Kerman in the first orchard. In the second orchard, 10 percent of the isolations from fruit lesions of cv. Red Aleppo and 10 percent of isolations from small spots in pistil were Colletotrichum species. Also, 40 percent of the fruit lesions produced B. dothidea, an indication that the conditions were conducive to both of these diseases in the summer of 2016. By early August lesions showed on fruit and leaves of cv. Joly, which was also planted in the first orchard, and isolations from fruit and leaf lesions of this cultivar also produced Colletotrichum species in the majority of isolations.

In Australia and China, the anthracnose of pistachio has been reported to cause significant yield losses, ranging from 25 percent to up to 50 percent in years with wet spring and summer (Yang et al., 2012; Hull et al., 2014). In California, it is considered a new discovery. Specifically, a 50 percent destruction of the Australian pistachios was reported following the very wet summer of 2016. The occurrence of this severe disease in a couple of orchards in Butte County reminds us of how the devastating Botryosphaeria pustule and shoot blight started in a pistachio orchard in northern California, and in about 12 years the disease became a devastating epidemic on pistachio throughout the state.
Anthracnose blight in pistachio

Dr Themis Michailides

University of California
Agriculture and Natural Resources
Botryosphaeria panicle and shoot blight in pistachio

Dr Themis Michailides

Bot first discovery in 1984; spread throughout CA in about 10-12 years.
Is Anthracnose a threat to California oil olives?
Is Anthracnose a threat to California oil olives?

- “Olive fruit usually becomes susceptible to the fungus under warm, humid conditions during summer as the fruit begins to develop and ripen.” Dr Vera Sergeeva - Australia

- “Anthracnose is a latent disease. The fungus infect the fruit when the environmental conditions are suitable but will remain dormant until the fruit begins to ripen.” Dr Vera Sergeeva - Australia

- “The disease incidence is not recognized until the symptoms appear on mature fruit. Early harvesting before ripening can avoid the disease.” Romero et al. 2017 - Spain

- CA environmental conditions are not too favorable for olive anthracnose

- New fungicides to be registered in CA

- **Conclusion**: Risks of anthracnose epidemic in CA oil olives are (very) low
Thank you!

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