A review of common fungal canker pathogens affecting native and cultivated woody plants in California

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What is a canker?

- Latin: Cancer (n.) "spreading sore, malignant tumor"
- Caused mainly by fungal pathogens in the **Ascomycetes**
- “Killing the bark/phloem and eventually the cambium” or “killing the wood and eventually the bark/phloem”
- Sunken lesion of the bark (bark canker) vs. wood discoloration (wood canker)

Eutypella canker

Nectria canker

Forest Pathology

Almond, grape, cherry canker diseases

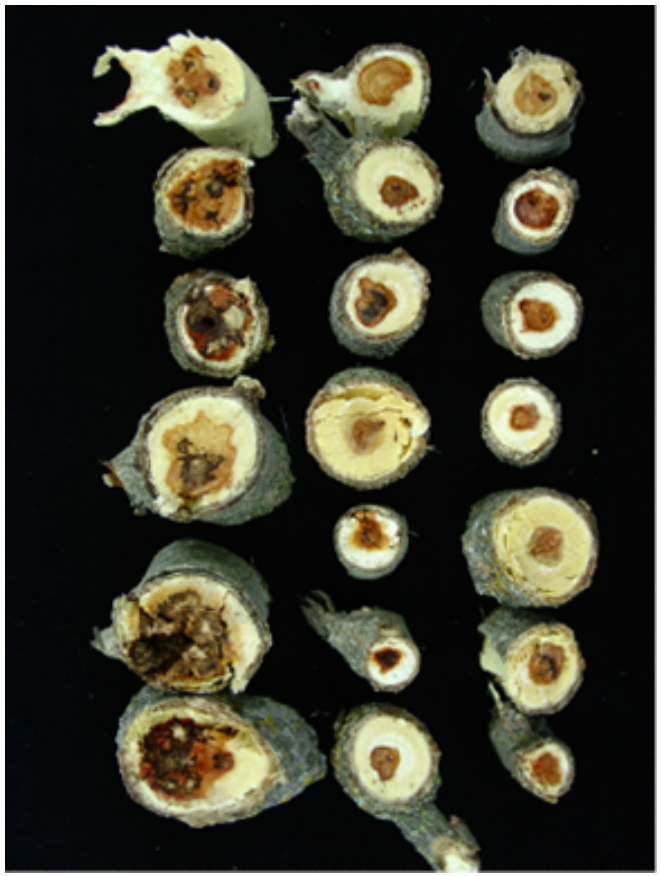
Tree crop pathology

Cankers in Chestnut blight:

- Caused by the fungal pathogen *Cryphonectria parasitica*
- The canker eventually girdles the branch or trunk, killing everything above it.

Wood cankers in trees:

- Discoloration of the wood (Xylem)
- Restrict water movement

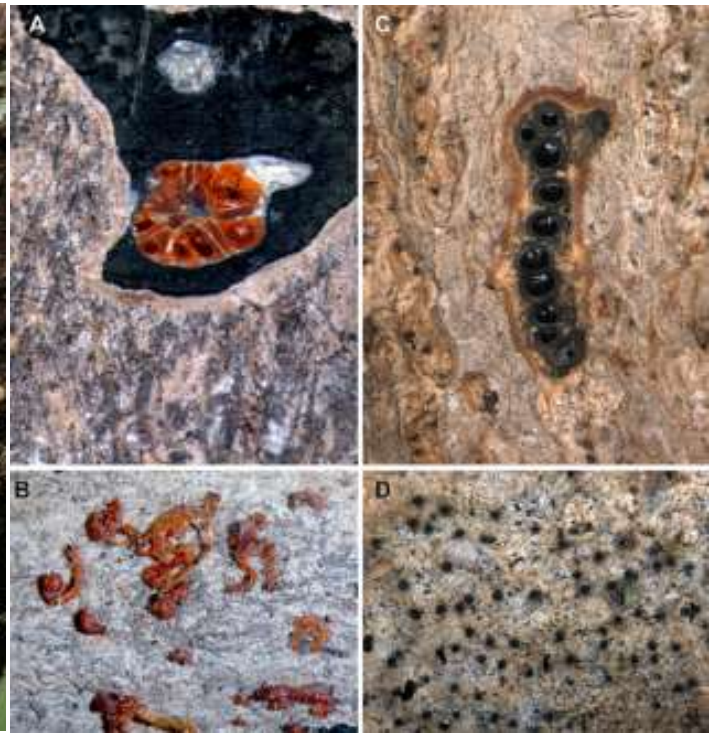


Dieback symptoms :

- The canker eventually girdles the branch or trunk, killing everything above it.
- Dieback symptoms usually appear when water demand is high

Disease signs:

- Common presence of fungal fruiting bodies (Ascomycetes, Pyrenomycetes)
- Pycnidia, perithecia
- Ease the diagnostic process



Infection court of canker diseases in natural systems:

- Insect damages
- Storm/wind damages
- Bird damages

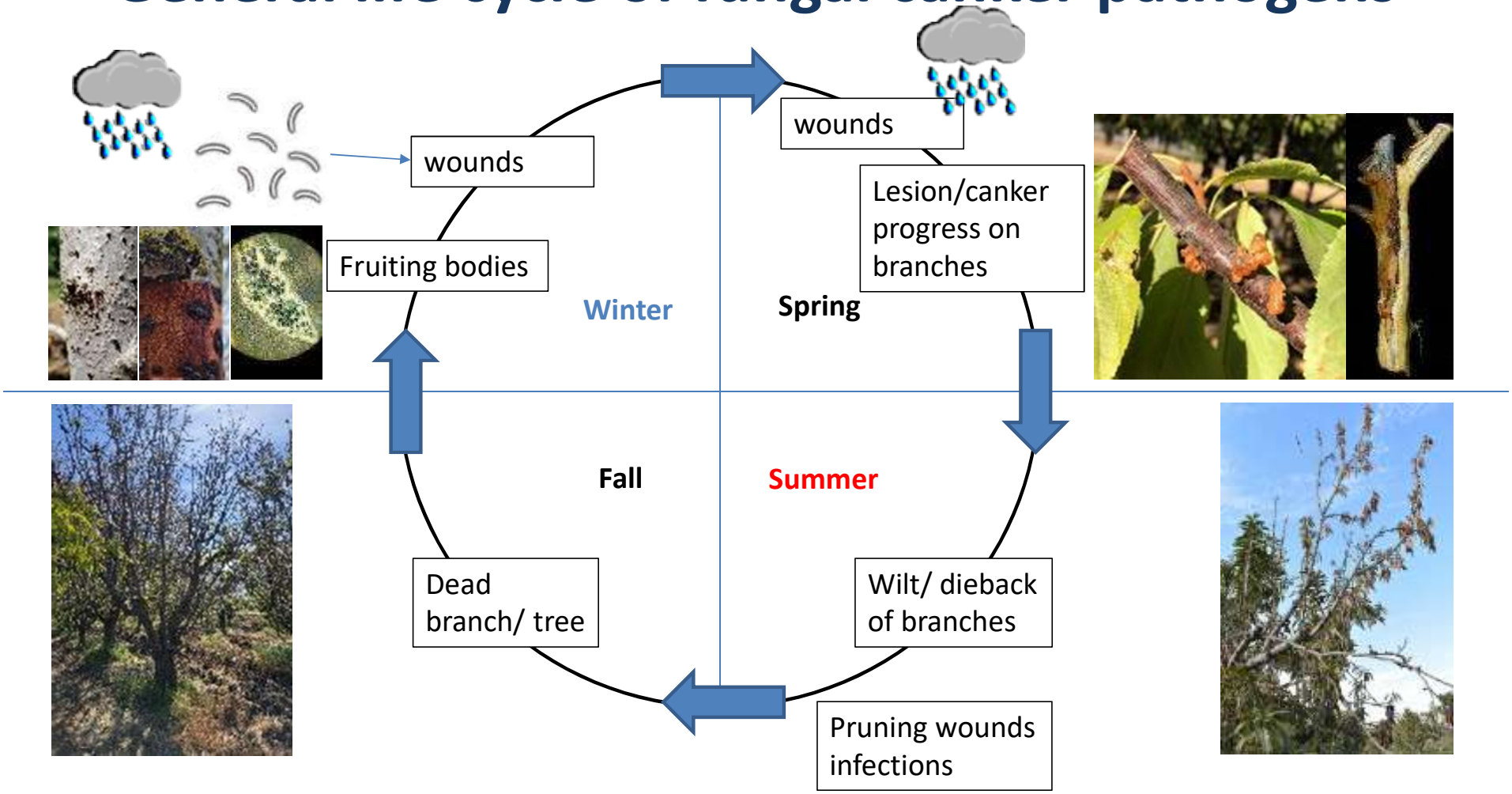
Infection court of canker diseases in agricultural systems:

- Infections occurs at wounds caused by cultural practices
- Pruning
- Mechanical harvest

Infection court of canker diseases in agricultural systems:

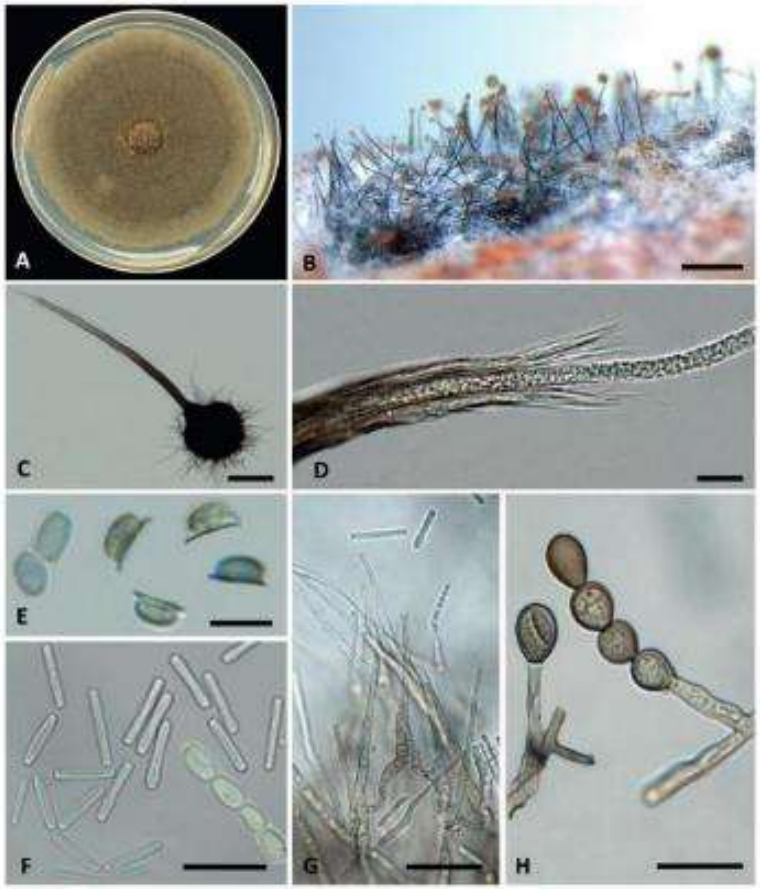
- Intensive pruning
- Yearly pruning of perennial tree crops:

General life cycle of fungal canker pathogens



Ceratocystis canker of almond:

- Spread by insects to fresh wounds
- Like in Dutch elm disease (wilt) caused by Ophiostoma novo-ulmi



Early grapevine research on canker diseases in California:

- The work on grapevine fungal canker diseases in CA set the foundation for exploring and better understanding canker diseases in perennial crops and woody plants in CA.
  - **Eutypa (Diatrypaceae) dieback:** Trouillas et al. 2010; 2011; 2015
  - **Botryosphaeriaceae canker diseases:** Úrbez-Torres et al. 2006, 2009
  - **Phomopsis (Diaporthe) dieback:** Urbez-Torres et al. 2013
  - **Esca disease:** Rooney-Latham et al. 2005; Eskalen et al. 2007
  - **Cytospora canker**: Lawrence et al. 2016

Early research on panicle and shoot blight of Pistachio and walnut blight:

- **Botryosphaeriaceae and Phomopsis (Diaporthe) species (T.M. Michailides et al.)**

Panicle and Shoot Blight of Pistachio: A Major Threat to the California Pistachio Industry

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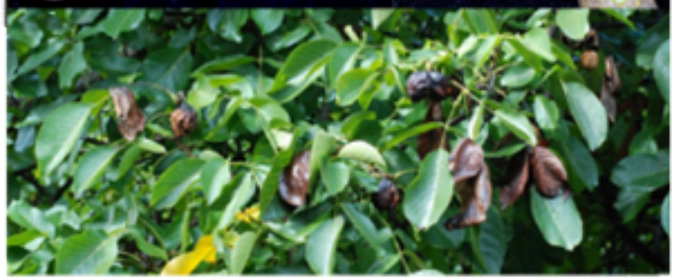
Pistachio is a dioecious plant with fruit drupes born in taxiarthies called panicles (clusters).



Phylogeny, Morphology, Distribution, and Pathogenicity of Botryosphaeriaceae and Diaporthaceae from English Walnut in California

Shaofei Chen and **David P. Morgan**, Department of Plant Pathology, University of California-Davis/Kearney Agricultural Research and Extension Center, Parlier 93648; **Janice K. Hasey**, University of California Cooperative Extension, Yuba/Sutter Co., Yuba City 95991; **Kathleen Anderson**, University of California Cooperative Extension, Stanislaus Co., Modesto 95358; and **Themis J. Michailides**, Department of Plant Pathology, University of California-Davis/Kearney Agricultural Research and Extension Center

Common fungal canker pathogens of cultivated and native woody plants:

- **Diatrypaceae**
- **Botryosphaeriaceae**
- **Cytospora spp. (Valsaceae)**
- **Phomopsis (Diaporthe)**

- Ceratocystis (almond trees)

- Phytophthora (aerial cankers)

Example: Fungal canker diseases of almond in California

Botryosphaeriaceae

- *Botryosphaeria dothidea*
- *Neofusicoccum mediterraneum*
- *Neofusicoccum vitifusiforme*
- *Neofusicoccum parvum*
- *Neofusicoccum arbuti*
- *Diplodia seriata*
- *Diplodia mutila*
- *Dothiorella iberica*
- *Macrophomina phaseolina*
- *Spencermartinsia viticola*
- *Neoscytalidium dimidiatum*

Cytospora eucalypti
Cytospora sorbicola
Cytospora sp. 1
Cytospora sp. 2
Cytospora sp. 11

Phytophthora cinnamomi
Phytophthora cactorum

Diaporthe australafricana
Diaporthe eres
Diaporthe rhusicola

Eutypa lata

Ceratocystis fimbriata

Botryosphaeriacea, Diaporthaceae (*Phomopsis*), Diatrypaceae and *Cytospora* spp. are global canker pathogens of perennial woody plants

The rise of fungal canker diseases in agricultural systems in CA:

- Intensification of agricultural practices
- Global warming and climate change
- Global movement of plant material
- Pathogen introduction
- Expanded geographical distribution of the host

- **Factors that contribute to a deviation in disease occurrence, expression and distribution**
- **California is at the forefront of new disease emergence**

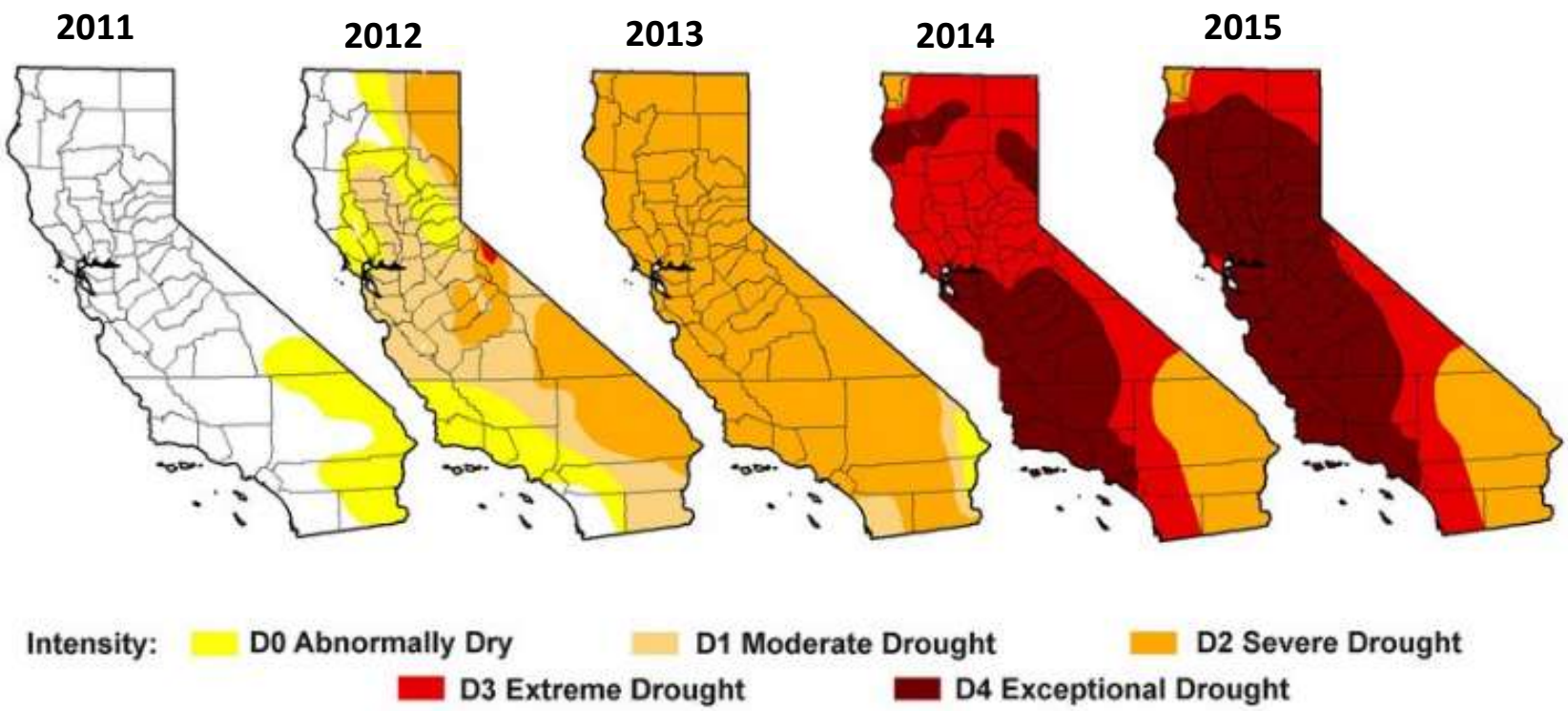
Intensification of agricultural practices in California:

- Labor shortage
- Mechanization
- High and Super High Density systems
- Intensive pruning
- Intensive clonal propagation of tree crops
- Large uses of water, Nitrogen



California at the forefront of global warming and climate change:

- Change in weather patterns:
  - 2011-2016 California drought: worst drought on records
  - Record wet year 2017
- Increased wet conditions of late winter and spring



Water stress (drought) exacerbates canker diseases:

Water Stress and the Development of Cankers by *Diplodia mutila* on *Quercus robur*

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Received June 4, 1998; accepted November 5, 1998

Keywords: *Quercus robur*, *Diplodia mutila*, osmotic and water potential

Table 2
Length of cankers produced by *Diplodia mutila* in relation to the pre-dawn water potential

	Pre-dawn water potential[a]		Canker length (m)			
Seedling type	Before inoculation (MPa)	After inoculation (MPa)	28	38	43	48[b]
Water-stressed	−2.93	−2.92[c]	25 ± 0.1	26 ± 0.2	30 ± 0.1	41 ± 0.1
Non-stressed	0.80	0.79[c]	10 ± 0.2	12 ± 0.2	23 ± 0.1	29 ± 0.1

[a]average values; [b]days after inoculation; [c]mean water potential (average of measurements made 28–48 days after inoculation using the Shoffander pressure chamber).

Effects of Water Stress on Botryosphaeria Blight of Pistachio Caused by *Botryosphaeria dothidea*

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Table 3. Effects of drought stress on Botryosphaeria blight of pistachio caused by *Botryosphaeria dothidea* in a greenhouse

Year/experiment	Days without water	Water potential (ψ) of mature leaves (−MPa)	Disease index*
1999 / I and II	0	0.485[x] c[y]	0.530[x] c[y]
	5	0.554 bc	1.070 b
	8	0.635 b	1.350 ab
	11	0.750 a	1.600 a
2000 / I	0	0.472[z] d	0.551[z] c
	5	0.576 c	0.692 bc
	8	0.702 b	0.746 b
	11	0.868 a	0.995 a
2000 / II	0	0.466[z] c	0.417[z] a
	5	0.524 b	0.434 a
	8	0.550 b	0.466 a
	11	0.584 a	0.510 a

Grapevine trunk disease fungi: their roles as latent pathogens and stress factors that favour disease development and symptom expression

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Drought Exacerbates Botryosphaeria Dieback Symptoms in Grapevines and Confounds Host-based Molecular Markers of Infection by *Neofusicoccum parvum*

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Endophytes and latent canker pathogens of woody plants:

Molecular Plant Pathology

MOLECULAR PLANT PATHOLOGY (2017) 18(4), 477–488 DOI: 10.1111/mpp.12495

Pathogen profile

Botryosphaeria dothidea: a latent pathogen of global importance to woody plant health

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Understanding the Process of Latent Infection of Canker-Causing Pathogens in Stone Fruit and Nut Crops in California

Yong Luo,[1,†] Paulo S. F. Lichtemberg,[1] Franz J. A. Niederholzer,[2] Danielle M. Lightle,[3] Daniel G. Felts,[1] and Themis J. Michailides[1,†]

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Review

Botryosphaeriaceae as endophytes and latent pathogens of woody plants: diversity, ecology and impact

Bernard Slippers, Michael J. Wingfield

Review

Grapevine trunk disease fungi: their roles as latent pathogens and stress factors that favour disease development and symptom expression

Jared HRYCAN[1,2], Miranda HART[2], Patricia BOWEN[1], Thomas FORGE[1], José Ramón ÚRBEZ-TORRES[1,*]

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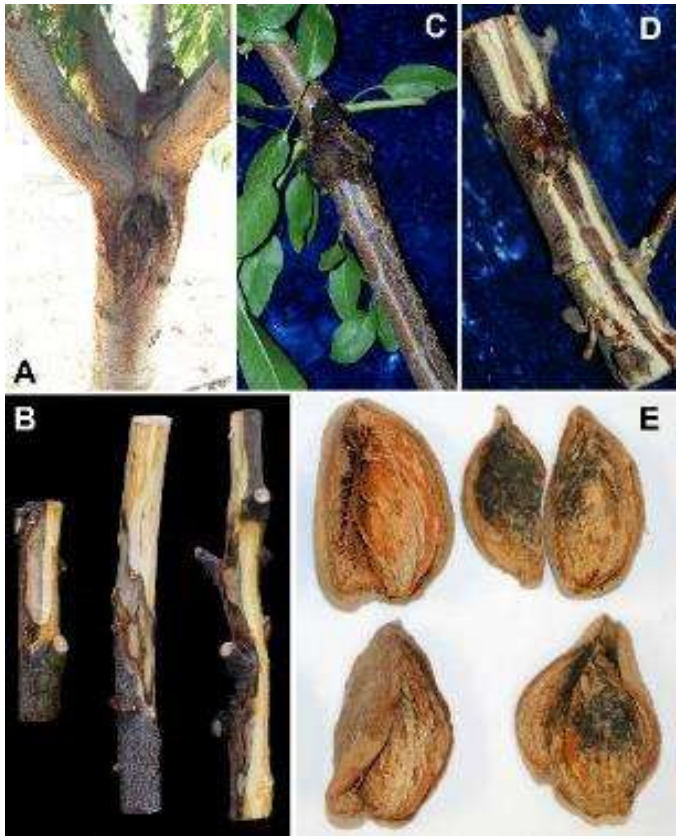
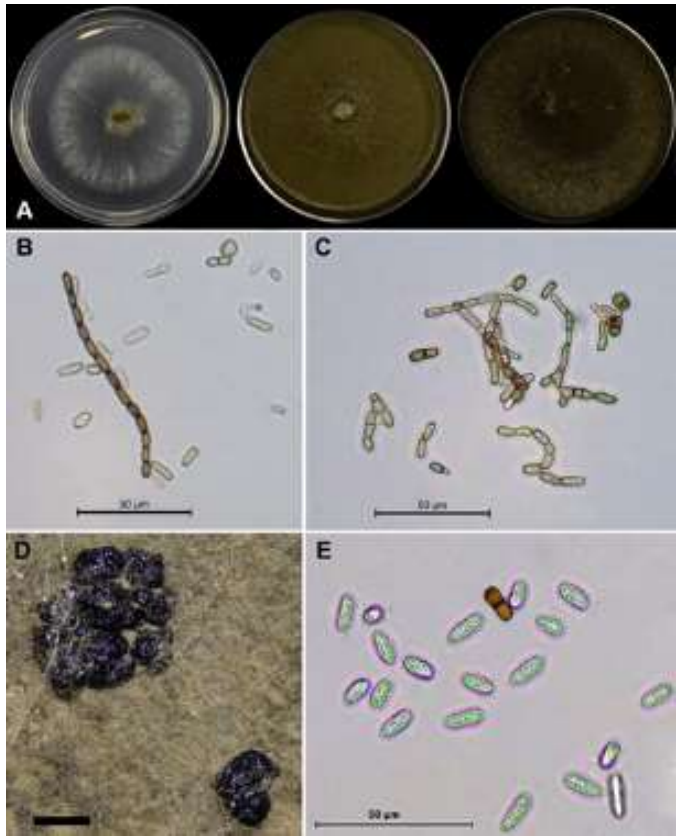
Drought/heat selected canker pathogens:

- ***Neoscytalidium dimidiatum*** **(Botryosphaeriaceae) causing canker and fruit rot diseases in various fruit & nut crops**

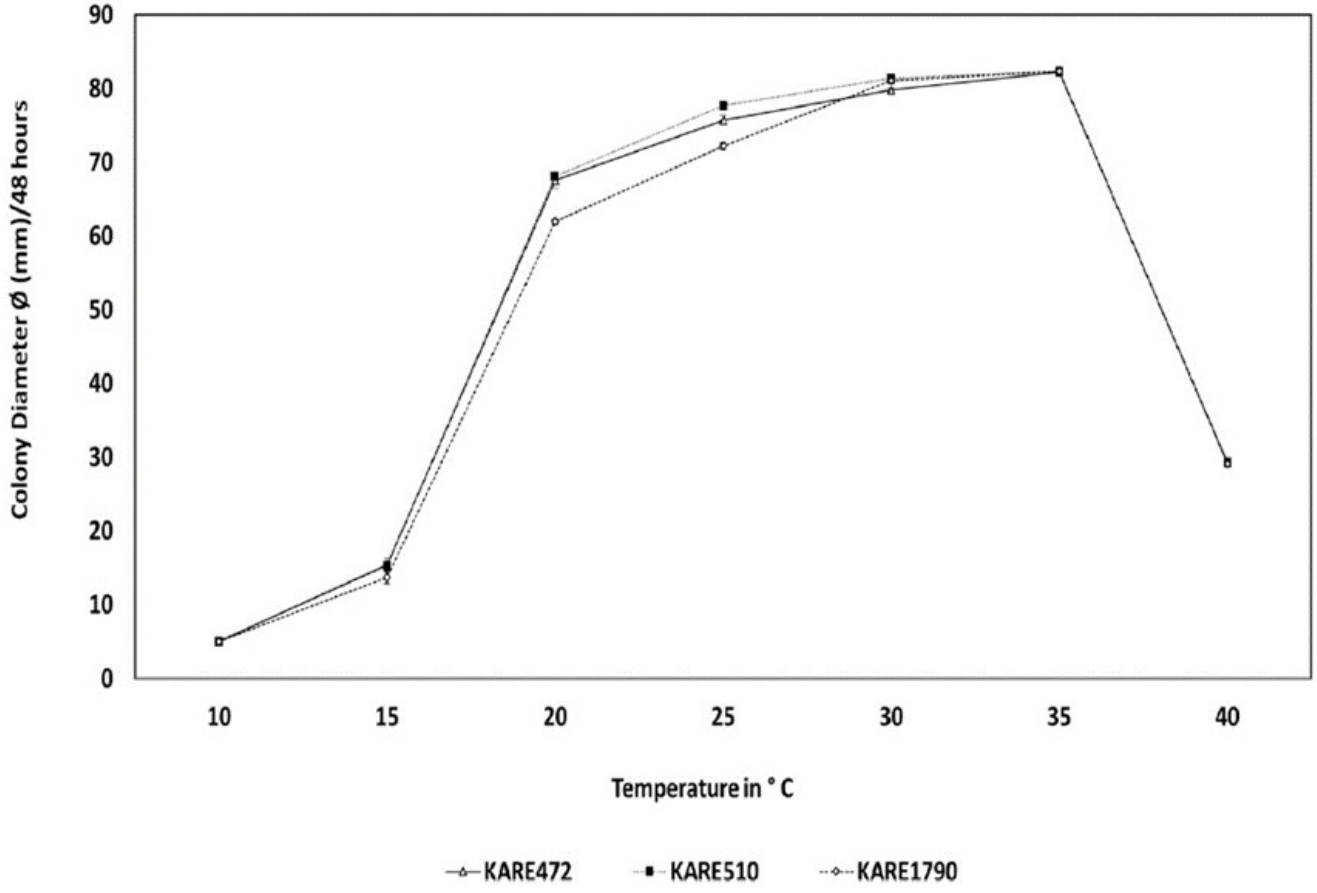
- **English walnut:** Teviotdale and Schroth, 1998
- **Figs:** Michailides et al., 2005
- **Table grape:** Rolshausen et al., 2013
- **Citrus:** Mayorquin et al. 2015
- **Almond:** Nouri et al. 2018





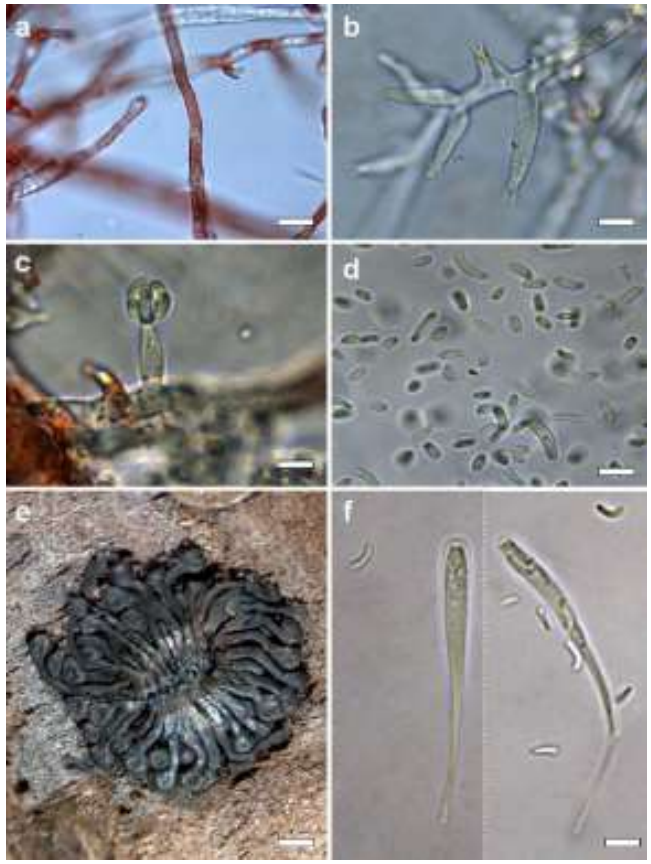
***Neoscytalidium dimidiatum*:**

Optimal temperature for growth



Calosphaeria canker of sweet cherry in CA:

- **Rather host specific but with global distribution**



e-Xtra*

Calosphaeria Canker of Sweet Cherry Caused by *Calosphaeria pulchella* in California and South Australia

F. P. Trouillas, F. Peduto, and **J. D. Lorber,** Department of Plant Pathology, University of California, Davis, California 95616; **M. R. Sosnowski,** South Australian Research and Development Institute, GPO Box 397, Adelaide, SA 5001, Australia; **J. Grant,** University of California Cooperative Extension, San Joaquin County, Stockton, California 95206; **W. W. Coates,** University of California Cooperative Extension, San Benito County, Hollister, California 95024; **K. K. Anderson,** University of California Cooperative Extension, Stanislaus County, Modesto, California 95358; **J. Caprile,** University of California Cooperative Extension, Contra Costa County, Pleasant Hill, California 94523-4215; and **W. D. Gubler,** Department of Plant Pathology, University of California, Davis, California 95616

Abstract

Trouillas, F. P., Peduto, F., Lorber, J. D., Sosnowski, M. R., Grant, J., Coates, W. W., Anderson, K. K., Caprile, J., and Gubler, W. D. 2012. Calosphaeria canker of sweet cherry caused by *Calosphaeria pulchella* in California and South Australia. Plant Dis. 96:648-658.

California is the second largest sweet cherry producer in the United States with annual revenues up to $200 million. The South Australian cherry industry generates about 10% of Australia's overall production with approximately 1,500 metric tons of cherries produced yearly. In California, perennial canker diseases and subsequent branch dieback are responsible for extensive damage throughout sweet cherry orchards, reducing annual yields and tree longevity. Surveys of cherry orchards and isolation work were conducted in California to identify the main canker-causing agents. *Calosphaeria pulchella* was the main fungus isolated from cankers, followed by *Eutypa lata* and *Leucostoma persoonii*, respectively. Preliminary surveys in cherry orchards in South Australia documented *C. pulchella* and *L. persoonii* in cankers. The pathogenicity of *C. pulchella* in sweet cherry was confirmed following field inoculations of 2- to 3-year-old branches. *C. pulchella* was able to infect healthy wood and produce cankers with as much virulence as *E. lata* or *L. persoonii*. Spore trapping studies were conducted in two sweet cherry orchards in California to investigate the seasonal abundance of *C. pulchella* spores. Experiments showed that rain and sprinkler irrigation were important factors for aerial dissemination. Finally, this study illustrates the symptoms and signs of the new disease Calosphaeria canker.

The California cherry industry currently produces about 25% of all sweet cherry (*Prunus avium*) grown in the United States, with 80,000 metric tons of cherries produced each year on approximately 12,800 ha (24,29,30). California produces the earliest sweet cherry crop in the United States as well as approximately 40 varieties of cherries. The California cherry industry is mostly represented by family-owned businesses, and current trends are for acreage increases and planting of new varieties.

The Australian cherry industry is a relatively small farming industry with approximately 485 growers distributed throughout the southern half of the country (12). The industry is concentrated in New South Wales, Victoria, Tasmania, and South Australia and has smaller production areas in Western Australia and Queensland. In 2010, the industry generated 15,243 metric tons of cherries on 2,845 ha according to the Cherry Growers of Australia Inc. (12). The gross value of the cherry industry for 2008–2009 was AU$126 million (Australian Bureau of Statistics). The South Australian cherry industry counts approximately 120 growers and produces 10% of Australia's production (12). Most cherry plantings occur in the Adelaide Hills and Riverland areas.

In recent years, the incidence of dieback and canker diseases has increased significantly in the main cherry producing regions of California. Canker diseases generally constitute major threats to productivity by reducing tree health, yield, and longevity. Canker diseases commonly develop in tree branches as necroses of vascular tissues (23). Water, as well as phloem movement, becomes increasingly diminished as functional conductive pathways are lost (3). Characteristic dieback symptoms appear when water demand exceeds the conductive capacity of the narrowing pathways (3). Despite the common occurrence of dieback in cherry trees in California, associated fungi have not been fully investigated. *Eutypa lata* (Pers.:Fr.) Tul. & C. Tul. (Syn: *E. armeniacae* Hansford & Carter) is known to be responsible for Eutypa dieback of sweet cherry (16), and since the first report of *E. lata* on sweet cherry in California, this fungus has been thought responsible for most dieback symptoms observed in cherry orchards. Nevertheless, the actual importance of *E. lata* and its contribution to the numerous wood cankers and branch dieback symptoms observed in California has not been determined. Leucostoma canker (=Cytospora or Valsa canker) caused by *Leucostoma persoonii* (Nitschke) Höhn. also is known to occur in stone fruits in California, but it is believed to be of relatively minor importance on sweet cherry (6). Other known pathogens of stone fruits in California include wood rotting and wood decay fungi, primarily in the Basidiomycetes (2).

In 2010, we first reported *Calosphaeria pulchella* (Pers.:Fr.) J. Schröt (anamorph: *Calosphaeriophora pulchella* Réblová, L. Mostert, W. Gams & Crous) to be associated with dieback of sweet cherry in California (27). However, much work remains to characterize the disease, incidence, distribution, and aggressiveness of *C. pulchella* in relation to other fungal pathogens of sweet cherry in California. *C. pulchella* has also been reported from decaying scaffold branches of peach trees (*Prunus persica*) in South Carolina; however, the type of decay produced by this fungus remained undetermined (1). The taxonomy of *C. pulchella* has been investigated using morphological and/or phylogenetic analyses (4,7,9,15,19,20). These studies have positioned *C. pulchella* in the order Calosphaeriales and have provided detailed descriptions and illustrations of its anamorphic and teleomorphic states.

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* The *e*-Xtra logo stands for "electronic extra" and indicates that Figures 1, 2, and 3 appear in color online.

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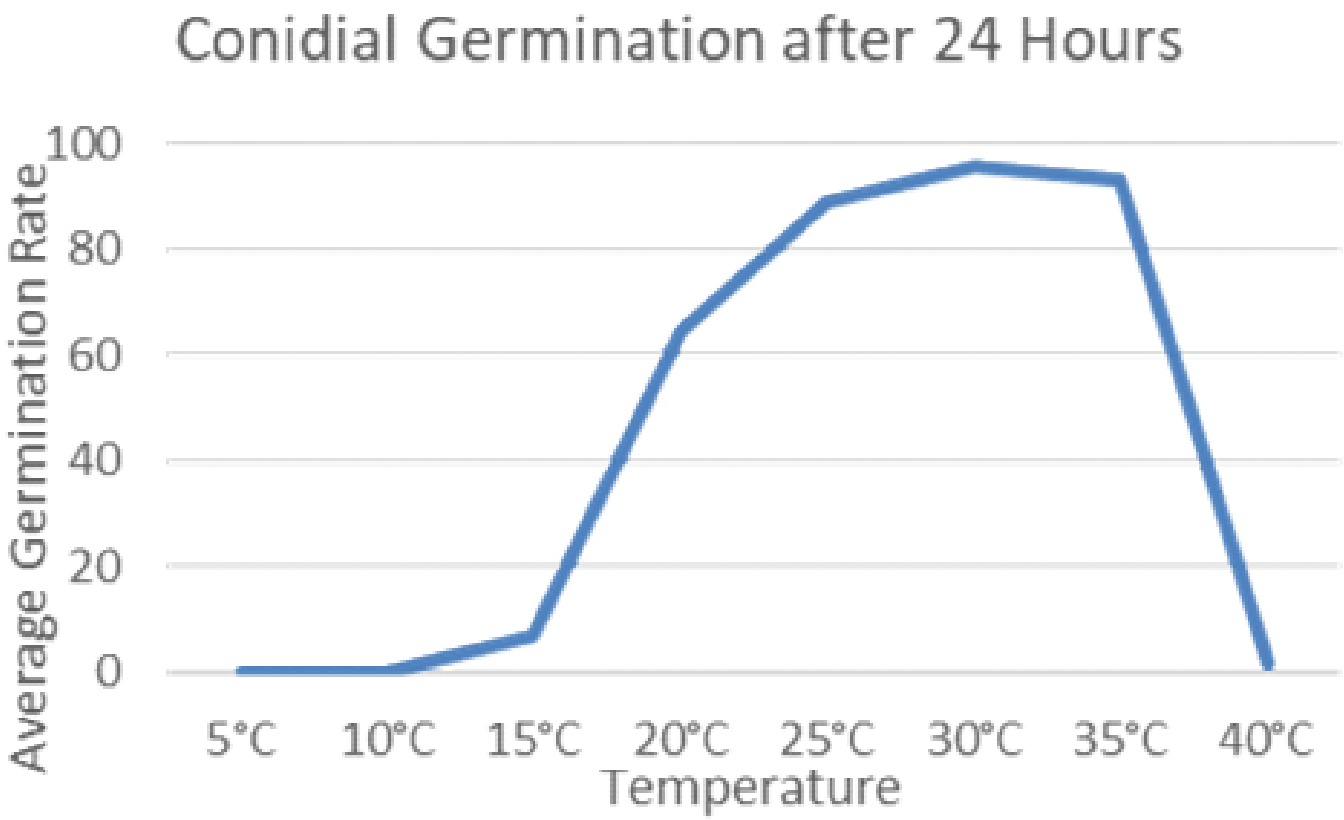
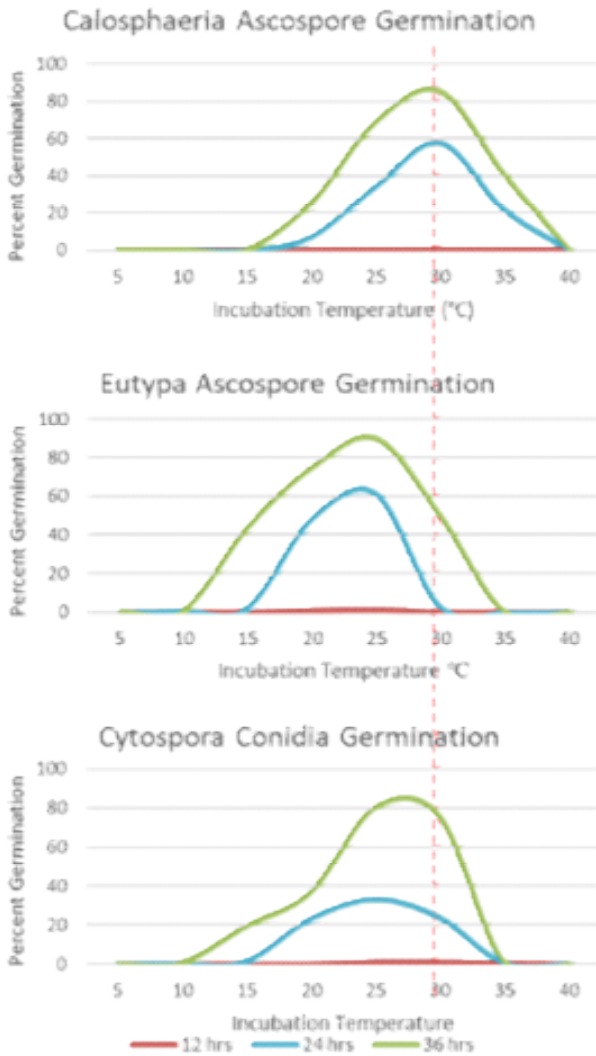
***Calosphaeria pulchella*:**





California drought:

More than 100 million dead trees in California from drought

Date: November 25, 2016

Source: U.S. Department of Agriculture

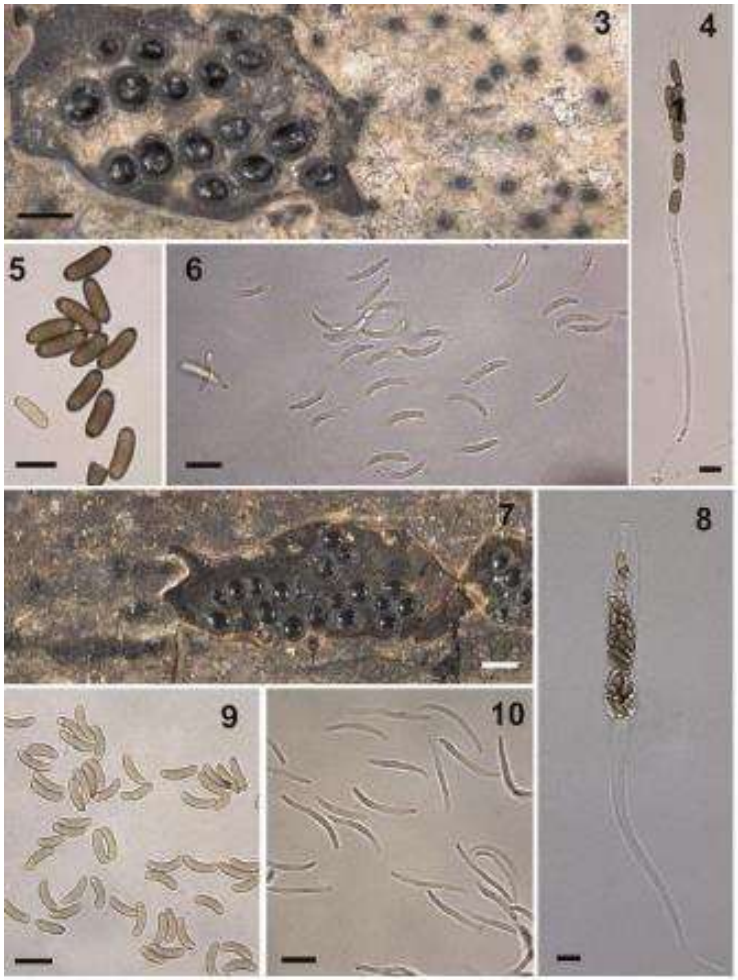
Summary: The U.S. Forest Service has identified an additional 36 million dead trees across California since its last aerial survey in May 2016. This brings the total number of dead trees since 2010 to over 102 million on 7.7 million acres of California's drought stricken forests. In 2016 alone, 62 million trees have died, representing more than a 100 percent increase in dead trees across the state from 2015. Millions of additional trees are weakened and expected to die in the coming months and years.

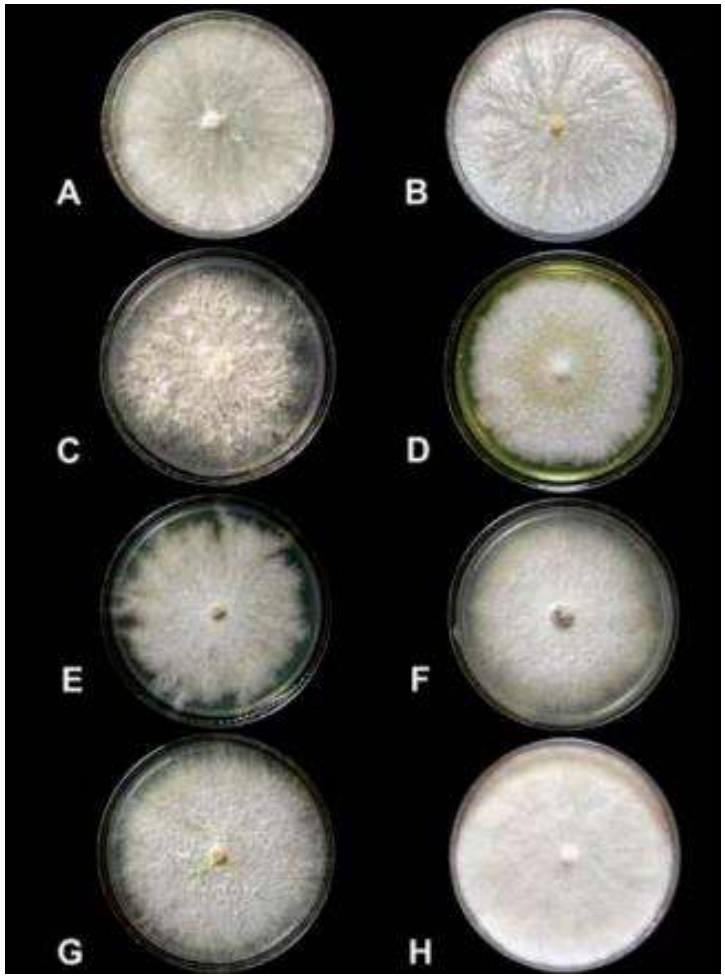
Share:

"Substantial increase in the number of dead trees in California may have increased significantly the amount of disease inoculum of many canker causing fungi."

Canker diseases caused by Diatrypaceae fungi

The Diatrypaceae fungi: (Pyrenomycetes, Xylariales)





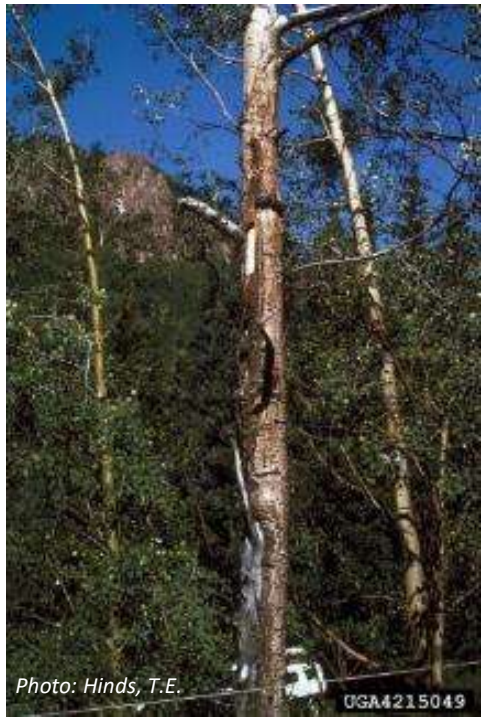
Common canker diseases of forest trees caused by Diatrypaceae

Eutypella canker

- *Eutypella parasitica* (Diatrypaceae)
- Maple (*Acer*) species
- Davidson RW, Lorenz RC. 1938.

Cryptosphaeria canker

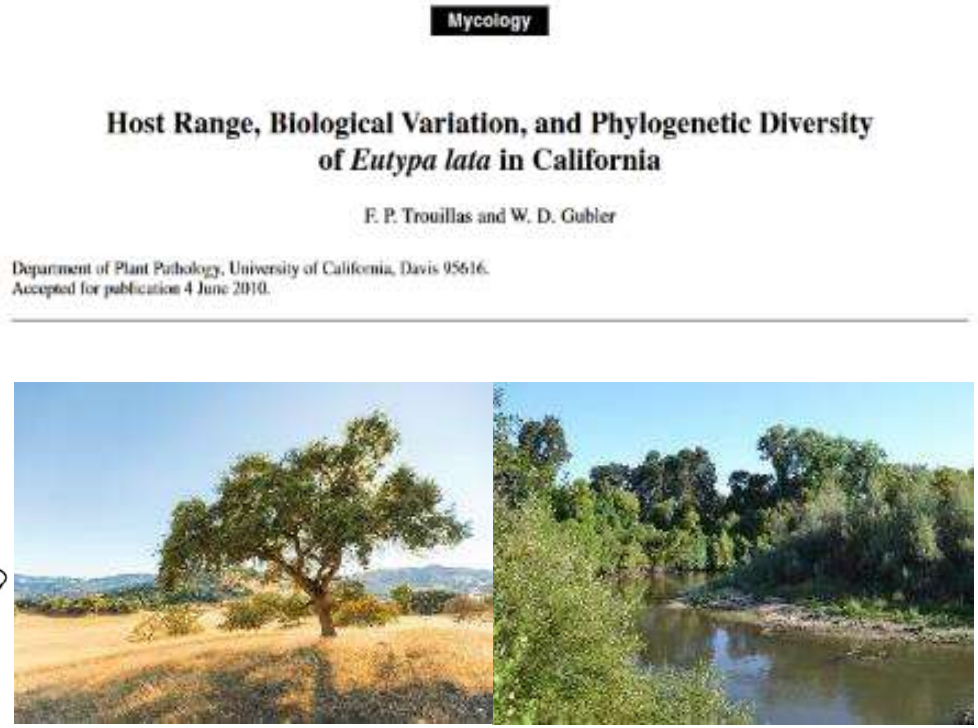
- *Cryptosphaeria lignyota* (Diatrypaceae)
- Aspens, *Populus tremuloides*
- Hinds TE. 1981.



Eutypa dieback of grapevine in California:

- Caused by ***Eutypa lata*** (Diatrypaceae)
- In 1990's, *E. lata was* the only known canker pathogen of grapevine
- Investigating the **host range and inoculum sources** of *Eutypa lata* in California
- I surveyed vineyards, orchards, forest trees and ornamentals around California

Investigating the host range (inoculum sources) of *Eutypa lata* in CA:



Mycology

Host Range, Biological Variation, and Phylogenetic Diversity of *Eutypa lata* in California

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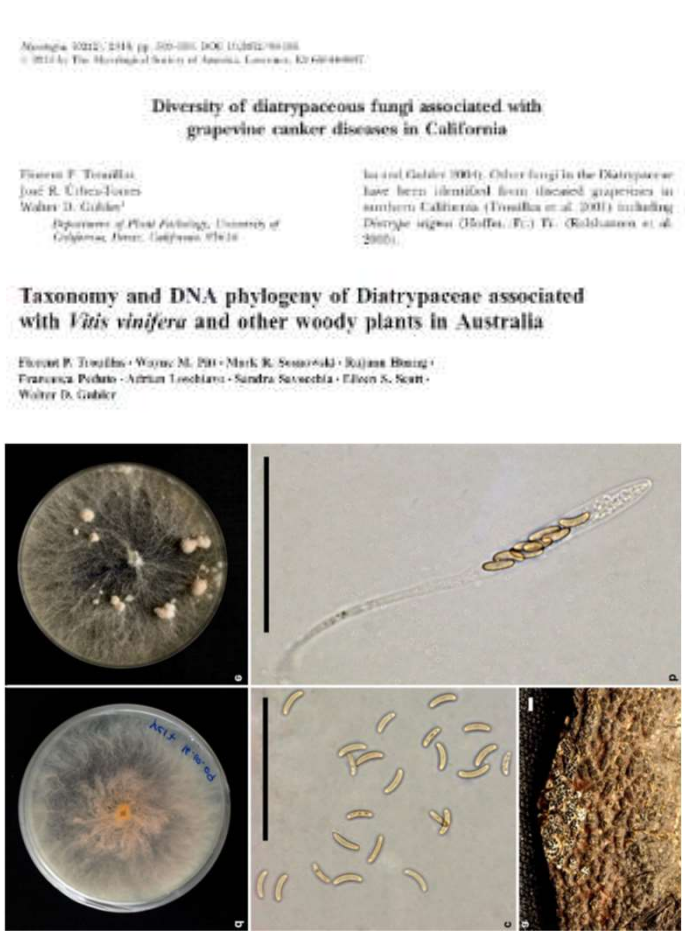
Accepted for publication 4 June 2010.

Diversity of Diatrypaceae associated with grapevine cankers in CA:



Diversity of diatrypaceous fungi associated with grapevine canker diseases in California

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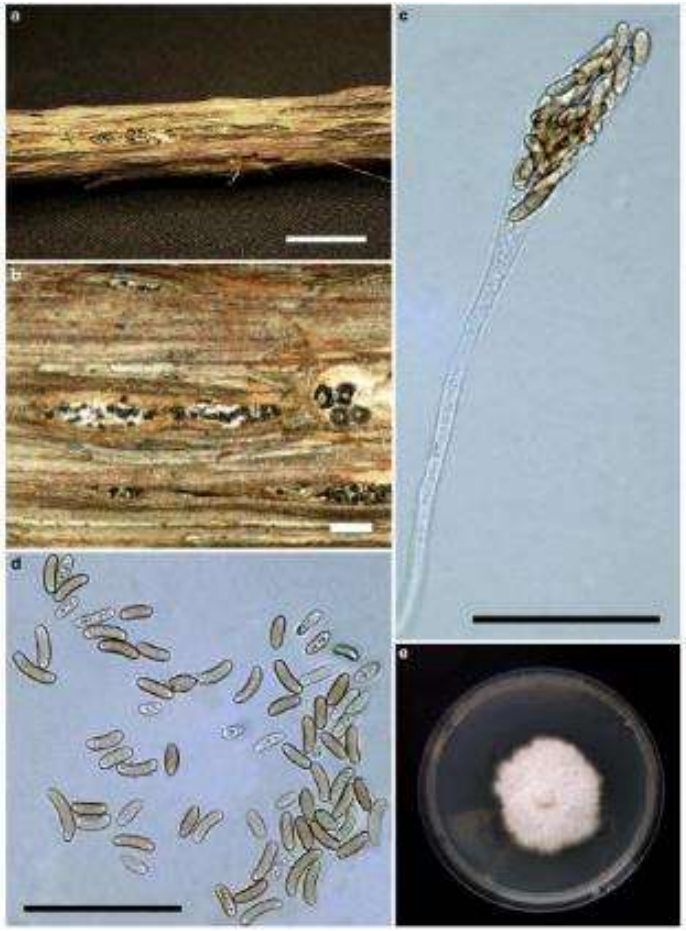
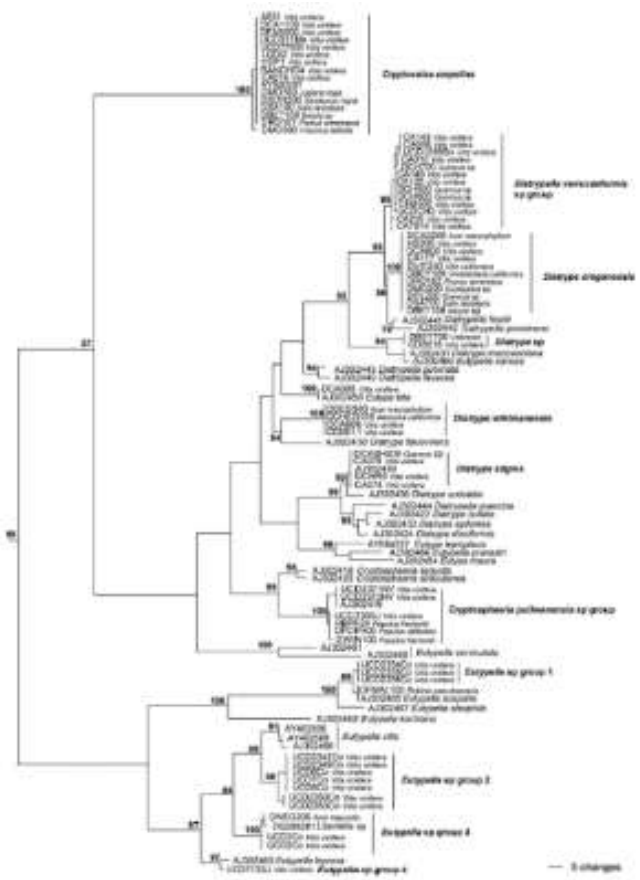
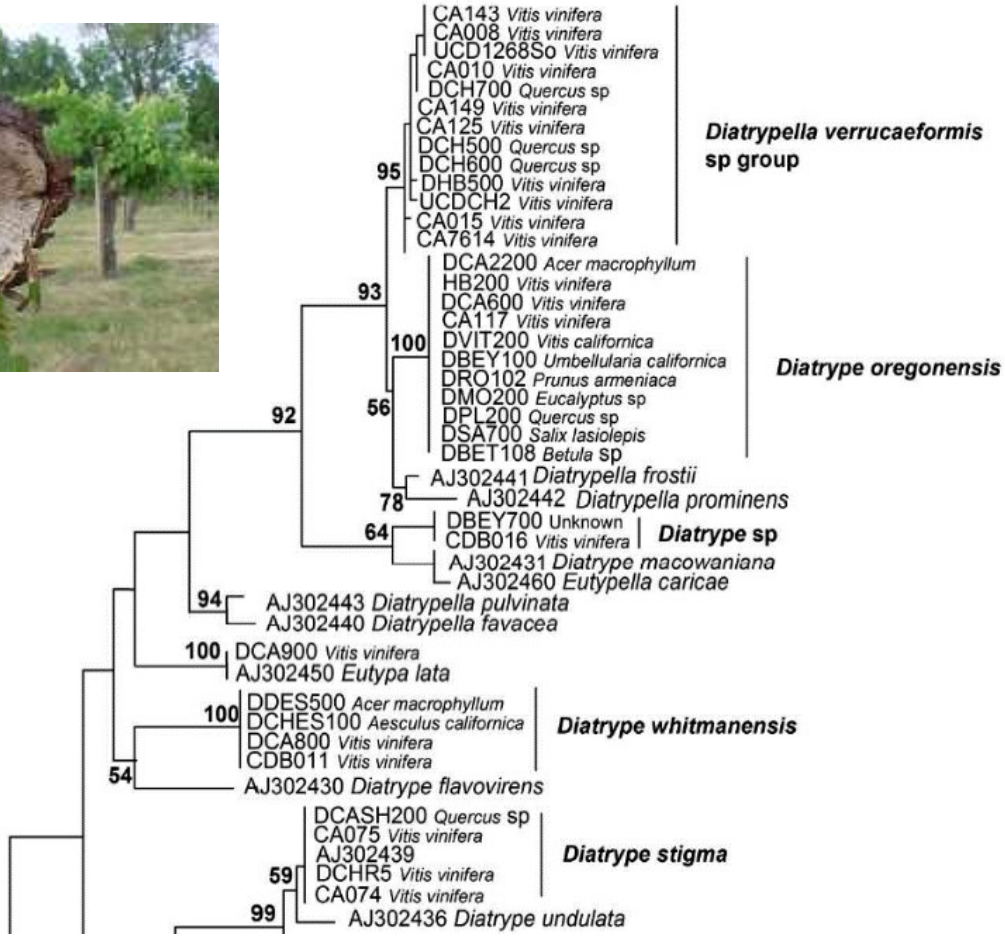
Taxonomy and DNA phylogeny of Diatrypaceae associated with *Vitis vinifera* and other woody plants in Australia

Florent P. Trouillas · Wayne M. Pitt · Mark R. Sosnowski · Rujian Huang · Francesca Peduto · Adrian Loschiavo · Sandra Savocchia · Eileen S. Scott · Walter D. Gubler

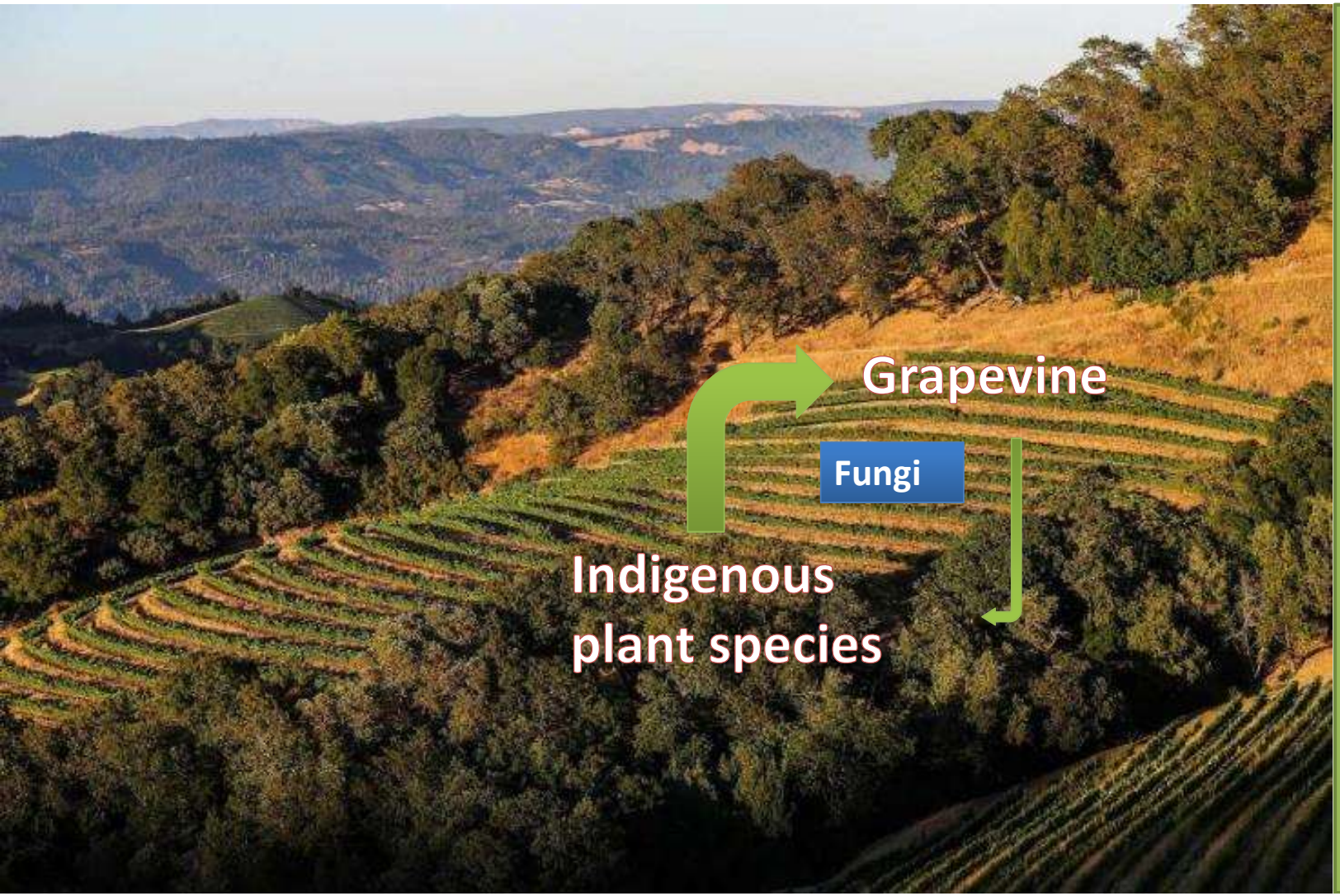




Natural host range of Diatrypaceae associated with grapevine cankers in CA:



The opportunistic pathogens:



Movement of fungal species between indigenous plant species and introduced perennial crop.

Hypothesis:

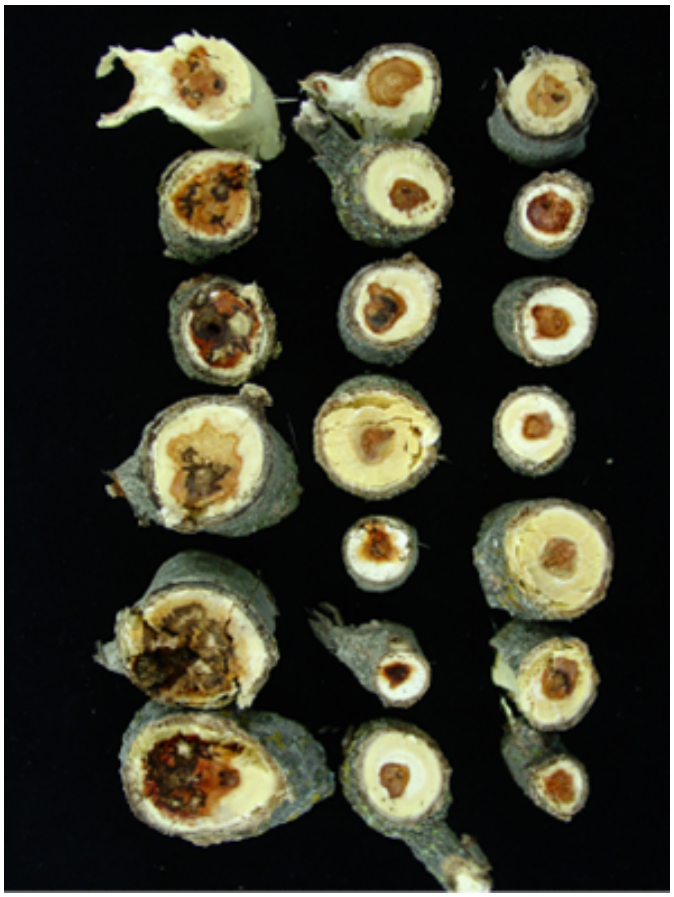
Emergence of new, opportunistic pathogens in the newly introduced host plant (grape).

Cryptosphaeria canker diseases:

- *Cryptosphaeria pullmanensis* was often isolated from grapevine cankers similar to Eutypa cankers
- *Cryptosphaeria* species had been mainly reported from *Populus* and *Salix* spp.
- Fremont cottonwood showing dieback commonly occurring nearby diseased grapevines

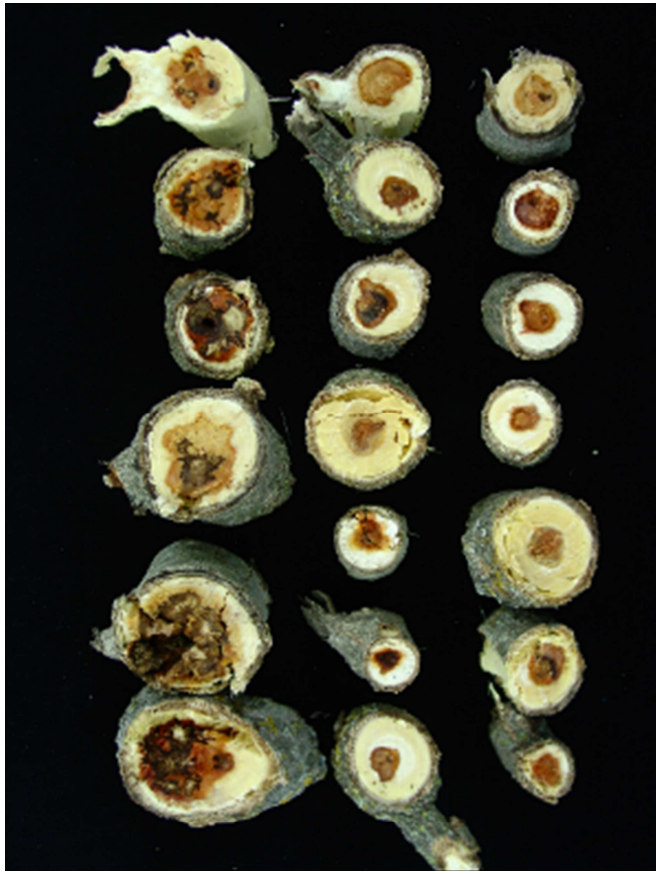
Cryptosphaeria canker signs and symptoms:

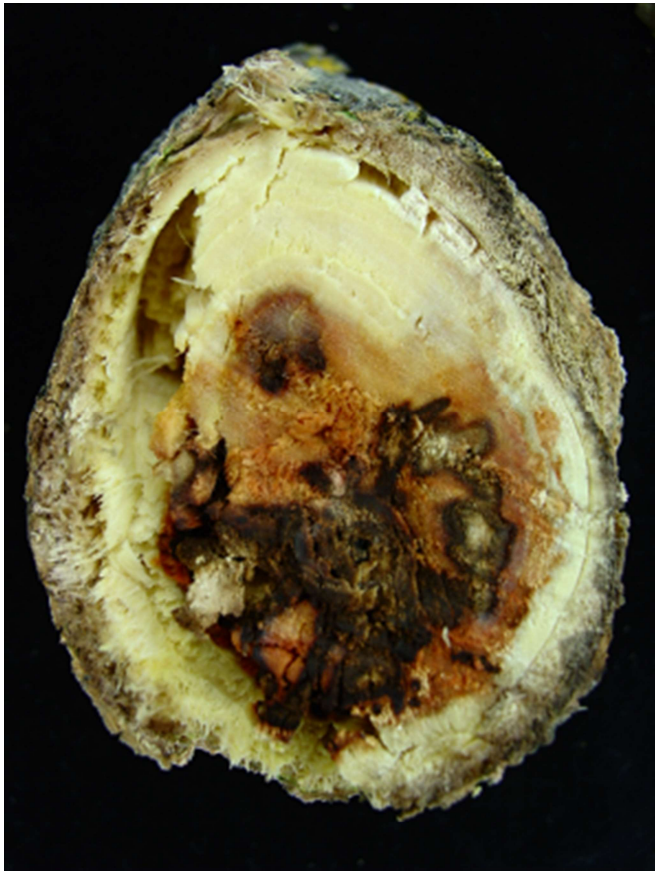
- Fremont cottonwoods and other poplars
- Dieback and wood cankers

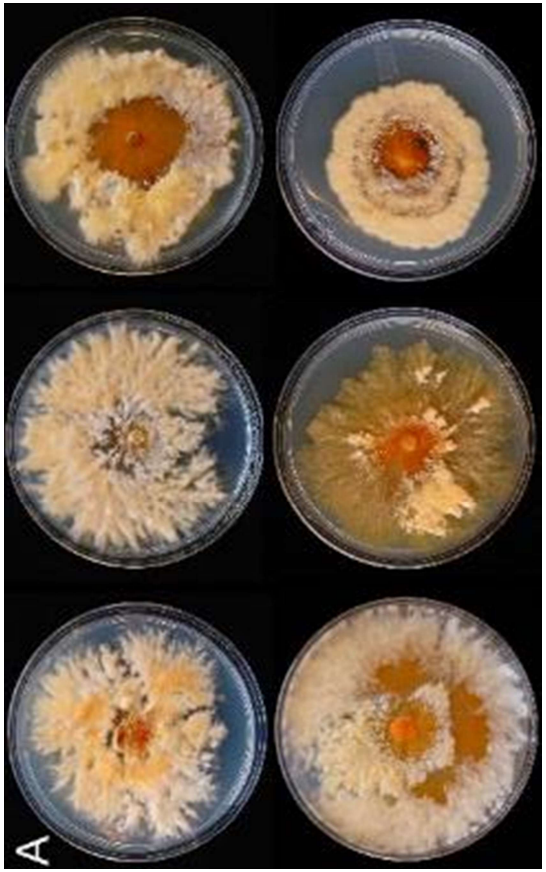


Cryptosphaeria canker sign and symptoms:

- Cankers initiate in the heart wood and spread into the sapwood
- Orange discoloration of the wood, similar to fungal colonies
- *Cryptosphaeria pullmanensis was* commonly associated with these cankers







Cryptosphaeria canker signs and symptoms:

- Pycnidia and perithecia are quickly and abundantly produced on infected trees
- Important sources of inoculum for *Cryptosphaeria pullmanensis* in CA
- Completely overlooked in CA, USA, often time confused with Cytospora
- First report of *C. pullmanensis* causing Cryptosphaeria canker in cottonwood worldwide

Little attention given to Fremont cottonwoods and other poplars in US

Ecology, role and distribution:

- Cottonwood trees are a key species of riparian ecosystems
- Shelter, nesting sites for many resident and migratory birds
- Slow floodwaters, trap nutrient-rich sediment
- Erosion prevention, pollutant sequestration
- Used in riparian rehabilitation projects

Other uses of *Populus* spp

- Cottonwood, aspen trees used as field windbreaks
- Paper industry
- Important as ornamentals in urban and rural systems

Cryptosphaeria canker and dieback diseases:

- Most *Populus* spp. were surveyed throughout the western US
- In various ecosystems (High Sierra, desert, riparian areas, etc…)
- Widespread occurrence of Cryptosphaeria cankers and associated pathogens in west USA

Ornamentals

Populus nigra

Populus deltoides

Native trees

Populus fremontii

Populus balsamifera ssp trichocarpa

Populus tremuloides

Phylogenetic studies suggest *Cryptosphaeria* species may have co-evolve with *Populus species*

Populus fremontii

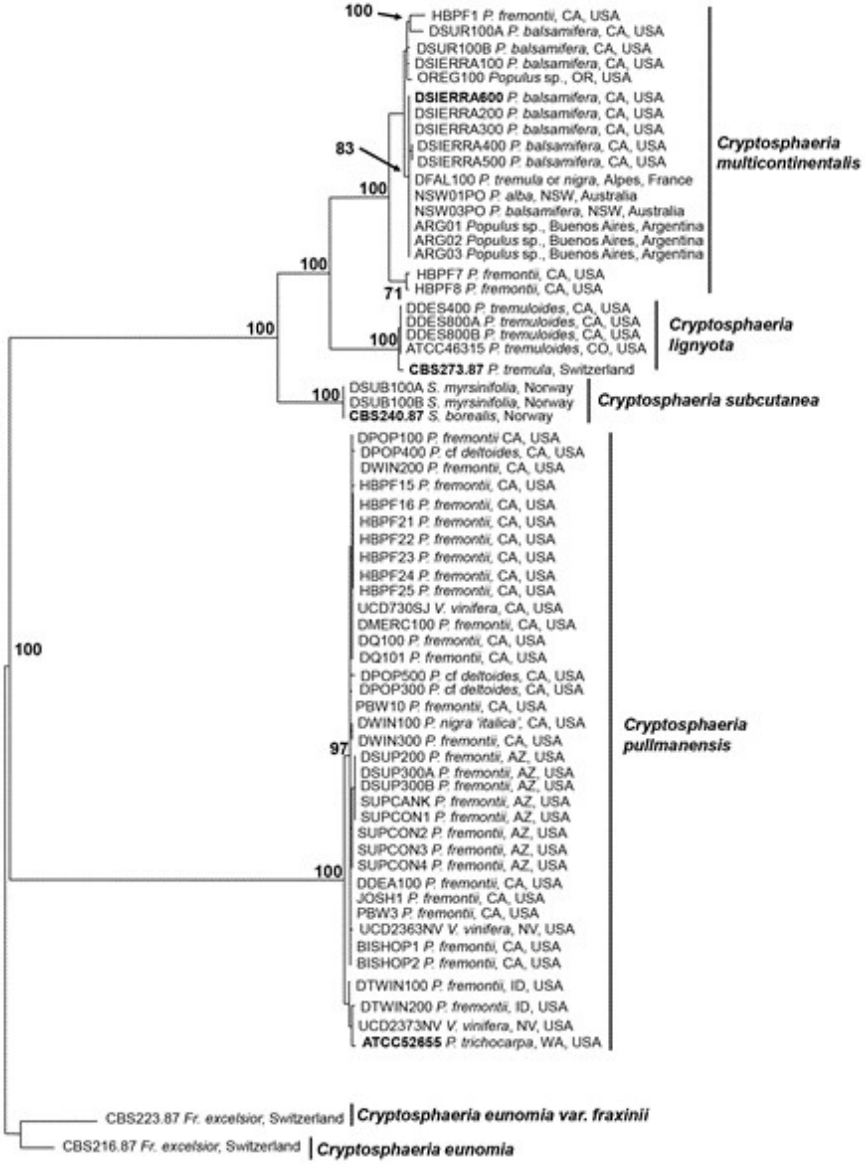
Cryptosphaeria pullmanensis

Populus balsamifera ssp trichocarpa

Cryptosphaeria multicontinentalis

Populus tremuloides

Cryptosphaeria lignyota



Disease emergence:

- *Cryptosphaeria* canker was not found in undisturbed, natural environments despite the presence of the pathogen. *C. pullmanensis* may act as an endophyte in undisturbed environments
- Global warming, human activities that lowered water tables and eliminated natural flooding (dams, groundwater pumping, agriculture irrigation) may have favored disease emergence
- Risk for agricultural ecosystems: associated with grapevine cankers in CA and Pacific Northwest
- **Trouillas et al. 2015; Trouillas and Gubler 2016**

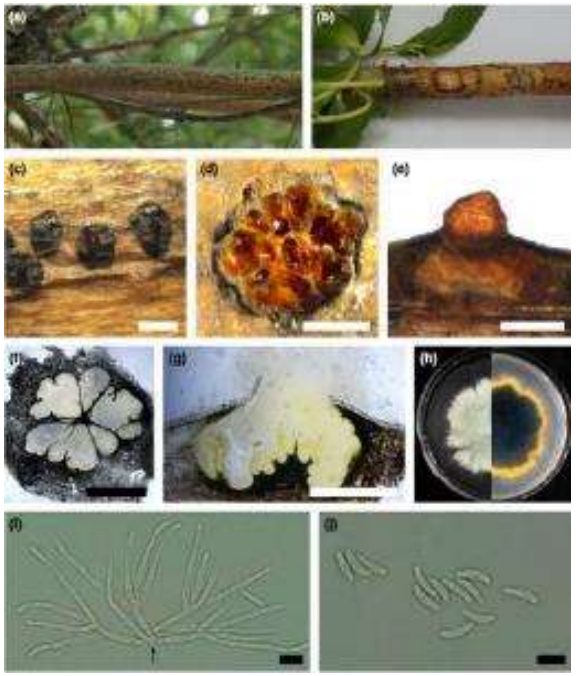


Cryptosphaeria canker, an increasing concern worldwide:

China


Forest Pathology

Canker disease of willow and poplar caused by *Cryptosphaeria pullmanensis* recorded in China



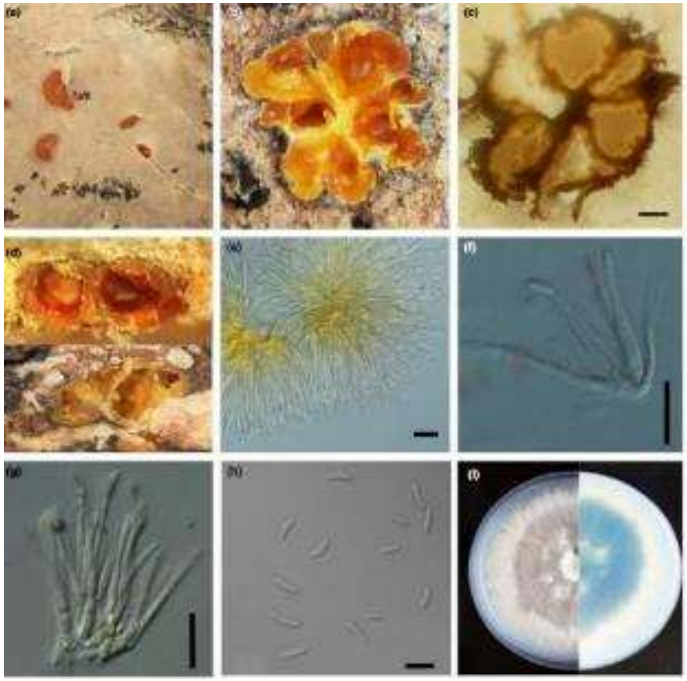
Iran


Journal of Phytopathology

ORIGINAL ARTICLE

Cryptosphaeria Canker of *Populus nigra* Caused by *Cryptosphaeria pullmanensis*, a New Threat to Poplar Industry in Iran

Abdulrahman Rashid Aghdam, Asadollah Babai-Ahari, Kalvan Karimi and Mahdi Arzanlou



Iran


SHORT COMMUNICATION

WILEY

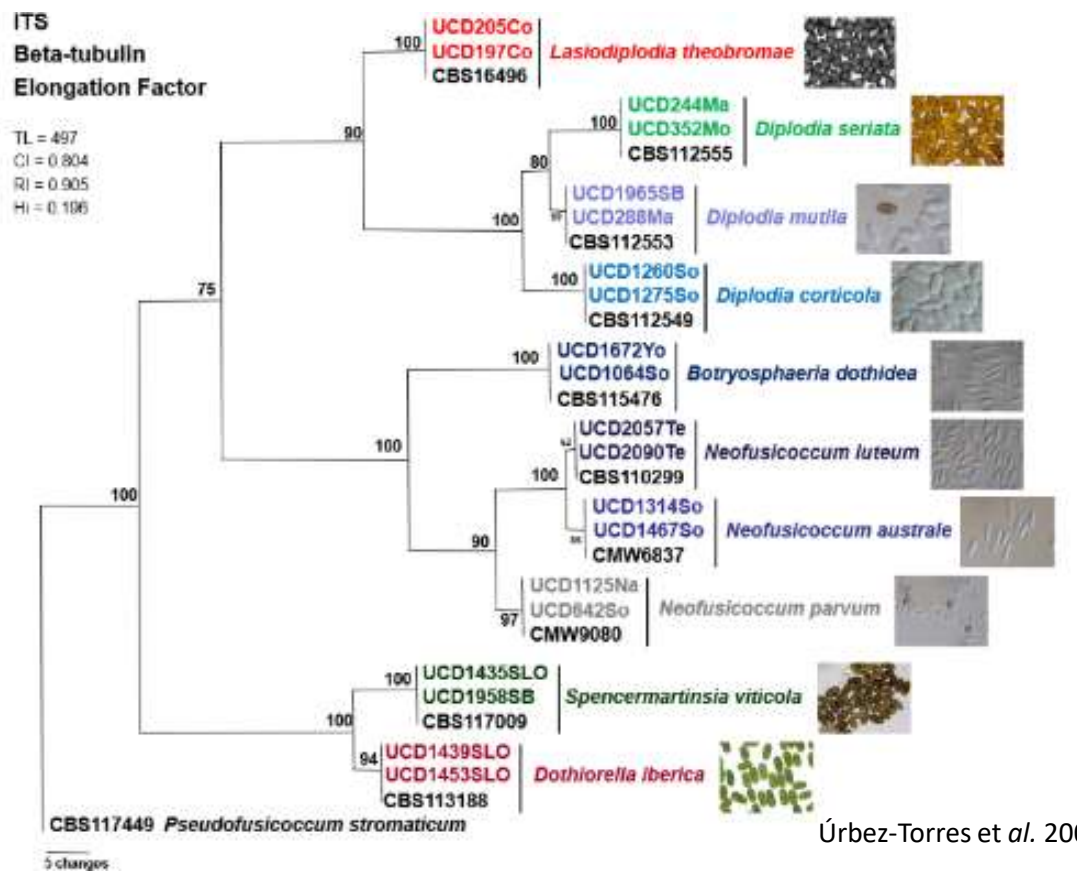
First report of *Cryptosphaeria pullmanensis* as causal agent of Cryptosphaeria canker of *Populus nigra* in Iran

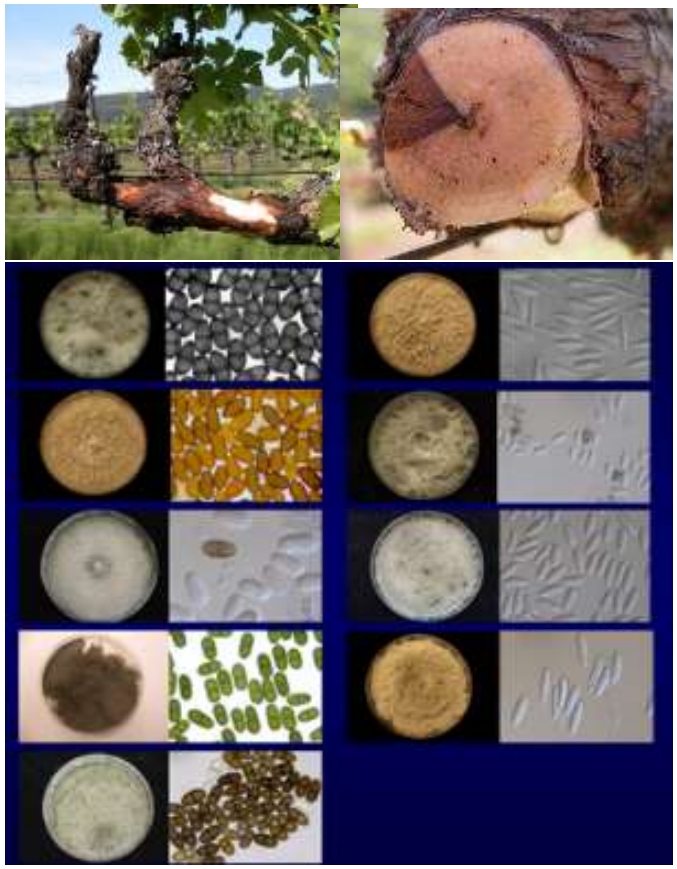
M. Mehrabi[1] | R. Hemmati[1] | F. P. Trouillas[2]

Canker diseases caused by Botryosphaeriaceae fungi

Botryosphaeriaceae canker diseases:

- Widespread pathogens of perennial crops: grape, almond, walnut, pistachio, olive
- Global pathogens of grape and many tree species





Úrbez-Torres et *al.* 2006, 2009.

Botryosphaeriaceae cankers of almond in CA:

- Infect young trees at pruning wound or cracks
- Cause canker, dieback and gumming
- Kill trees




Botryosphaeriaceae in the nut crops in CA:

Themis Michailides, UC Davis

Fungal species	Walnut	Pistachio	Almond
Botryosphaeria dothidea	+	+	+
Neofusicoccum parvum	+	+	+
Neofusicoccum mediterraneum	+	+	+
Diplodia mutila	+	---	---
Neofusicoccum nonquaesitum	+	---	+
Neofusicoccum vitifusiforme	+	+	---
Diplodia seriata	+	+	+
Dothiorella iberica	+	+	+
Lasiodiplodia citricola	+	+	+
Neoscytalidium dimitiatum (=*Hendersonula toruloidea*)	+	+	+

Botryosphaeriaceae associated with native trees in CA:

Mycologia

Identification and pathogenicity of Botryosphaeriaceae species associated with coast live oak (*Quercus agrifolia*) decline in southern California

Shannon C. Lynch, Akif Eskalen, Paul J. Zambino, Joey S. Mayorquin & Danny H. Wang

Photo: S.C. Linch, A. Eskalen

Photos: S.C. Linch, A. Eskalen

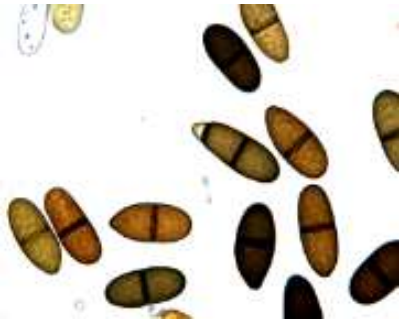
Diplodia corticola, Dothiorella iberica and *Diplodia agrifolia*

British Mycological Society

ELSEVIER

Botryosphaeriaceae species associated with dieback and canker disease of bay laurel in northern California with the description of *Dothiorella californica* sp. nov.

Daniel P. LAWRENCE, Francesca PEDUTO HAND, W. Douglas GUBLER, Florent P. TROUILLAS



Botryosphaeriaceae associated with native trees in CA:

- *Sequoia sempervirens*
- *Sequoiadendron giganteum*

Characterization and Pathogenicity of Botryosphaeriaceae Fungi Associated with Declining Urban Stands of Coast Redwood in California

Srđan G. Aćimović,[1] Plant Pathology and Plant Microbe Biology Section, Cornell University, Hudson Valley Research Laboratory, Highland, NY; and Research and Development Laboratory, Arborjet Inc., Woburn, MA; **Suzanne Rooney-Latham** and **Sebastian Albu,** Plant Pest Diagnostics Branch, California Department of Food & Agriculture, Sacramento, CA; and **Donald M. Grosman** and **Joseph J. Doccola,** Research and Development Laboratory, Arborjet Inc., Woburn, MA

Needle blight, leading to branch canker and dieback

Photos: S.G. Acimovic

Botryosphaeria dothidea, Neofusicoccum australe, N. luteum, N. mediterraneum, and N. parvum.

forests MDPI

Article

***Neofusicoccum parvum*, A New Agent of Sequoia Canker and Dieback Identified in Geneva, Switzerland**

Martine Haenzi, Bastien Cochard, Romain Chablais, Julien Crovadore and François Lefort *

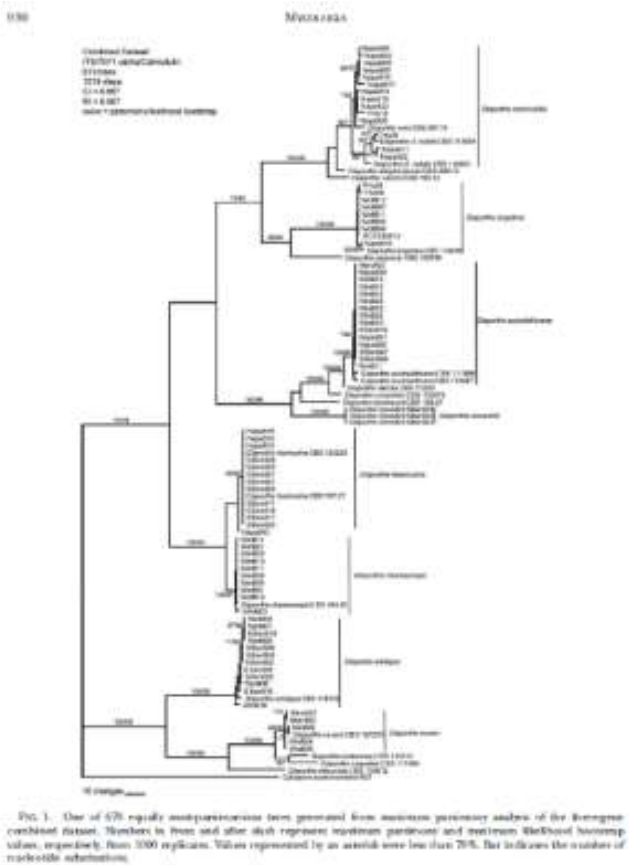
Canker diseases caused by Diaporthaceae fungi (*Phomospis*)

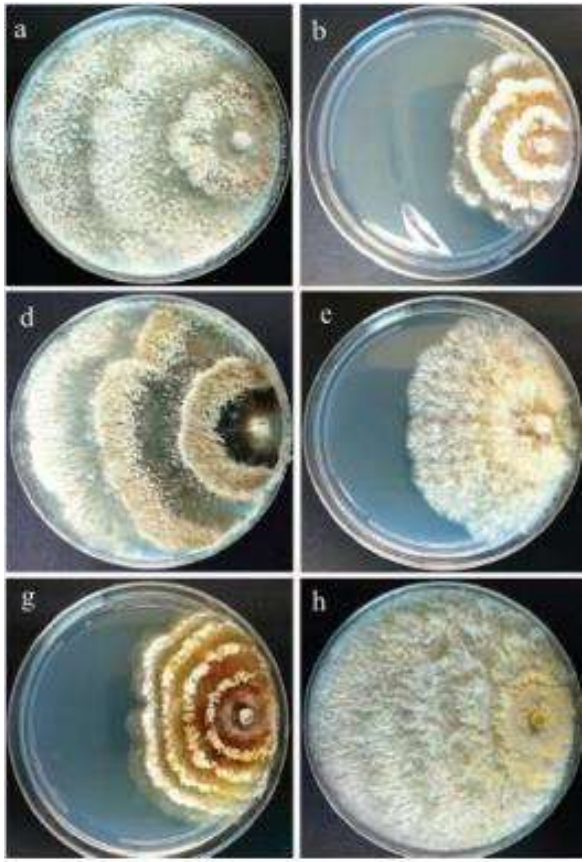
Phomopsis (*Diaporthe*) spp. associated with the fruit and nut crops in CA:

- Species characterized from cankers in walnut, grape, pear, apricot, almond and willow

Lawrence et al. 2015

Diversity of *Diaporthe* species associated with wood cankers of fruit and nut crops in northern California





Phomopsis (Diaporthe) canker diseases (and blight):

- Generally not a main canker (wood) pathogen, often secondary to an abiotic stress
- Usually infect soft, green, fleshy tissues in plants

Grapevine

Urbez-Torres et al. 2013

Walnut

Douglas Fir

OSU Plant Path Collection

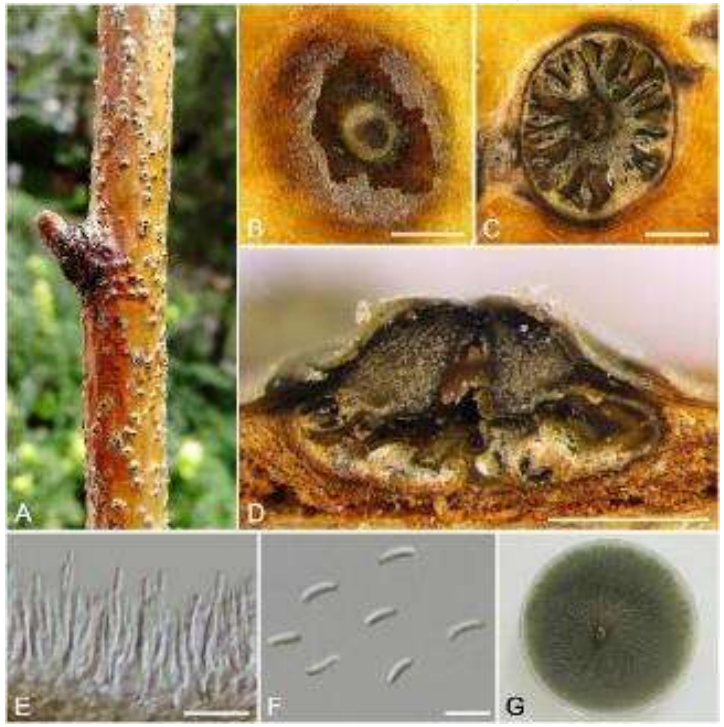
OSU Plant Clinic Collection

Canker diseases caused by *Cytospora* species

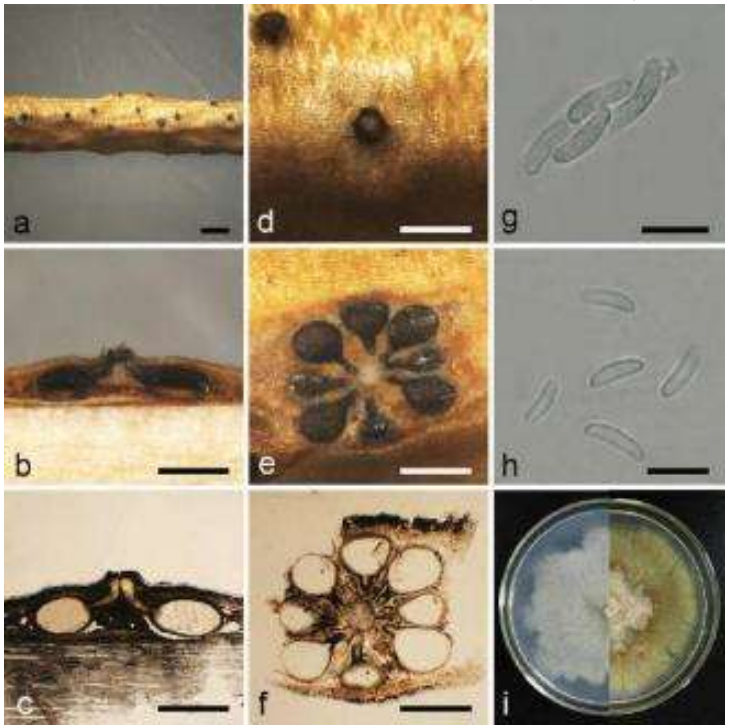
Cytospora cankers

- ❑ Wide spread in stone fruits, pome fruits and in wild woody plants worlwide
- ❑ Associated with sun burn injuries, pruning wounds
- ❑ Cytospora canker of spruce trees, aspens

Pan, M. et *al.*, 2020



Fan, X. et *al.*, 2015



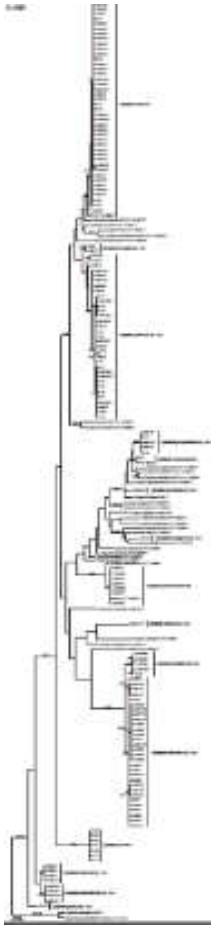
USDA forest service

Cytospora canker of plum/prune:

- Main limiting factor for prune production in CA

Photo credits: Franz Niederholzer

Molecular phylogeny of *Cytospora* species associated with canker diseases of fruit and nut crops in CA: Lawrence et *al*. 2018



doi:10.5598/imafungus.2018.09.02.07 IMA FUNGUS · 9(2): 333–370 (2018)

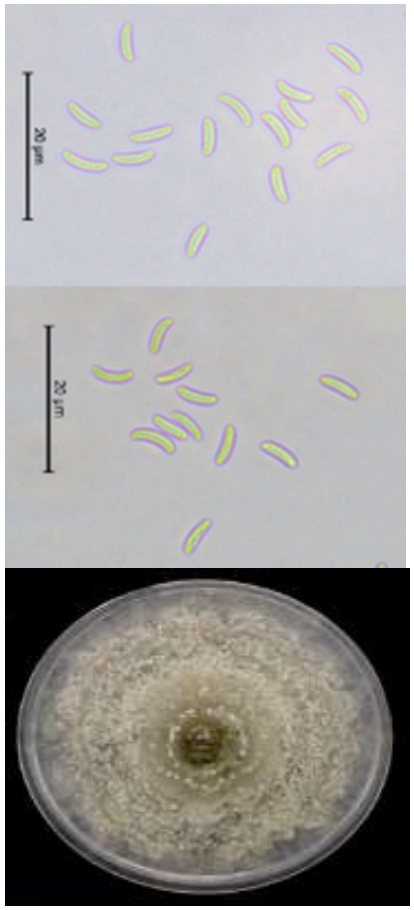
ARTICLE

Molecular phylogeny of *Cytospora* species associated with canker diseases of fruit and nut crops in California, with the descriptions of ten new species and one new combination

Daniel P. Lawrence[1], Leslie A. Holland[1], Mohamed T. Nouri[2], Renaud Travadon[1], Ara Abramians[1], Themis J. Michailides[2], and Florent P. Trouillas[2]

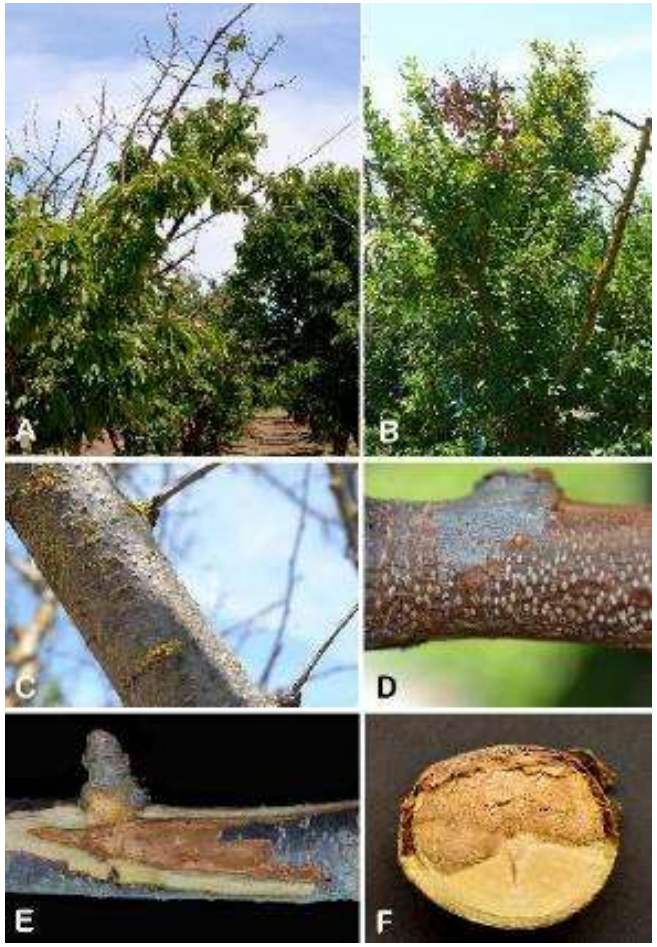
[1]Department of Plant Pathology, University of California, Davis, One Shields Avenue, Davis, CA 95616, USA
[2]Department of Plant Pathology, University of California, Davis and Kearney Agricultural Research and Extension Centre, Parlier, CA 93648, USA; corresponding author e-mail: ftrouillas@ucdavis.edu

- **150 Californian isolates analyzed** (ITS, translation elongation factor 1-alpha, actin, and beta-tubulin)
- **15 *Cytospora* species associated with cankers in the fruit and nut crops**
- **Descriptions of 10 new species and one new combination**
- **Almond, apricot, cherry, cottonwood, olive, peach, pistachio, plum, pomegranate, and walnut**



Cytospora cankers in CA:

Stone fruits
(Cherry, Prune, Apricots, Peaches)

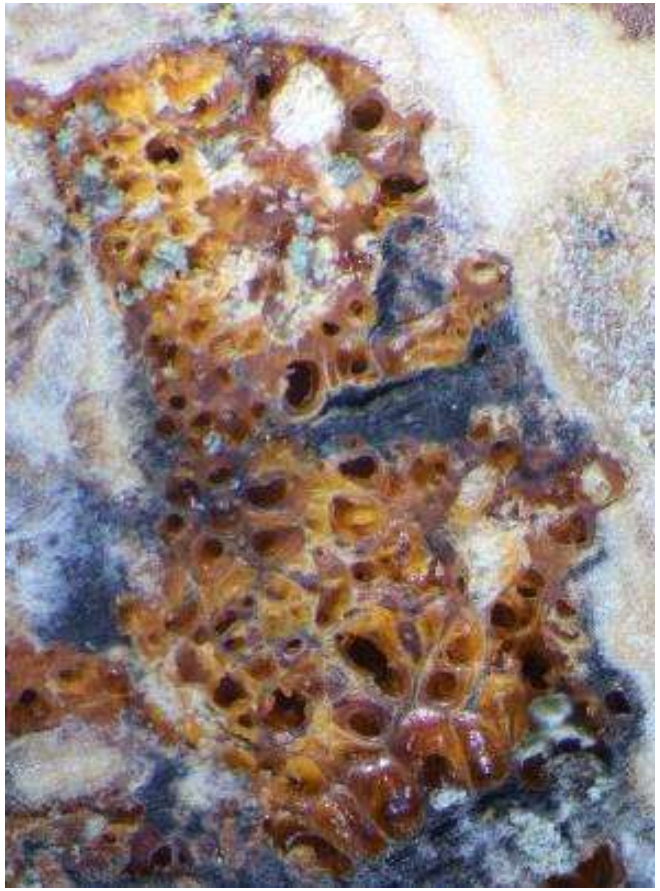


Nut crops
(Almond, Pistachio, Walnut)

Other hosts
(Poplars, Pomegranate, Olive, grape)

Cytospora canker of cottonwood in CA:

- Often time confused with Cryptosphaeria



Cytospora cankers of pistachio

- Most common canker pathogens in pistachio
- Associated with sun burn injuries, pruning wounds

Photo credits: Carla Youngblood

Phytophthora: update from the fruit and nut crops

Perennial Phytophthora cankers of almond:

- Risks increase with poor scaffold selection (pocket formed at the tree crotch)
- Spores are deposited at the tree crotch with dust from harvest
- Fast growing cankers




Phytophthora root and crown rot of pistachio:

- Affects the tree trunk at or near the ground level
- Girdling of trees; relatively fast decline
- Crown rot/canker visible below the bark and gumming area




Phytophthora species associated with pistachios in CA:

- *Phytophthora niederhauserii*
- *Phytophthora mediterranea*
- *Phytophthora taxon walnut*

e-Xtra*

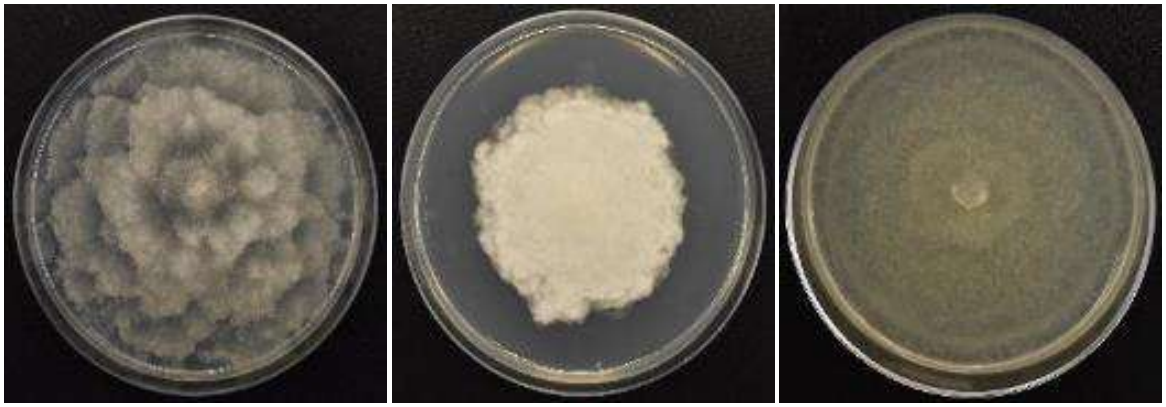
Identification and Characterization of *Phytophthora* Species Associated With Crown and Root Rot of Pistachio Trees in California

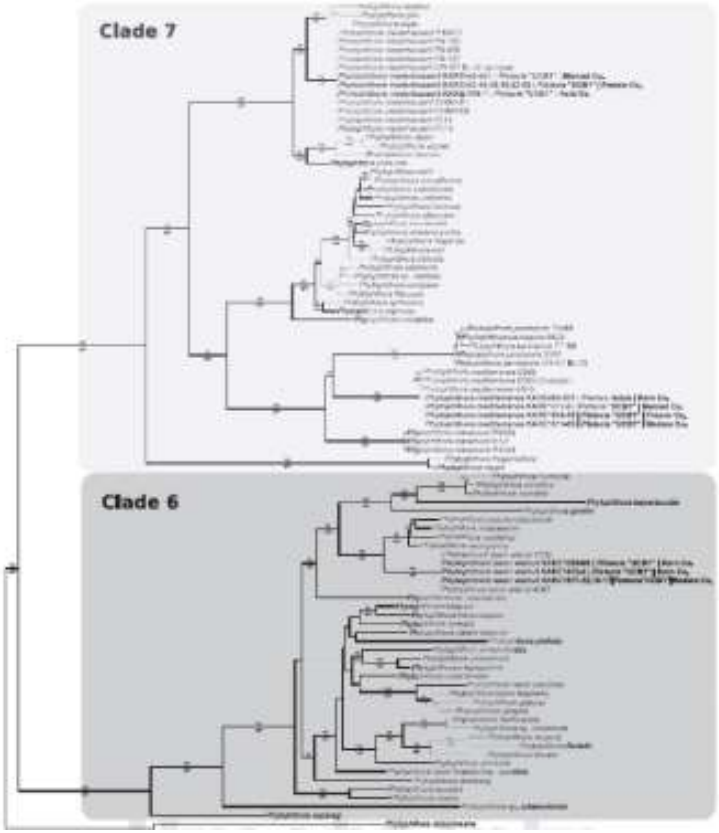
Florent P. Trouillas,[1,†] Mohamed T. Nouri,[2] and Tyler B. Bourret[3]

[1] University of California, Davis, Department of Plant Pathology and Kearney Agricultural Research and Extension Center, Parlier, CA 93648

[2] University of California Cooperative Extension San Joaquin County, Stockton, CA 95206

[3] University of California, Davis, Department of Plant Pathology, Davis, CA 95616

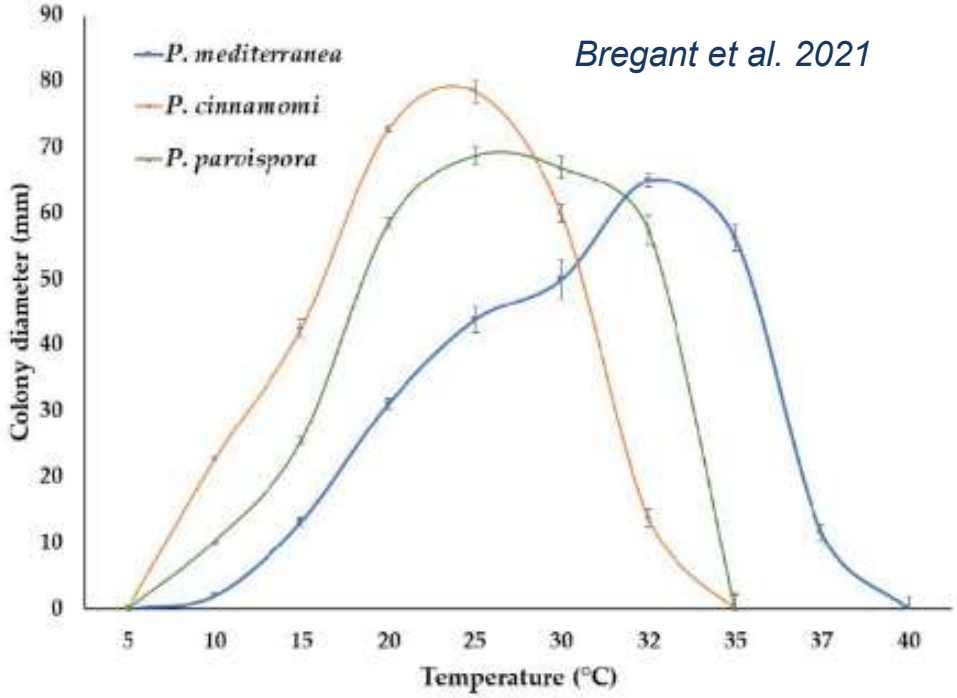




Phytophthora species associated with pistachios in CA:

➢ Thermophilic species

- ***Phytophthora niederhauserii*:** optimum growth temperature **30°C**, isolates grew well at **37°C** (Pérez-Sierra et al. 2010)
- ***Phytophthora mediterranea*:** optimum and maximum temperatures for growth were **32°C** and **37°C**, respectively (Bregant et al. 2021).
- ***Phytophthora taxon walnut*:** optimal growth at **32°C** with a maximum at **37°C** (Ginetti et al. 2014)



Bregant et al. 2021

Emergence of Phytophthora diseases Pistachio in CA

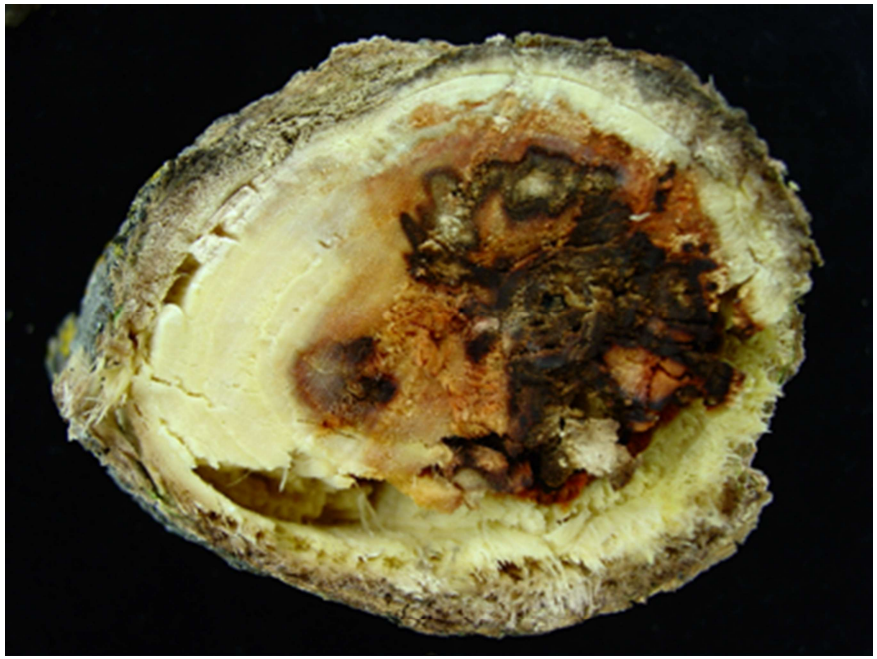
- ❑ Increase planting of pistachio in marginal soils (high salts soils, hardpan, heavy soils, etc…) - Leaching
- ❑ Increased soil compaction with time due to numerous tractor passes
- ❑ Improper irrigation scheduling for the type of soil and tree size
- ❑ Over irrigation (spring)
- ❑ Floods?
- ❑ Introduction?

Abiotic disorders, injuries: some resembling canker diseases

- ❑ **Acid burns**
- ❑ **Herbicide injuries**
- ❑ **Boron toxicity**
- ❑ **Freeze**




Thank you!



@FloTrouillas