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

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2016 disease discovered in CA:

Super High Density olive orchards in SJ County
2018 Surveys for Neofabraea diseases of olive:

Mainly found in Super High Density orchards and **Arbosana** olive so far

Minor finds in **Arbequina**

Not found in **Koroneiki**
Olive oil olives, San Joaquin County, Spring 2016:
Symptoms: defoliation

Arbosana  Koroneiki
Symptoms: Arbosana
Not to be confused with:

Neofabraea leaf spots

Peacock leaf spots
Fungal disease causing leaf drop may increase the incidence of olive knot (Increased number of leaf scars)
Symptoms: Branch cankers (Arbosana)
Symptoms: host susceptibility

Arbosana	Koroneiki
Symptoms: twig dieback (Arbosana)
Neofabraea diseases in olive:

- Fruits can also get infected in CA (Arbequina)
**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


Photo credits: J. Romero
Neofabraea diseases in olive:

- Detected in SHD olives in Italy
Disease diagnosis: An old disease, “Lepra”

SERGIO FOSCHI

GLOEOSPORIUM OLIVAE (PETRI) N. COMB., AGENTE DI ANTRACNOSI SU RAMI, FOGLIE E FRUTTI D’OLIVO

Nel 1907 il Petri rinvenne e studiò una malattia delle olive comparsa in Toscana su duree delle var. « Morainola » e « Mignola » all’epoca della loro maturazione. Egli determinò che l’agente di tale malattia era una criptogama cui diede il nome di Cylindrosporium olivae n. sp.

Noi abbiamo trovato il medesimo micorganismo su alcune varietà* d’olivo, nel 1953, in Romagna, dove però, oltre ai frutti, attaccava i rami e le foglie.

Alla descrizione delle alterazioni macro e microscopiche, che l’infezione fungina produce su questi vari organi, sono appunto destinate le pagine di cui è composta la prima parte del presente lavoro. Ad esse segue una relazione sugli esiti delle prove di riproduzione artificiale della malattia, e, infine, uno studio delle caratteristiche morfologiche e colturali del parassita insieme con una discussione sulla sua posizione sistematica; a conclusione della quale, anticipiamo fin da ora, ci è parso opportuno di compiere un trasferimento di genere, per cui la vecchia specie di Petri diviene Gloeosporium olivae.

SINTOMATOLOGIA

a) Rametti. — Abbiamo iniziato queste indagini nella primavera del 1953 quando venne richiamata la nostra attenzione su un caso di deperimento manifestatosi su numerose piante d’olivo, site in località « Madonna dell’olivo », a Cesena (Forlì). La varietà particolarmente colpita — che è anche la più diffusa nella zona — risultò essere il « Correggiolo ».

In un esame preliminare effettuato, verso la fine di maggio, alle piante malate abbiamo constatato un evidente appassimento e secchezza,

* Come è noto, è stato proposto di recente che la varietà di piante coltivate venga indicata col termine « cultivar » (abbreviazione: « cv. »), e già in alcuni lavori pubblicati in questa stessa rivista è stata applicata tale regola di nomenclatura. Noi però usiamo ancora la vecchia denominazione, nell’attesa che sia raggiunto l’argomento il pieno accordo fra i botanici e gli agronomi italiani.
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.

Photo credits: Iain MacSwann
Neofabraea diseases in apple and pear: Bull’s eye rot and canker

- The fungus overwinters in cankers and infected fruits
- Conidia are exuded from acervuli and dispersed by rain
- Perennial canker is associated with the low temperature or southwest injury, and pruning wounds
- The fungus can infect through the wounded portions of the tree
- Oregon, Washington, and California

Photo credits: OSU Extension Plant Pathology Collection
Pathogenicity in apple: Possible inoculum source

plant disease

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https://doi.org/10.1094/PDIS-08-15-0949-PDN

DISEASE NOTES

First Report of Neofabraea alba Causing Branch Canker Dieback of Apple in California

S. Rooney-Latham and M. C. Soriano, California Department of Food and Agriculture, Sacramento 95832.
Pathogenicity in apple:

- CA olive isolates are pathogenic to apple: source of inoculum?
Neofabrea coin disease of ash:

- Found on nursery stock Michigan, Oregon, and Ontario, Canada
- Cankers are annual
- Fraxinus species were examined around olive orchards in CA, but the olive pathogens were not detected

Photo credits: Linnea Skoglund and OSU Plant Clinic
Disease emergence: super-high-density oil olive

- Intensification of agricultural practices
- Mechanical harvest
- Changing weather conditions

University of California
Agriculture and Natural Resources
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 on leaves:
- **Wounds** are required for infection!
- New growth in the spring does not get infected
Pathogenicity in leaves:

- **Arbosana**: Lesion diameter is higher compared to **Arbequina** and **Koroneiki**.
- **Arbequina** and **Koroneiki**: Lesion diameters are similar.

### Graph:
- **Neofabraea kienholzii**
- **Phlyctema vagabunda**
- **Olive Cultivar**

- **Arbosana**: Lesion diameter (mm)
- **Arbequina**: Lesion diameter (mm)
- **Koroneiki**: Lesion diameter (mm)
Pathogenicity in shoots:

![Image of infected olive shoots]

**Graph:**
- **X-axis:** Olive Cultivar
  - Arbosana
  - Arbequina
  - Koroneiki
- **Y-axis:** Lesion length (mm)
- **Bars:**
  - Light gray: *Neofabraea kienholzii*
  - Gray: *Phlyctema vagabunda*
- **Significance:**
  - Arbosana: b
  - Arbequina: b
  - Koroneiki: a

*University of California
Agriculture and Natural Resources*
Pathogenicity in olive fruits:

![Graph showing lesion diameter for different fungal species and olive cultivars.](image)
Pathogenicity in olive fruits:

Gordal Sevillana olives
Temperature study:

[Graphs showing colony diameter vs. temperature for different strains of fungi]
Disease cycle:

Fall: Mechanical harvest

Rain

Fall: Infection of fresh wounds

Symptoms best visible in March

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

April: Defoliation
Disease control: fungicide trials

Copper fungicides?
Fungicide trials 2016-2017:

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

- Single application at harvest: November 22, 2017
- Two applications, one at harvest: November 22, 2017 and 2\textsuperscript{nd} on January 5, 2018

- Topsin M (thiophanate-methyl – group 1)
- Inspire Super (difenconazole/cyproconazole – 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 (Cyproconazole 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

Number of Leaf Spots

Treatment

Water control
Luna Experience
Vangard
Ziram
Inspire Super
Luna Sensation
Topsin M

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Fungicide trials 2016-2017:

Twig Lesion Incidence

Control: A
Vangard: B
Luna Experience: BC
Ziram: BC
Inspire Super: BC
Luna Sensation: C
Topsin M: C
Fungicide trials 2016-2017:

Leaf Spot Incidence

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Number of Leaf Spots</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water control</td>
<td>A</td>
</tr>
<tr>
<td>Kocide 3000</td>
<td>A</td>
</tr>
<tr>
<td>Mertect</td>
<td>AB</td>
</tr>
<tr>
<td>Bravo</td>
<td>BC</td>
</tr>
<tr>
<td>Tebucon</td>
<td>CD</td>
</tr>
<tr>
<td>Ziram</td>
<td>CD</td>
</tr>
<tr>
<td>Luna Experience</td>
<td>D</td>
</tr>
</tbody>
</table>
Fungicide trials 2016-2017:

Twig Lesion Incidence

- Water control
- Kocide 3000
- Bravo
- Tebucon
- Mertect
- Luna Experience
- Ziram

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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 (difenconazole/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)
Trial 1, single spray application: Average number of leaf lesions per olive tree according to various fungicide treatments and compared to the water treatment 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 a copper treatment (Kocide 3000).
### Fungicide trials 2018-2019: Trial 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 Phosphosus Inc</td>
<td>Ziram 76DF</td>
<td>37.5</td>
<td>6 pounds / acre</td>
<td>37.5</td>
<td>gr</td>
</tr>
<tr>
<td>Syngenta</td>
<td>Inspire Super</td>
<td>8.2</td>
<td>20 fl oz</td>
<td>8.2</td>
<td>mL</td>
</tr>
<tr>
<td>Certis</td>
<td>Kocide 3000</td>
<td>43.7</td>
<td>7 lb</td>
<td>43.7</td>
<td>gr</td>
</tr>
<tr>
<td>Control</td>
<td>W</td>
<td></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>
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</tbody>
</table>
## Duration of wound susceptibility: Leaves

<table>
<thead>
<tr>
<th>Week</th>
<th>Flag color</th>
<th>Inoculation</th>
<th>Record</th>
</tr>
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<tbody>
<tr>
<td>W 0</td>
<td>Orange</td>
<td>22-Nov</td>
<td>2/1/2018</td>
</tr>
<tr>
<td>W 1</td>
<td>Blue</td>
<td>29-Nov</td>
<td>2/8/2018</td>
</tr>
<tr>
<td>W 2</td>
<td>Green</td>
<td>6-Dec</td>
<td>2/15/2017</td>
</tr>
<tr>
<td>W 3</td>
<td>Purple</td>
<td>13-Dec</td>
<td>2/22/2017</td>
</tr>
<tr>
<td>W 4</td>
<td>Red</td>
<td>20-Dec</td>
<td>3/1/2017</td>
</tr>
<tr>
<td>W 5</td>
<td>Yellow</td>
<td>27-Dec</td>
<td>3/8/2018</td>
</tr>
</tbody>
</table>
Duration of wound susceptibility: Leaves

Graph showing the percentage of incidence leaf spots over time, with a linear trend line and the equation $y = -17.27x + 111.96$ and $R^2 = 0.88$. The graph is labeled "Neofabrae kienholzii - Leaf wound susceptibility over time Lath-house data 2017-2018."
Duration of wound susceptibility: Leaves

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

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

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

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

![Graph showing incidence of leaf spots over weeks after harvest.](image)
Duration of wound susceptibility: Twigs

**Graph:**
- **Title:** Neofabraea kienholzii
- **Y-axis:** Percent of infection (%)
- **X-axis:** Weeks (Week 0 to Week 5)

The graph shows the percentage of infection over time for Neofabraea kienholzii. The infection rate decreases significantly from Week 0 to Week 5.
Duration of wound susceptibility: Twigs

Neofabraea Vagabunda

Percent of infection (%)

Weeks

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

Weeks

Log. (N Vagabunda)
Timing of fungicide applications:

![Graph showing the timing of fungicide applications with bars for each week from Week 0 to Week 5. The graph indicates a decrease in percent of infection over time.](Image)

- **Week 0**: High percent of infection
- **Week 1**: Decrease in percent of infection
- **Week 2**: Further decrease in percent of infection
- **Week 3**: Continued decrease in percent of infection
- **Week 4**: Mild decrease in percent of infection
- **Week 5**: Minimal decrease in percent of infection

**Arrow indicators**:
- **T1**: Indicates the timing of the first fungicide application
- **T2**: Indicates the timing of the second fungicide application

**Harvest**: Peak in percent of infection.
Fungicide registration:

- IR-4 Registration
- Section 18 emergency exception on pesticide use
- Requires efficacy data from field trials (UC)
- Working with OCCC to submit a section 18 request to DPR
- If granted, the Section 18 label would allow growers to use the “new” fungicide for one year
Section 18: in coordination with Dr. Jim Adaskaveg for Neofabraea and peacock spots control

<table>
<thead>
<tr>
<th>State of California</th>
</tr>
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<tbody>
<tr>
<td>Department of Pesticide Regulation</td>
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<tr>
<td>Pesticide Registration Branch</td>
</tr>
<tr>
<td>PR-REG-003 (Est. 7/91) (Rev. 3/10)</td>
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**APPLICATION**

**FOR SECTION 18 EMERGENCY EXEMPTION**

The following information is required for an emergency exemption request based on the revised United States Environmental Protection Agency (USEPA) Code of Federal Regulations, Title 40, Part 166 concerning Section 18 requests. Requests which are incomplete will be denied by the USEPA without review. In order to comply with these requirements, the information listed below must be provided. Use additional pages if necessary. Please note that the more complete the questionnaire, the better your chances are of obtaining the exemption.

**[ ] Check box if this is a reissuance request. (Year __)**

<table>
<thead>
<tr>
<th>TYPE OF EXEMPTION BEING REQUESTED (check one)</th>
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<tr>
<td>[ ] SPECIFIC</td>
</tr>
<tr>
<td>[ ] QUARANTINE</td>
</tr>
<tr>
<td>[ ] PUBLIC HEALTH</td>
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## Section 18:

### Table 1:

<table>
<thead>
<tr>
<th>Client Sample</th>
<th>EMA Sample No</th>
<th>Sample</th>
<th>Date Analyzed</th>
<th>Method</th>
<th>Chemical</th>
<th>Amount</th>
<th>RL</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1-P</td>
<td>18071821-01</td>
<td>Olive Fruits</td>
<td>07/26/18</td>
<td>LC/MS/MS Extended</td>
<td>Cyprodinil</td>
<td>ND</td>
<td>0.01</td>
<td>ppm</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Difenoconazole</td>
<td>ND</td>
<td>0.01</td>
<td>ppm</td>
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<tr>
<td>T2-P</td>
<td>18071821-02</td>
<td>Olive Fruits</td>
<td>07/26/18</td>
<td>LC/MS/MS Extended</td>
<td>Cyprodinil</td>
<td>ND</td>
<td>0.01</td>
<td>ppm</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Difenoconazole</td>
<td>ND</td>
<td>0.01</td>
<td>ppm</td>
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<tr>
<td>T1-O</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>
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<tr>
<td>T1-P</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>
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<td>ppm</td>
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</table>

### Table 2:

<table>
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<tr>
<th>Client Sample</th>
<th>EMA Sample No</th>
<th>Sample</th>
<th>Date Analyzed</th>
<th>Method</th>
<th>Chemical</th>
<th>Amount</th>
<th>RL</th>
<th>Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>T2-O</td>
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<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 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](http://emalab.com/ISO17025.pdf)
Table 1. Yield data for two locations where Neofabrae diseases have been documented.

<table>
<thead>
<tr>
<th></th>
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<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.
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 (leaves 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
- Section 18 emergency exception on pesticide use + IR4
Field observation and disease diagnosis:

- Neofabraea on fruits
Field observation and disease diagnosis:

- Botryosphaeria
Field observation and disease diagnosis:

- Lygus or Stink bug
Thank you!

Dr. Mohamed T. Nouri, UCD
Dr. Renaud Travadon, UCD
Dr. Juan Moral, UCD
Dr. Jim Adaskaveg, UCR
Dr. Brenna Aegerter, UCCE
Dr. Dani Lightle, UCCE