Instituto de Ciencias de la Vid y del Vino

Gobierno de La Rioja

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UNIVERSIDAD DE LA RIOJA

Status and control of grapevine trunk diseases at the nursery and young vineyard level

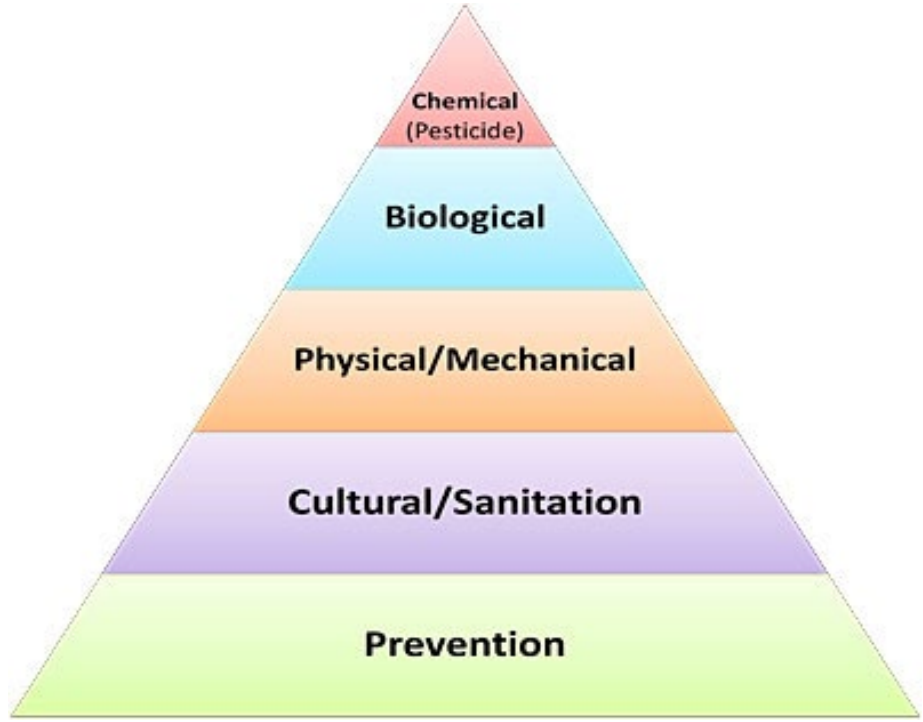
David Gramaje

GRAPEVINE TRUNK DISEASES (GTD)

Complexity of this pathosystem

1. Many fungal species associated with GTD symptoms
2. Fungi with different biology and epidemiology
3. No curative measures are known for control of GTD

INTEGRATED DISEASE MANAGEMENT STRATEGY



Integrated disease management strategy

Nursery mother blocks

Propagation processes

Nursery field

Newly established vineyards

Integrated disease management strategy

Nursery mother blocks	**Cultural practices and sanitation** **Pruning wound protection**
Propagation processes	**Chemical/biological/physical treatments**
Nursery field	**Biofumigation**
Newly established vineyards	**Selection of planting material** **Site preparation and vine management** **Biological control** **Pruning wound protection**

Integrated disease management strategy

Nursery mother blocks

Cultural practices and sanitation

Pruning wound protection

Propagation processes

Chemical/biological/physical treatments

Nursery field

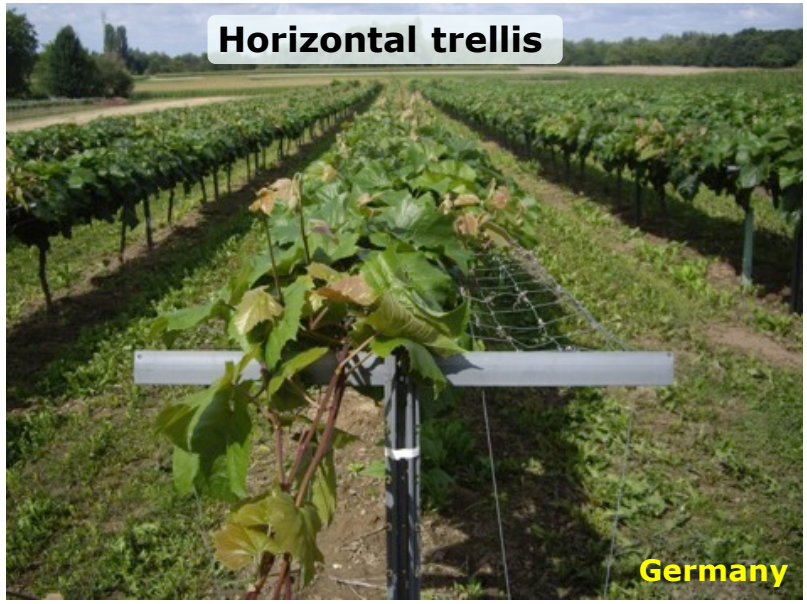
Biofumigation

Newly established vineyards

Selection of planting material
Site preparation and vine management
Biological control
Pruning wound protection

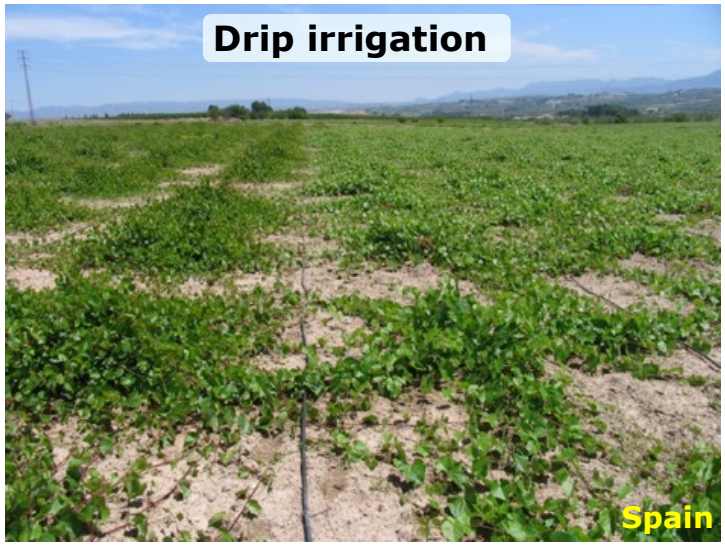
Nursery mother blocks

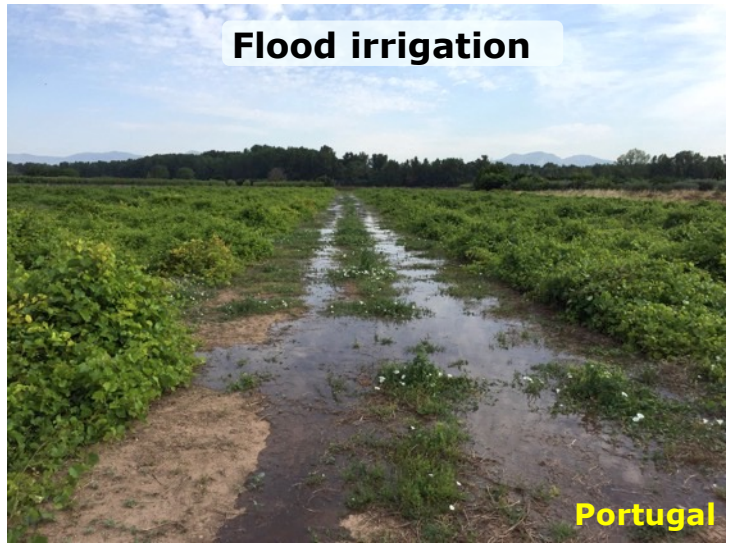
Cultural practices and sanitation: rootstock mother vine cultivation

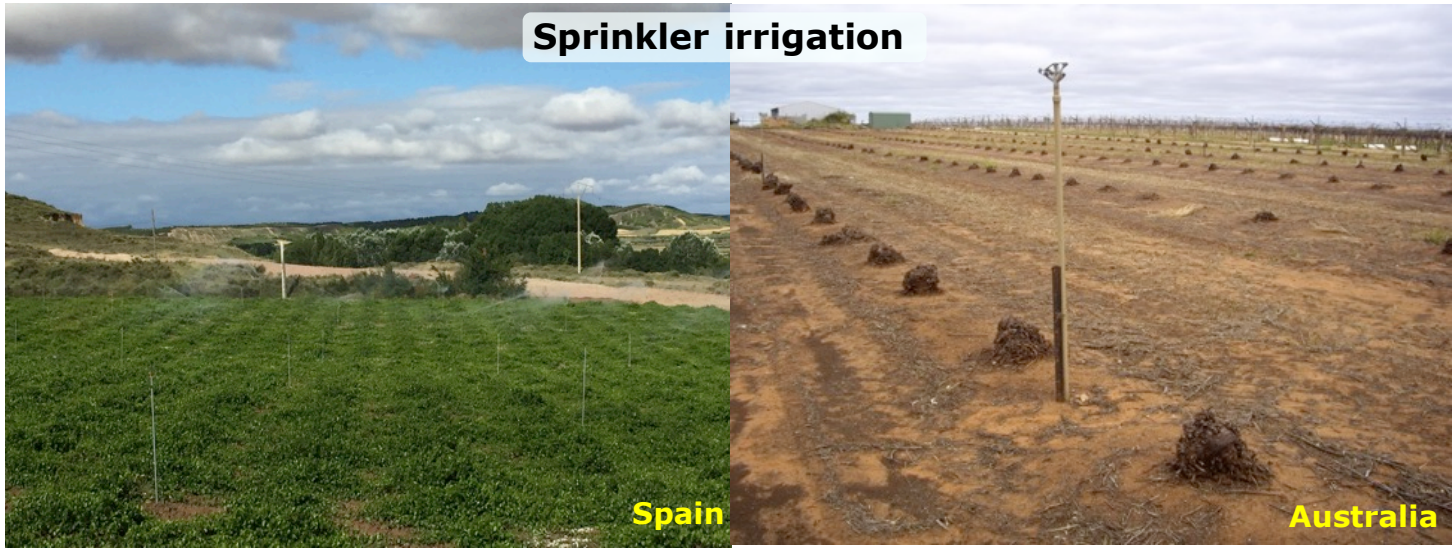


Nursery mother blocks

Cultural practices and sanitation: irrigation







Botryosphaeriaceae spp.
Úrbez-Torres et al. 2010

***Phaeoacremonium* spp.**
Gubler et al. 2013

Diatrypaceae spp.
Úrbez-Torres et al. 2019

Nursery mother blocks & vineyard

Cultural practices and sanitation: removal of dead wood or pruning debris

Elena and Luque 2016 Eur. J. Plant Pathol. 144

Nursery mother blocks & vineyard

Cultural practices and sanitation: removal of dead wood or pruning debris

1) Composting

LIFE SARMIENTO

lifesarmiento.eu

2) Mulching

Lecomte et al. 2006 Phytopathol. Mediterr 45

A protocol for the management of grapevine rootstock mother vines to reduce latent infections by grapevine trunk pathogens in cuttings

Helen WAITE[1], Josep ARMENGOL[2], Regina BILLONES-BAAIJENS[3], David GRAMAJE[4], Francois HALLEEN[5,6], Stefano DI MARCO[7] and Richard SMART[8]

Phytopathologia Mediterranea (2018), 57, 3, 384–398

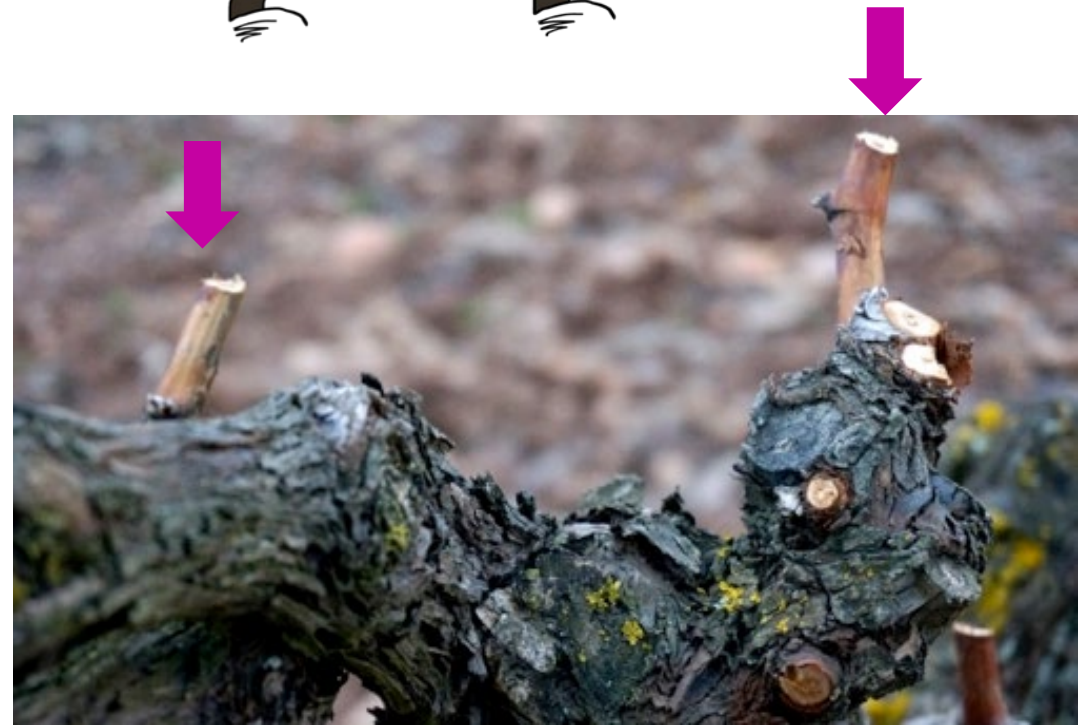
3) Burning

- ✓ **Training systems**
- ✓ **Irrigation**
- ✓ **Cultural practices and sanitation**
- ✓ **Pruning wound protection**

Winter pruning: practice and protection

Diatrypaceae spp.
Botryosphaeriaceae spp.
Basidiomycetes
Phaeomoniella chlamydospora
***Phaeoacremonium* spp.**

Mother vine



Mature vine

Pruning wound protection

Mastic/paste + fungicides

Benzimidazole carbamate mode of action group (benomyl, carbendazim, and thiophanate methyl)

Eutypa dieback
Australia (Sosnowski et al. 2008 Aus. J. Grape Wine Res. 14)
USA (Rolshausen et al. 2010 Am. J. Enol. Vitic. 61)

Botryosphaeria dieback
South Africa (Halleen et al. 2010)
Chile (Díaz and Latorre 2013 Crop Prot. 46)
USA (Rolshausen et al. 2010 Am. J. Enol. Vitic. 61)

Esca
Chile (Díaz and Latorre 2013 Crop Prot. 46)
South Africa (Mutawila et al. 2015 BioControl 60)

The demethylation inhibitors (tebuconazole & flusilazole)

Eutypa dieback
Australia (Ayres et al. 2017 Aus. J. Grape Wine Res. 23)
South Africa (Halleen et al. 2010 S. Afr. J. Enol. Vitic. 31)

Botryosphaeria dieback
Chile (Díaz and Latorre 2013 Crop Prot. 46)
New Zealand (Amponsah et al. 2012 Pest. Manag. Sci. 68)
Australia (Pitt et al. 2012 Plant Dis. 96)
South Africa (Halleen et al. 2010 S. Afr. J. Enol. Vitic. 31)

Restrictions and difficulties that chemicals are facing in most countries around the world

Mastic or paste

Pruning wound protection

Pruning-wound protectants for trunk-disease management in California table grapes

Albre A. Brown [a], Renaud Travadon [a], Daniel P. Lawrence [a], Gabriel Torres [b], George Zhuang [c], Kendra Baumgartner [d,*]

Protection of grapevine pruning wounds against *Phaeomoniella chlamydospora* and *Diplodia seriata* by commercial biological and chemical methods

María del Pilar Martínez-Diz [a,b], Emilia Díaz-Losada [a], Ángela Díaz-Fernández [a], Yolanda Bouzas-Cid [a], David Gramaje [c,*]

pyraclostrobin + boscalid
with or without a liquid polymer

ALTERNATIVE: Biological Control Agents (BCA)

Good performance with *Trichoderma* spp.:

South Africa:
Kotze et al. 2011 Phytopathol. Mediterr. 50
Mutawila et al. 2016 Aus. J. Grape Wine Res. 22

Italy:
Di Marco et al. 2004 Phytopathol. Mediterr. 43

Bad performance with *Trichoderma* spp.:

Spain:
Martínez-Diz et al. 2021 Crop Protection 143

In general, BCA have shown variable results for preventing infection by GTD pathogens

Trichoderma harzianum *Trichoderma reesei* *Trichoderma atroviride*

Integrated disease management strategy

Nursery mother blocks

Pruning wound protection

Cultural practices and sanitation

Propagation processes

Chemical/biological/physical treatments

Nursery field

Biofumigation

Newly established vineyards

Selection of planting material
Site preparation and vine management
Biological control
Pruning wound protection

NURSERIES ARE SOURCES OF DISEASED MATERIAL

1 Nurseries are favorable for fungal trunk pathogens

- ✓ Wet and humid conditions
- ✓ High root density
- ✓ Close spacing of plants

au
wi
sp
su
au
wi
sp

NURSERY PROCESS

Grapevine rootstock mother fields
Grapevine scion mother fields
Rootstock cuttings
Scion cuttings
Hydration
Cold storage
Disbudding
Hydration
Cold storage
Hydration
Grafting
Callusing and rooting
Nursery field
Potted plants
Distribution and sale
Uprooting and pruning
Distribution and sale

Hydration tanks

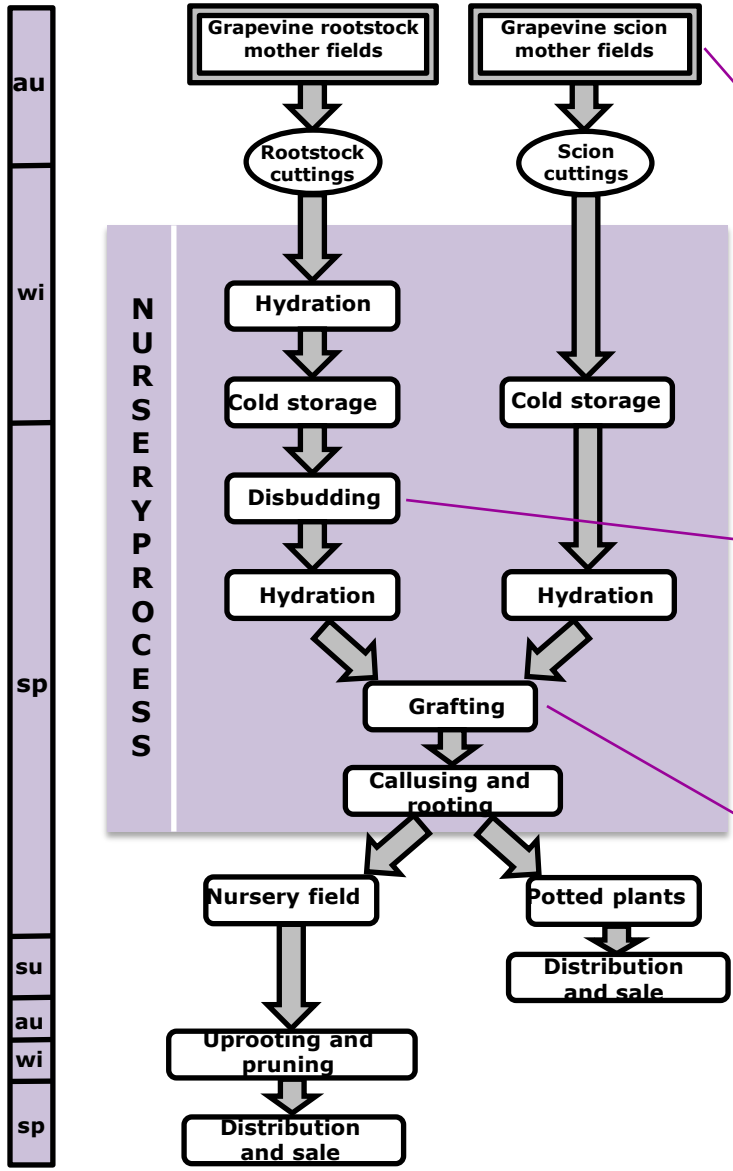
Callusing

Rooting

Gramaje and Armengol 2011. Plant Disease 95

NURSERIES ARE SOURCES OF DISEASED MATERIAL

2 Practices increase infection risk



Pruning wounds

Disbudding

Grafting

Gramaje and Armengol 2011. Plant Disease 95

NURSERIES ARE SOURCES OF DISEASED MATERIAL

3 Diseased plants are difficult to detect

External symptomless plants

Latent pathogens: asymptomatic tissues

Pathogenic: biotic and/or abiotic stress factors

Destructive sampling

THE SOLUTION: CLEAN PLANT PRODUCTION

START CLEAN, KEEP IT CLEAN

- ✓ **Use pathogen-free plant material**
- ✓ **Clean grafting machines frequently**
- ✓ **Maintain a high standard of general cleanliness in the nursery, particularly the grafting room, callusing room and cool room**
- ✓ **Never reuse callusing media**
- ✓ **Avoid soaking cuttings**

Propagation processes in the nursery

CHEMICAL CONTROL

Carbendazim [Petri disease and Botryosphaeria dieback]
(Gramaje et al. 2009 Crop Prot. 28; Billones-Baaijens et al. 2015 Phytopathol. Mediterr. 54)

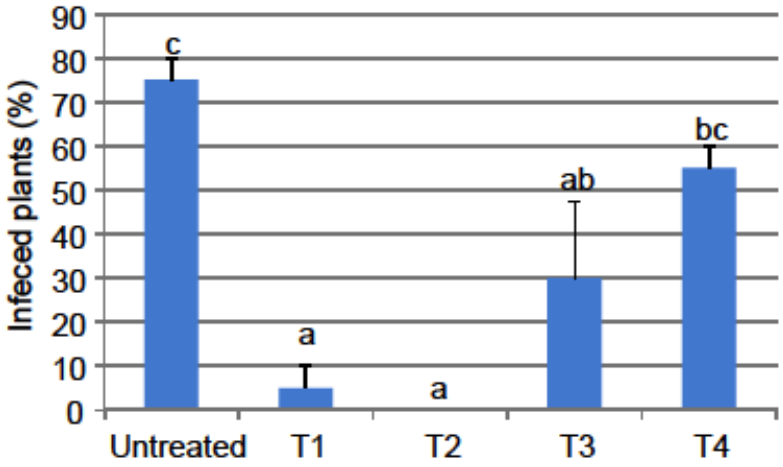
Cyprodinil + Fludioxinil (Switch®) [Black-foot disease and Botryosphaeria dieback]
(Rego et al. 2009 Phytopathol. Mediter. 48)

FUNGICIDE AUTHORIZED IN EUROPE AGAINST GTDs IN NURSERIES: Chinosol (Hydroxyquinoline sulphate) in Germany

BIOLOGICAL CONTROL

***Trichoderma atroviride* SC1 (Vintec®)**

Phaeomoniella chlamydospora



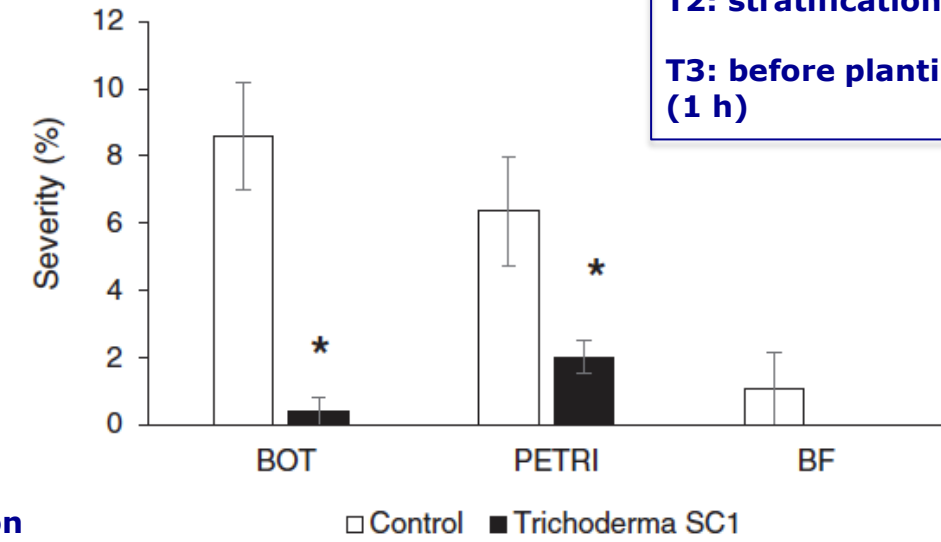
T1: pre-storage hydration
T2: pre-grafting hydration

Pertot et al. 2016. BioControl 61

T1: prior to grafting (24 h)

T2: stratification

T3: before planting (1 h)



Berbegal et al. 2019. Pest Manag. Sci.

Propagation processes in the nursery

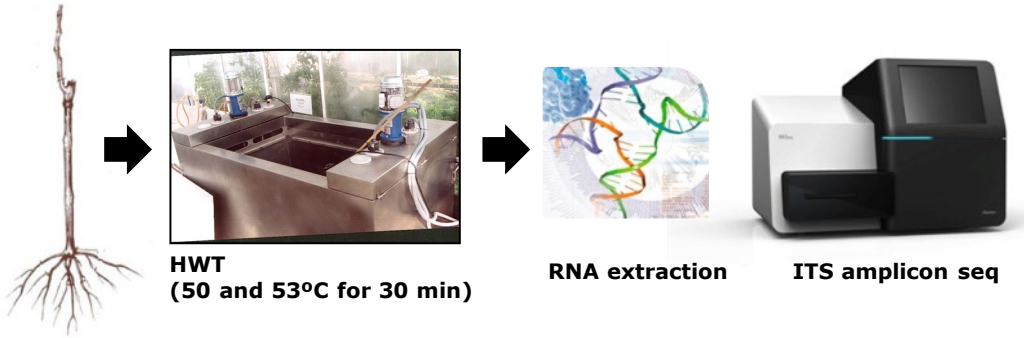
HOT-WATER TREATMENT (HWT)

Standard treatment: 50ºC – 30 min.
Several pests and diseases: Phytoplasma organisms. *Xylella fastidiosa* (50ºC – 45 min. EFSA Journal 2015)

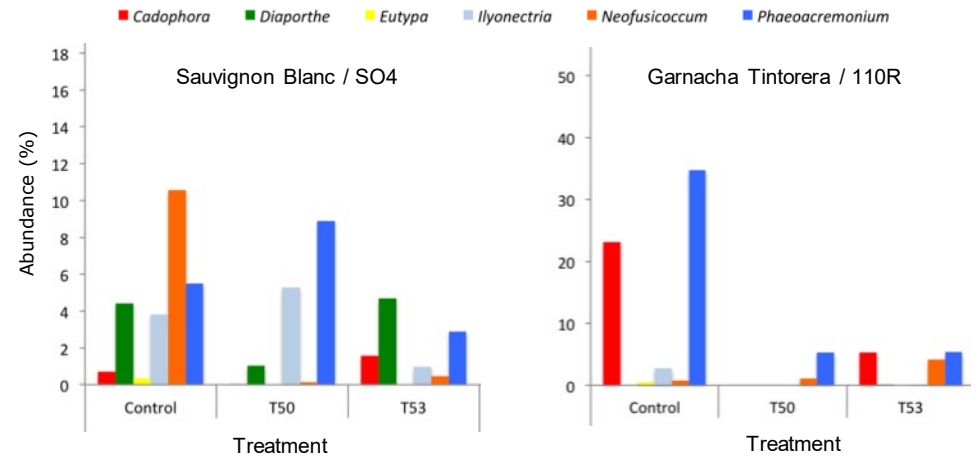
1. **Some *Vitis vinifera* varieties are more sensitive to HWT than others (Waite et al. 2001)**

   Pinot Noir: highly sensitive
   Chardonnay, Reisling and Merlot: moderately sensitive
   Cabernet Sauvignon: the least sensitive

2. **Tolerance of plants to HWT is affected by the climate in which the cuttings are grown**
3. **HWT is not completely effective in eliminating fungal trunk disease pathogens growth**



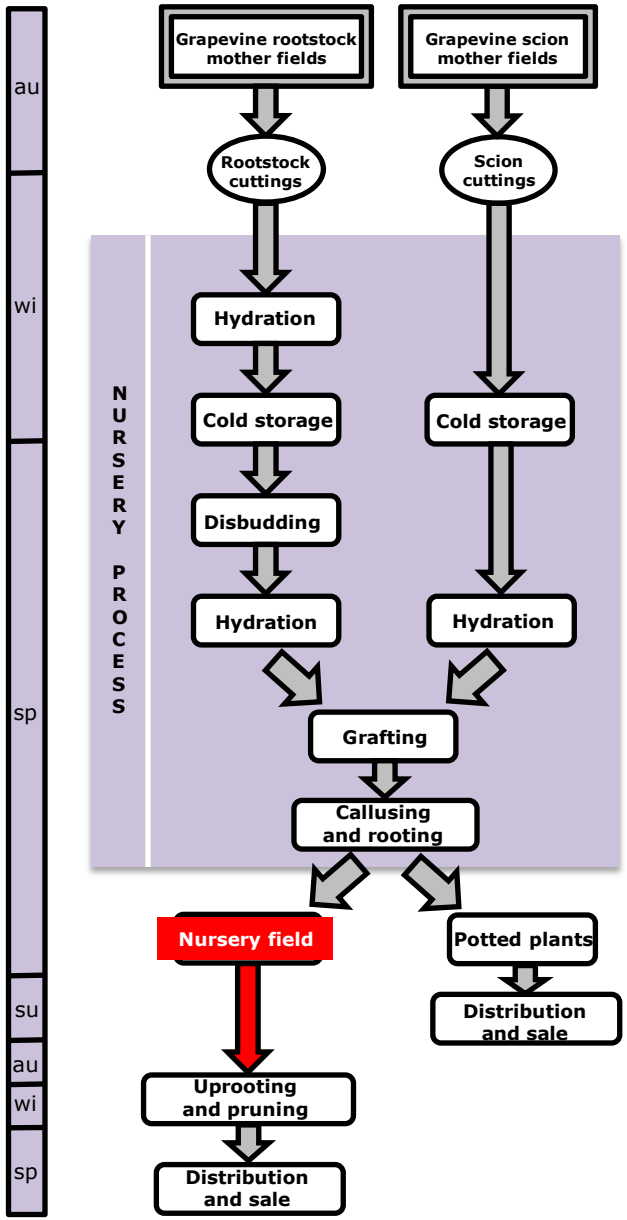
Eichmeier et al. 2018. Fungal Ecology 36

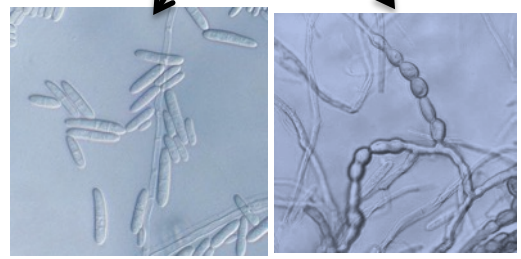


Integrated disease management strategy

Nursery mother blocks	Pruning wound protection Cultural practices and sanitation
Propagation processes	Chemical/biological/physical treatments
Nursery field	**Biofumigation**
Newly established vineyards	Selection of planting material Site preparation and vine management Biological control Pruning wound protection

Nursery propagation beds





BLACK-FOOT DISEASE PATHOGENS

Gramaje and Armengol 2011. Plant Disease 95

Nursery propagation beds

CROP ROTATION IN NURSERY FIELDS

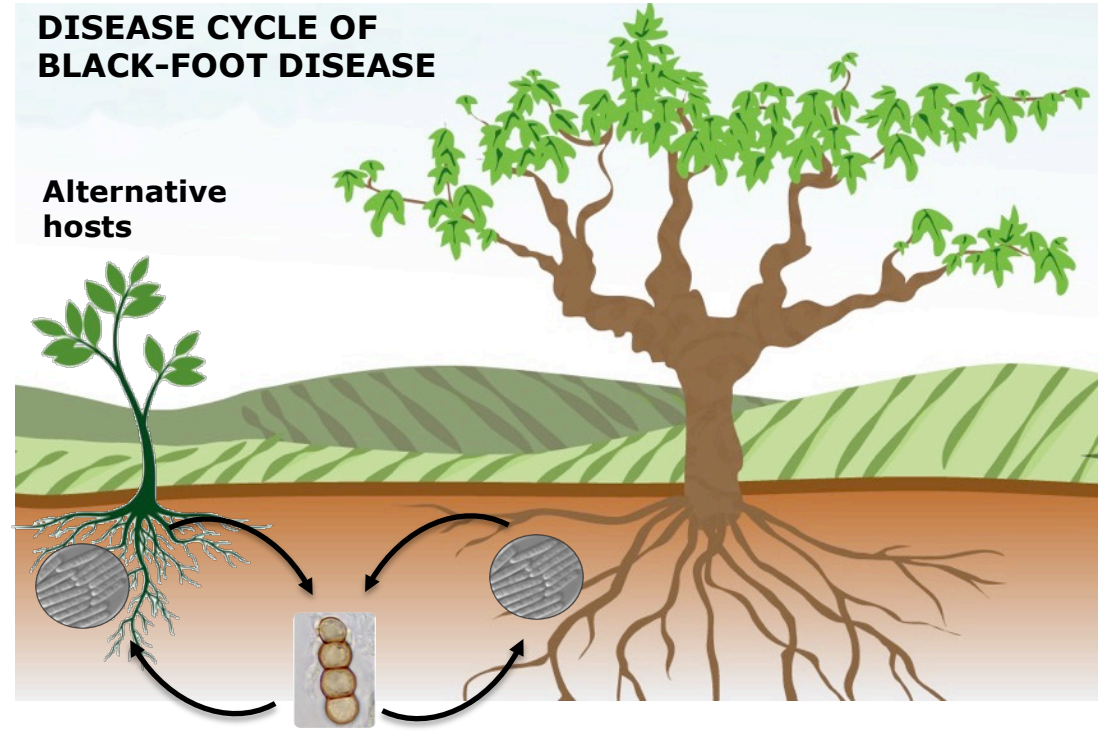
Increase of black-foot disease incidence

Portugal
Grapevines + 3-year rotation (e.g. potato, garlic, carrot, cereals)
(Rego et al. 2009 Phytopathol. Mediterr. 48)

South Africa
Grapevines every second year + cover crop
(Halleen et al. 2003 Australa. Plant Pathol. 32)

Fungal detection in soil during rotation

Wheat and barley
Portugal (Cardoso et al. 2013 Phytop. Mediterr. 52)
Spain (Berlanas et al. 2017 Plant Soil 417)



Resting spores (chlamydospores)
Mycelium in rotten root fragments

✓ **Biofumigation**

Indian mustard seed meal

New Zealand
Barbour et al. 2014 Phytopathol. Mediterr. 53
Bleach et al. 2010 Phytopathol. Mediterr. 49

White mustard

Spain
Berlanas et al. 2018 Pest Manag. Sci. 74

Canada
Richards et al. 2020 Diversity 12

Reduction of black-foot disease incidence and fungal inoculum in soil

Integrated disease management strategy

Nursery mother blocks

Pruning wound protection

Cultural practices and sanitation

Propagation processes

Chemical/biological/physical treatments

Nursery field

Biofumigation

Newly established vineyards

Selection of planting material
Site preparation and vine management
Biological control
Pruning wound protection

Commercial production settings

SELECTION OF GRAFTED PLANTS

- ✓ Vines should be of an even size and vigor
- ✓ Vines should be free of signs of disease
- ✓ Vines should not be broken or show signs of damage
- ✓ Each vine should have at least 1 well-developed shoot with healthy buds
- ✓ Each vine should have at least 3 healthy, undamaged, evenly spaced roots

Petri disease pathogens

Commercial production settings

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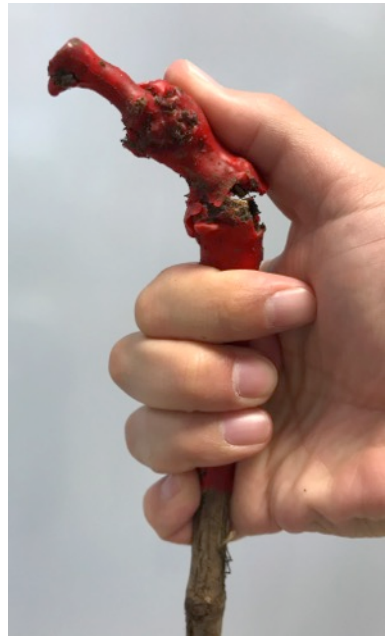

Grafts should be fully healed, not overgrown and not able to be broken by "moderate" pressure applied by the thumb

Commercial production settings

SITE PREPARATION FOR NEWLY ESTABLISHED VINEYARDS

Preplanting method: **mustard seed meal can be incorporated into the soil, or a rotation crop of mustard can be grown until flowering and then incorporated before planting**

Planting practice: **compacted soil layers should be broken up before planting and vine should be well placed in large planting holes. Avoid soil compaction with heavy vehicles.**

"J-rooting"

Photo: J. Vivancos (APA Québec)

Commercial production settings

PREPLANTING TREATMENTS: Biological control agents

Pest Management Science

Investigation of *Trichoderma* species colonization of nursery grapevines for improved management of black foot disease

Wynand J van Jaarsveld,[a,b] Francois Halleen,[a,b] Michael C Bester,[a] Romain JG Pierron,[c] Elodie Stempien[a] and Lizel Mostert[a*]

➡ ***Trichoderma* spp. were not sufficient to prevent infections by BFD pathogens, but a certain degree of protection was obtained in the basal ends.**

Field evaluation of biocontrol agents against black-foot and Petri diseases of grapevine

María del Pilar Martínez-Diz,[a,b] Emilia Díaz-Losada,[a] Marcos Andrés-Sodupe,[c] Rebeca Bujanda,[c] María M Maldonado-González,[c] Sonia Ojeda,[c] Amira Yacoub,[d] Patrice Rey[d] and David Gramaje[c*]

➡ **The combination of the disease-suppressive activity of two or more beneficial microbes is required to prevent fungal infection**

- ***Streptomyces* sp. E1 + R4**
- ***Pythium oligandrum* Po37**
- ***Trichoderma atroviride* SC1**
- ***Trichoderma koningii* TK7**
- ***Pseudomonas fluorescens* + *Bacillus atrophaeus***

Commercial production settings

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Arbuscular mycorrhizal fungi

horticulturae

Does Inoculation with Arbuscular Mycorrhizal Fungi Reduce Trunk Disease in Grapevine Rootstocks?

Taylor Holland [1], Patricia Bowen [2], Vasilis Kokkoris [1], Jose Ramon Urbez-Torres [2] and Miranda Hart [1,*]

PeerJ

Commercial arbuscular mycorrhizal fungal inoculant failed to establish in a vineyard despite priority advantage

Corrina Thomsen[1], Laura Loverock[1], Vasilis Kokkoris[2,4], Taylor Holland[1], Patricia A. Bowen[3] and Miranda Hart[1]

agriculture

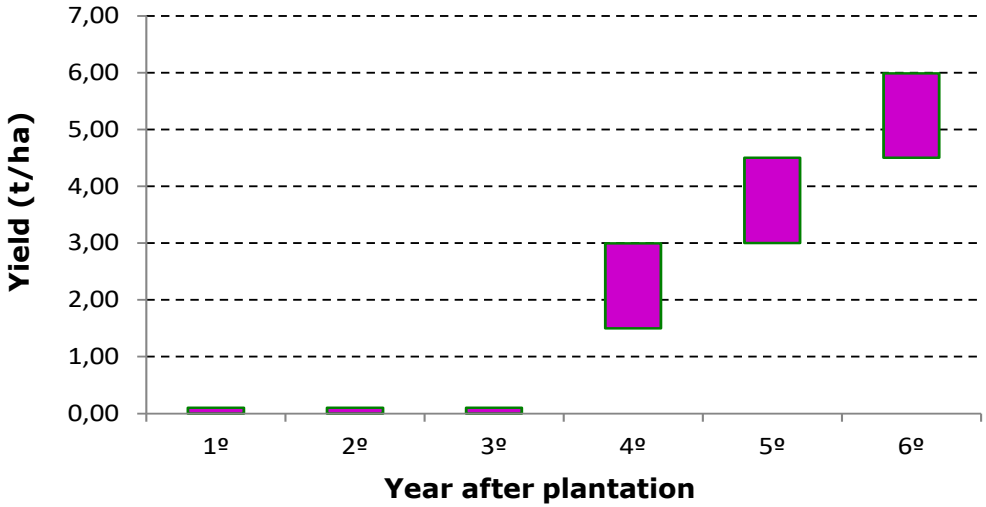
Performance and Establishment of a Commercial Mycorrhizal Inoculant in Viticulture

Daniel Rosa [1,*], Antreas Pogiatzis [1], Pat Bowen [2], Vasilis Kokkoris [3], Andrew Richards [1,*], Taylor Holland [1] and Miranda Hart [1]

Commercial production settings

MANAGEMENT OF YOUNG VINEYARDS

Avoid placing a heavy fruit load on vines in the early production years



AVOID OVERCROPPING

Vines that are stressed are more susceptible to disease than unstressed vines.

2016
Plantation in 2014
Cultivar Macabeo

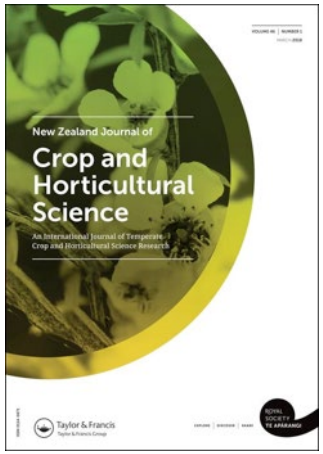
PHYTOPATHOLOGIA MEDITERRANEA

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

José Ramón ÚRBEZ-TORRES, Jared HRYCAN, Miranda HART, Patricia BOWEN, Thomas FORGE

3rd YEAR

Royo, B. et al. UPNA



New Zealand Journal of Crop and Horticultural Science

Publication details, including instructions for authors and subscription information:
http://www.tandfonline.com/loi/tnzc20

Grapevine propagation: principles and methods for the production of high-quality grapevine planting material

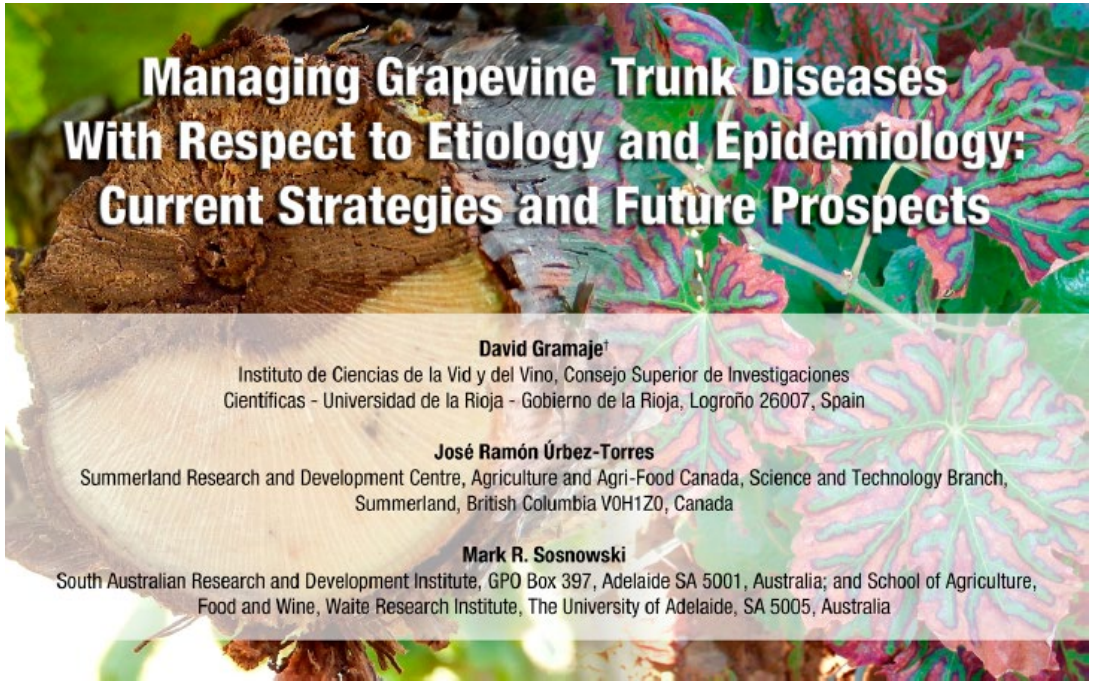
H Waite[ab], M Whitelaw-Weckert[ac] & P Torley[ab]

[a] National Wine and Grape Industry Centre, Charles Sturt University, Wagga Wagga, Australia

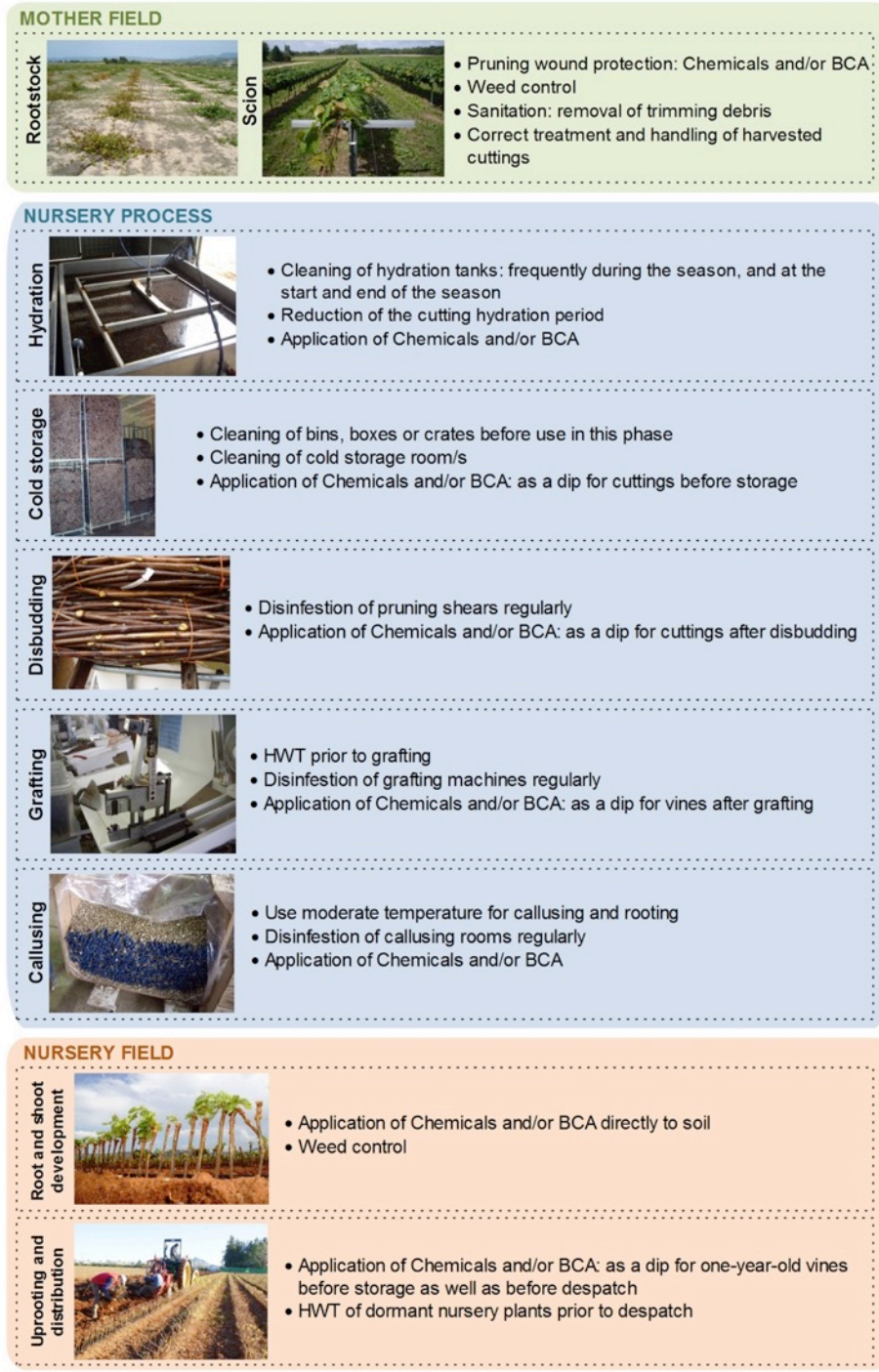
[b] School of Agricultural and Wine Sciences, Charles Sturt University, Wagga Wagga, Australia

[c] New South Wales Department of Primary Industries, National Wine and Grape Industry Centre, Charles Sturt University, Wagga Wagga, Australia

Published online: 21 Nov 2014.



D. Gramaje, J. R. Úrbez-Torres, M. Sosnowski, 2018. Plant Dis. 102.



Conclusions

- The spread of fungal trunk pathogens via infected nursery material is a long-established problem that cannot be solved quicky.
- Nurseries must undertake subtantial efforts to improve sanitation.
- Tree crop nurseries are struggling to meet demands for plant material.

Almond nurseries in Spain

Phaeoacremonium minimum **(20% incidence)**

Marín-Terrazas et al. 2016 Plant Dis. 100

Blueberry nurseries in New Zealand

Four nurseries tested positive (45% incidence)
Neofusicoccum spp.

Tennakoon et al. 2018 Eur. J. Plant Pathol. 150

Forest nurseries in Spain

17 nurseries
12 species
Cylindrodendrum
Dactylonectria
Ilyonectria

Mora-Sala et al. 2018 Plant Dis. 102

Olive nurseries in South Africa

2 nurseries
Nectriaceae
Diaporthaceae
Botryosphaeriaceae
Phaeomoniellaceae
Pleurotomaceae
Togniniaceae

Van Dyk et al. 2021 Plant Dis. (in press)

Can we really produce "disease-free" plant material even when following clean production best management practices?

Future direction

CLEAN PLANT CERTIFICATION PROGRAM

Challenges

Broad range of taxonomically unrelated pathogens
Plant nursery conditions and practices favor fungal infection
Detection and identification requires destructive sampling

Develop fast and reliable methods for screening large number of plants for fungal trunk pathogens infections.

DNA-macroarray (Úrbez-Torres et al. 2015 Phytopathology 105)
Use of NGS from asymptomatic tissues (Vettraino et al. 2017 Plos One 12)

Impact of global trade and implications of trunk disease infection in other tree crop nurseries.

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Thanks for your attention!

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