



Department of
Primary Industries

Grapevine management guide 2019–20

NSW DPI MANAGEMENT GUIDE



Darren Fahey and Adrian Englefield

WE'VE GOT YOUR VINES COVERED



TRIBASIC LIQUID

Protectant Fungicide/Bactericide
190g/L COPPER (Cu) present as
Tri-basic copper sulphate

- Control of Downy mildew
- An SC (Suspension concentrate) liquid formulation of Tribasic Copper Sulphate
- Superior mixing
- Available in 20L, 200L and 800L packs

MYCLONIL WG

Systemic fungicide with Protective and Curative action
400 g/kg MYCLOBUTANIL

- Control of Powdery mildew
- Unique wettable granule (WG) formulation
- IPM compatible – low bee and beneficial insect toxicity
- Low hazard to the handler/operator
- Robust packaging and easy-to-pour jug
- Available in handy 1kg bucket



BORDEAUX WG

Protectant Fungicide/Bactericide
200g/kg COPPER (Cu) present as
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- Control of Downy mildew
- Dry-Flowable granule for ease of mixing and minimal dust
- Superior weathering and sticking properties
- Available in 15kg bags



DINON 700WG

Protectant fungicide with some curative action
700 g/kg DITHIANON

- Control of Downy mildew, Black spot, Phomopsis cane and Leaf blight
- Multisite mode of action for disease resistance
- Dry-Flowable granule for easy of mixing and minimal dust
- Low hazard to predatory mites
- Low toxicity to bees at > 0.1mg/bee (contact)
- Available in 2.5kg packs



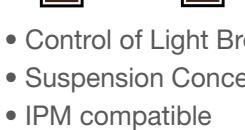
PEARL™ PEARL

Systemic fungicide with Protective and Curative action
200g/L PENCONAZOLE the form of an oil in water emulsion

- Control of Powdery mildew
- Advanced 200G/L formulation of Penconazole as an oil in water emulsion (EW)
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- Suspension Concentrate
- IPM compatible
- Controls both eggs and early instar larvae
- Available in 5L and 10L packs



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Grapevine management guide 2019–20

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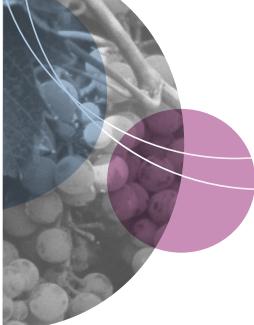
Kaolin clay on Pinot Noir grapes in Orange NSW to protect grapes from sunburn. Photo: Darren Fahey.

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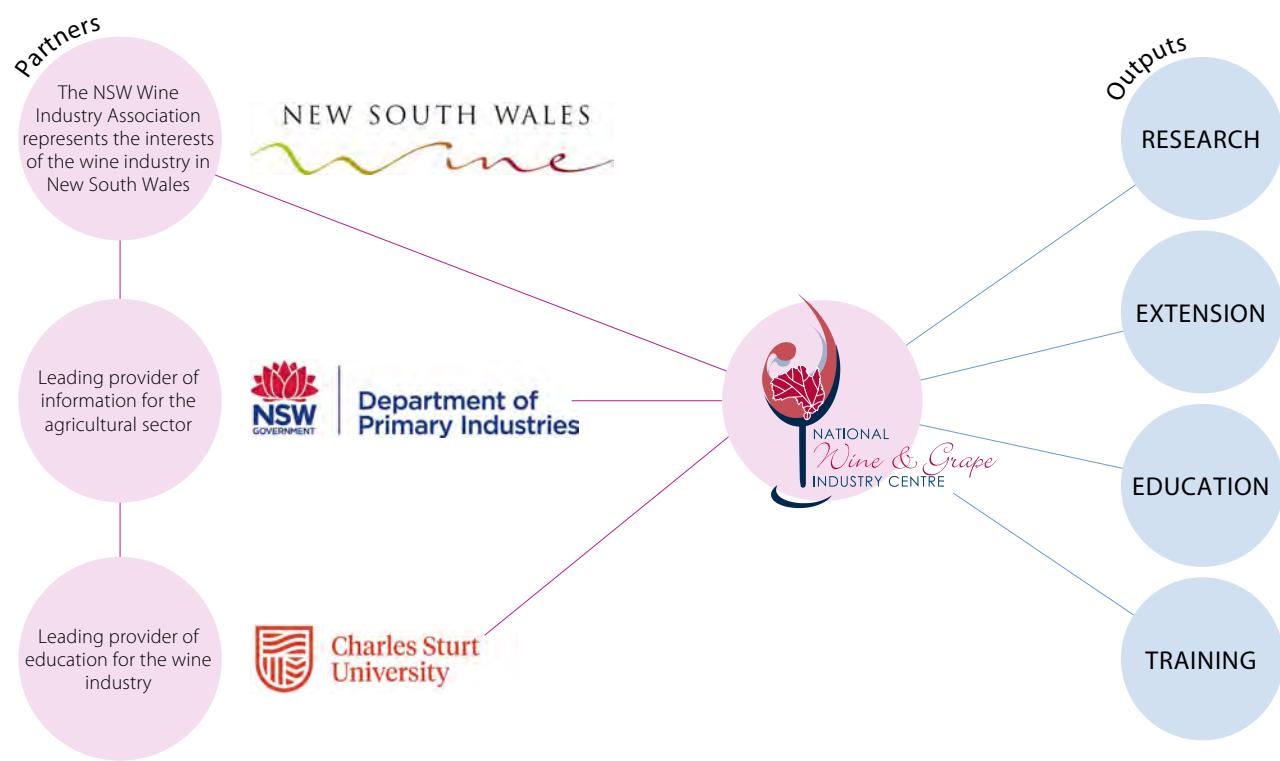


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The National Wine and Grape Industry Centre is an alliance between NSW Department of Primary Industries, the NSW Wine Industry Association and Charles Sturt University.

The National Wine and Grape Industry Centre delivers high-value research, education, training and extension to the Australian Wine Industry.



Introduction

Research, innovation and adoption

With great pleasure we welcome you to read, benefit and grow from the information contained within *The Grapevine Management Guide 2019–20*.

Skills Development Program

It is exciting to announce the continuation of the NSW DPI funded Skills Development Program (SDP) for the next 5 years 2019–2024. The previous SDP, which ran from 2014–2019, delivered:

- more than 40 workshops across NSW via the annual Spring Vine Health Field Days, Durif, Chardonnay and Shiraz masterclasses, sustainability, compost/mulches, nutrition and soils workshops
- provided subsidised intrastate and interstate vineyard and winery tours including attending the Sparkling Wine Symposium in 2018 and the MPVA Pinot Celebration in 2019
- contributed to developing the inaugural Innovators Forum and continue to assist in ongoing event planning and facilitation
- sponsored events such as the Australian Alternative Varieties Wine Show
- funded numerous scientific and applied field trials including experiments on managing antitranspirants, Botrytis and powdery mildew across various regions.

We both look forward to further developing the NSW wine industry through projects such as the aforementioned and more over the coming years. We also seek your input as industry participants to help us improve the financial viability and environmental sustainability of the NSW wine industry.

Feature articles

Within this year's guide, readers will find contributions on topics such as alternative weed control measures, antitranspirants, vineyard technology, hail damage and European wasp control. The latest research from the NWGIC is outlined by centre Director, Professor Leigh Schmidtke, and there is a profile on viticulture scientist Dr Jason Smith who returns to Orange from Hochschule Geisenheim University to undertake new research.

The Grapevine management guide 2019–2020 is one of NSW DPI's flagship publications. Such publications are a crucial means of packaging information for producers, and as such we recommend this current edition to you.

Darren Fahey and Adrian Englefield,
Development Officers – Viticulture

Feedback please

The NSW DPI wants to make sure the information we are providing is what you need to make your business grow. We would like to receive any feedback that you care to offer – good, bad or indifferent. This will help us to make future editions even more useful. Please contact us with your suggestions by mail, phone or email.

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NSW DPI Development Officers – Viticulture (left) Darren Fahey and (right) Adrian Englefield.



NATIONAL WINE AND GRAPE INDUSTRY CENTRE



A leader in viticulture and wine science research, education and industry training.

Our research aims to increase the development, sustainability and profitability of the wine industry, delivering solutions throughout the value chain.

OUR KEY AREAS OF RESEARCH

Vine health and disease management

- > Diagnostics
- > Pest and disease management
- > Grapevine trunk diseases
- > Bunch rots and wine quality

Vine science

- > Vine physiology and nutrition
- > Root functioning
- > Flowering and berry growth

Wine science

- > Fruit and wine composition
- > Process engineering

Sensory and consumer sciences

- > Wine styles

OUR RESEARCH AIMS

- > Reduce costs in the vineyard and cellar
- > Develop decision support tools
- > Improve understanding of grape maturation cycles, harvest dates and wine styles
- > Improve pest and disease detection, and management options

WHAT WE'RE INVESTIGATING

- > Solutions to the negative impact of warmer growing environments on vine and wine production
- > Methods to manage the alcohol content and desired flavour characteristics of wines
- > Sustainable resource management, including water and soils
- > How to reduce chemical spray applications and other inputs through the development of more environmentally friendly methods and products

An alliance between

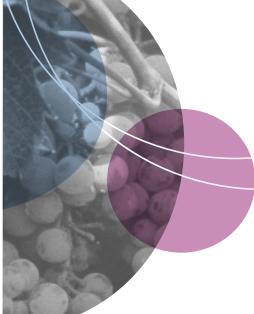


Department of
Primary Industries

NEW SOUTH WALES
wine



Charles Sturt
University



Current research projects

Entomopathogenic fungi as potential biocontrol agents of grapevine phylloxera

Research aims

1. survey Australian vineyard soils for entomopathogenic fungi belonging to the genera *Beauveria* and *Metarhizium*
2. test the pathogenicity of selected fungal isolates originating from vineyard soils against a test insect (aphid) and a root galling form of grapevine phylloxera
3. assess the ability of entomopathogenic fungi to endophytically colonise grapevine root tissue
4. use scanning electron microscopy and quantitative PCR to examine post application effects of entomopathogenic fungi on a test insect (aphid) and root galling phylloxera.

Industry outcomes and relevance: there is increasing interest surrounding the use of biological control agents as alternatives to chemical management options. Currently in Australia, phylloxera is managed by adhering to strict quarantine regulations and planting on phylloxera-resistant rootstocks. This project aims to determine if entomopathogenic fungi belonging to the genera *Beauveria* and *Metarhizium* could be a viable biological control option to manage root galling grapevine phylloxera.

Researcher/s students involved

NWGIC:

Associate Professor Sandra Savocchia, principal supervisor

Ms Ginger Korosi, PhD candidate

Hochschule Geisenheim University:

Professor Annette Reineke, co-supervisor

University of Southern Queensland:

Professor Gavin Ash, co-supervisor

Dr Bree Wilson, co-supervisor

Sugar Research Australia:

Dr Kevin Powell, co-supervisor.

Time frame: July 2015 – August 2019.

Funding bodies and collaborators: Australian Postgraduate Award and Wine Australia.

Benchmarking regional and subregional influences on Shiraz fine wines

Research aims: this project is strongly aligned with the AGWA Strategic Plan Priority 1, increasing demand and Strategy 3, building Australian grape and wine excellence, wine provenance and measures of quality. This multidisciplinary project will define the sensory properties of Shiraz wines from selected regions in New South Wales, Victoria and South Australia and identify the sensory and chemical attributes associated with typicality from these regions by drawing upon the collective expertise of climate scientists, wine scientists and sensory experts. Geographical indications (GI) will be selected based on commercial reputation for consistent fine wine production and systematic searches of climate data (SILO/AWAP) to match regions with similar and differing climatic conditions as designated by climatic indices (Huglin, cool night, rainfall). Typicality and regionality of fine Shiraz wines will be identified using comprehensive sensory profiling of a selection of wines chosen by an expert panel of winemakers. Specific terroir markers will be identified using a range of targeted and untargeted chemical analyses. In addition, an international sommelier delegation will sort and ascribe preferences to a selection of premium Shiraz/Syrah wines.

Industry outcomes and relevance: a concept of terroir is important for fine wine producers who aim to associate their product with unique geographical areas, associated mesoclimates and landscapes that influence wine typicality. Defining a terroir influence for fine wine producers will enhance the uniqueness of Australian Wines in a global context. Commoditisation of agricultural products arises from global financial pressures to lower inputs and expenses while enhancing profitability. The ability for fine wine producers to substantiate uniqueness claims will reverse this trend, enabling product positioning within markets as distinctive and exclusive wines that command premium prices in a global context.

Researcher/s students involved

Dr John Blackman

Dr Andrew Hall

Professor Leigh Schmidtke

Dr Andrew Clark

Dr Sijing Li
Dr Leigh Francis
Wes Pearson, PhD candidate.

Time frame: April 2017 – December 2019.

Funding bodies and collaborators: Wine Australia in collaboration with The Australian Wine Research Institute.

Vascular transport into the grape berry

Research aims: fruits, roots and leaves are interconnected by a dynamic vascular system allowing transport of essential materials and a system for whole plant communication and integration. Long distance transport through the grapevine's vascular network ultimately defines fruit size and composition, affecting yield and wine style. This project aims to understand how the grapevine's transport system drives berry development and composition.

Industry outcomes and relevance: improving vineyard performance; efficient and sustainable vineyard management.

Researcher/s students involved

Dr Suzy Rogiers
Professor Leigh Schmidtke
Dr Steve Tyerman
Dr Vinnay Pagay
Dr Bill Price
Dr Timothy Stait-Gardner
Dr Zeyu Xiao
Ms Yin Liu.

Time frame: January 2018 – December 2022.

Funding bodies and collaborators: Australian Research Council in collaboration with the University of Adelaide.

Managing wine pH in a changing climate

Research aims

1. to better understand the relationship between vineyard cultural strategies and site characteristics on berry composition and its ultimate effect on wine acidity
2. to devise a management strategy so that appropriate sugar-acid balance is achieved and maintained.

Industry outcomes and relevance: improving vineyard performance; efficient and sustainable vineyard management.

Researcher/s students involved

Dr Suzy Rogiers
Dr Bruno Holzapfel
Professor Leigh Schmidtke

Dr Rob Walker
Dr Tintu Baby
Dr Zeyu Xiao
Darren Fahey
Adrian Englefield.

Time frame: July 2019 – December 2022.

Funding bodies and collaborators: NSW Department of Primary Industries, Wine Australia and Charles Sturt University.

Vine nutrition

Research aims

1. to characterise nutrient deficiency and toxicity symptoms in red and white varieties
2. to develop an App that provides information to growers on nutritional disorders in red and white varieties.

Industry outcomes and relevance: improving vineyard performance; efficient and sustainable vineyard management.

Researcher/s students involved

Dr Suzy Rogiers
Dr Bruno Holzapfel
Professor Leigh Schmidtke
Dr Lihong Zheng
Dr Manoranjan Paul
Dr Tintu Baby
Dr Motiur Rahaman
Alexander Oczkowski
Darren Fahey.

Time frame: July 2018 – December 2021.

Funding bodies and collaborators: NSW Department of Primary Industries, Wine Australia and Charles Sturt University.

The influence of rootstock on potassium in grapes and wine

Research aim: to select rootstock types with lower potassium accumulation in grapes to achieve lower grape juice pH and therefore reduce the need for adjusting pH during winemaking.

Industry outcomes and relevance: to compare the performance of low to moderate vigour rootstocks on Terra Rossa soil and with Cabernet Sauvignon scion in the Coonawarra region. The detailed knowledge on the performance of different rootstocks will assist growers in choosing the most appropriate rootstocks.

Researcher/s students involved

Dr Zeyu Xiao
Dr Tintu Baby
Dr Suzy Rogiers

Professor Leigh Schmidtke
Dr Rob Walker
Dr Bruno Holzapfel
Dr Kerry DeGaris
Ms Suzanne McLoughlin
Dr Catherine Kidman.

Time frame: June 2018 – June 2019.

Funding bodies and collaborators: Wine Australia, The National Wine and Grape Industry Centre, Limestone Coast Grape and Wine Council, Vinehealth Australia, Treasury Wine Estates and the Commonwealth Scientific and Industrial Research Organisation.

Grapevine trunk disease management for vineyard longevity in diverse climates of Australia

Research aims

1. investigate spore dispersal patterns of *Eutypa* dieback and *Botryosphaeria* dieback (BD) pathogens throughout the growing season
2. use remedial surgery techniques to manage BD infected vines
3. develop DNA-based diagnostic tools to detect and quantify grapevine trunk disease pathogens from the environment and grapevine plant materials.

Industry outcomes and relevance: improving our understanding of grapevine trunk disease pathogen epidemiology will allow targeted control methods, thereby reducing vineyard inputs. It will also provide growers with better disease forecasting and management options, ultimately improving vineyard performance.

Researcher/s students involved

NWGIC:

Associate Professor Sandra Savocchia, principal supervisor
Dr Regina Billones Baaijens, postdoctoral research fellow

Mrs Meifang Liu, technical assistant
Professor Chris Steel, collaborator

SARDI:

Dr Mark Sosnowski, project leader
Mr Matthew Ayres, research officer

The University of Adelaide:

Professor Eileen Scott, collaborator.

Time frame: January 2017 – June 2020.

Funding bodies and collaborators: Wine Australia with leverage from Charles Sturt University and industry collaborators.

Isolate and characterise phytotoxins produced by the *Botryosphaeriaceae* and their role in grapevine trunk diseases

Research aims: to investigate the phytotoxic metabolites (PMs) produced by *Botryosphaeriaceae* species associated with grapevine trunk diseases (GTDs) in Australia and their role in the pathogenesis, virulence and symptom expression of these pathogens in vineyards.

Industry outcomes and relevance:

characterising secondary metabolites and their role in the pathogenicity and symptom development of *Botryosphaeriaceae* species could assist in field diagnosis and the development of control strategies for BD in vineyards. Furthermore, developing a fast and economical method for analysing wood samples based on detecting specific phytotoxins produced by the pathogen may assist in the early detection of BD infections, avoiding the need to perform expensive remedial surgery and therefore reducing economic losses for winegrowers.

Researcher/s students involved

Mr Pierluigi Reveglia, PhD candidate
Associate Professor Sandra Savocchia, principal supervisor
Dr Regina Billones-Baaijens, co-supervisor
Professor Antonio Evidente, co-supervisor
Dr Alessio Cimmino, co-supervisor.

Time frame: July 2016 – August 2019.

Funding bodies and collaborators: National Wine Grape Industry Centre, University of Naples Federico II and Wine Australia.

The effect of extreme high temperature on grape berry tannin composition in cv. Shiraz

Research aim: to determine if berry tannin accumulation is sensitive to high temperature.

Industry outcomes and relevance: learning more about the effects of heat on berry quality parameters will have both immediate and long-term economic benefits for growers and winemakers. In the short term, understanding the physiological responses of berries to high temperature will inform vineyard management decisions, including when heat mitigation methods should be implemented, particularly when most critical. In addition, understanding the effect of temperature on berry phenolic composition and extractability might allow adaptation of winemaking protocols. In the

longer term, the work will assist with strategic planning for grape growing regions and newly developing regions by providing insight into the temperature extremes that may be the upper limit for production viability.

Researcher/s students involved

Ms Julia Gouot, PhD candidate
Dr Celia Barril, principal supervisor
Dr Bruno Holzapfel, co-supervisor
Dr Jason Smith, co-supervisor.

Time frame: July 2016 – January 2020.

Funding bodies and collaborators: Charles Sturt University, Postgraduate Research and International Tuition Payment scholarship.

Rapid preharvest grape assessment to quantify fungal off-flavours and product composition

Research aims: to develop in-field assessment capability for grape quality, composition and fungal taint compounds. This work builds on our expertise for quantifying volatiles linked to grape fungal infection and will extend to volatiles linked to wine faults and taints. New instrumentation will aid growers and winemakers to ensure quality, thereby offering better wine to consumers, but could also be applied more broadly to other horticultural crops. Working in collaboration with the University of New South Wales, new instrumentation that collects targeted chemical signatures from the volatile compounds of grapes will be developed and used to fingerprint biomarkers associated with taint compounds, with an initial emphasis on Botrytis detection. Non-specific grape composition measures will also be assessed for objective grape quality measures.

Industry outcomes and relevance: harvest decisions are often pressured by transport, winery logistics and the need to coordinate with the ripening of other grape varieties. Vintage compression, late rain and associated mould growth and off-flavours add to the problem. Rapid objective methods to assess grape quality and mould taints would help decision-making and grading of grapes but currently no methods exist.

Researcher/s students involved

Professor Leigh Schmidtke
Professor Chris Steel
Dr Alex Donald, The University of New South Wales
Dr Morphy Dumlao.

Time frame: March 2019 – December 2022.

Funding bodies and collaborators: Australian Research Council Training Centre for Innovative Wine Production in collaboration with the University of New South Wales.

Biological control of grapevine trunk diseases using bacterial endophytes from grapevines

Research aims: to characterise the microbiome associated with grapevine wood and to identify potential biocontrol agents to suppress grapevine trunk disease pathogens.

Industry outcomes and relevance: biological control agents could be used as an alternative control strategy and in an integrated approach to managing grapevine trunk diseases in the wine industry.

Researcher/s students involved

Jennifer M Niem, PhD candidate
Associate Professor Sandra Savocchia, principal supervisor
Dr Regina Billones-Baaijens, co-supervisor
Dr Benjamin Stodart, co-supervisor.

Time frame: July 2016 – December 2019.

Funding bodies and collaborators: Charles Sturt University International Postgraduate Research Scholarship with Wine Australia Top-Up.

Determining thresholds for bunch rot tolerance in wine and detecting unwanted fungal aromas

Research aims: to accurately define bunch rot contamination thresholds for wine grapes and find solutions for winemakers to allow them to cope with situations where these thresholds have been exceeded. Outcomes from the project will provide the industry with better indicators of bunch rot thresholds before the fruit has to be rejected or downgraded.

Industry outcomes and relevance: current management practices for bunch rots include a combination of cultural practices (e.g. canopy management, varietal selection) and chemical control. While these practices are effective in low disease pressure years, bunch rot management frequently fails in years that have high rainfall. In severe seasons when bunch rots are a problem, growers often waste money on applying fungicides when disease control practices may be too late and fungal taints have reached an unacceptable level. Establishing bunch rot thresholds and early bunch rot detection will help prevent this economic loss to the wine industry.

Aside from yield losses, bunch rots can affect wine quality by producing off flavours and taints. If detected, this leads to the downgrading or possible rejection of fruit at the winery with a huge cost to the industry, particularly in years that have high rainfall. If the fungal contamination is not detected or is ignored, the result can be inferior quality wine which has the potential to damage the reputation of Australian wine as a quality product. Detecting fungal taints in grapes before they are turned into wine will circumvent this problem and reduce wine production costs.

Researcher/s students involved

Professor Christopher Steel, principal supervisor

Professor Leigh Schmidtke

Dr Andrew Clark

Dr John Blackman

Dr Joanna Gambetta

Postdoctoral research candidate (to be appointed).

Time frame: July 2018 – December 2020.

Funding bodies and collaborators: Wine Australia and Charles Sturt University.

Defining regional sensory variability of premium Shiraz wines

Research aims: to better understand the sensory characteristics defining Shiraz wines produced in different regions of Australia, along with the development and testing of a novel sensory method. This project forms the basis for Wes Pearson's PhD submission and is closely aligned to the NWGIC project 'Benchmarking regional and subregional influences on Shiraz fine wines'.

Industry outcomes and relevance: industry gains more fundamental knowledge of the wines they are producing and the regions from which they are produced. Also, the development of a new rapid sensory method to be used by industry.

Researcher/s students involved

Wes Pearson, PhD candidate

Dr John Blackman

Professor Leigh Schmidtke

Dr Leigh Francis.

Time frame: 2017–2020.

Funding bodies and collaborators: Wine Australia, National Wine and Grape Industry Centre and The Australian Wine Research Institute.

Determining the most effective management strategies for minimising sunburn damage in Chardonnay vineyards around Orange

Research aims

1. to compare the effect of leaf removal timing (post-flowering vs. véraison) and level on the appearance and severity of sunburn symptoms in Chardonnay grapes
2. to determine whether performing early leaf removal increases photoprotective compound production and its effect on grape quality
3. create a visual record of sunburn progression
4. correlate different sunburn intensities with objective measures (i.e. total polyphenol content, colour measurements).

Industry outcomes and relevance: this research focuses on reducing sunburn damage by managing leaf removal, which is a common practice in cooler viticultural areas such as Orange. Currently, there are no clear guidelines for the optimal timing of this practice in relation to berry sunburn. This project compares current leaf removal practices to objectively evaluate their effect on sunburn damage. Results will determine whether early defoliation helps protect berries from sunburn through the production of more photoprotective compounds without negatively affecting wine quality. Depending on the outcome of the study, recommendations on defoliation timing will be issued.

Researcher/s students involved

Dr Joanna M Gambetta

Dr Bruno Holzapfel

Professor Leigh Schmidtke

Ms Valentina Romat.

Time frame: July 2018 – July 2019.

Funding bodies and collaborators: Wine Australia.

The effect of metal speciation on the development, shelf-life and sensory properties of wine

Research aims: to produce wine with improved bottle development by understanding how metal speciation influences wine ageing in-bottle, and providing options to minimise detrimental influences of metals through wine production processes. Specific objectives include:

1. determine the influence of metal speciation and wine composition on the amount of sulfur dioxide consumed per mg/L oxygen in red and white wine

2. assess the reversibility of key copper speciation forms and their activity on mechanisms directly relevant to the development of red and white wines
3. establish the influence of ascorbic acid on the stability and activity of copper (I) sulfide during wine ageing
4. determine the effect of metal speciation and metal concentration ratios on mechanisms that contribute to colour and flavour development in wine
5. establish a link between metal speciation and steps in the wine production process that allow efficient removal of metals from wine and juice.

Industry outcomes and relevance: the Australian wine industry will be the immediate beneficiary by applying the operations that stem from previously untapped fundamental research results. Improved understanding of the reaction of sulfur dioxide in wine may allow a reduction in the amount of the preservative used, which should be viewed as a positive by consumers. The greater our understanding of the effect of metal forms on wine development will allow identification of the potential for negative development of wine. This will be particularly important for the ascorbic acid/metal speciation interplay, given the widespread use of ascorbic acid in Australian white wines. Furthermore, options to allow remediation of the metal speciation profile during wine production will be provided.

Researcher/s students involved

Dr Andrew Clark
Dr Nikos Kontoudakis
Dr John Blackman
Professor Leigh Schmidtke
Dr Geoffrey Scollary.

Time frame: April 2018 – December 2022.

Funding bodies and collaborators: Wine Australia.

Changes in red wine composition during bottle ageing: effects of viticultural conditions and oxygen availability

Research aims: this research investigated the effects of viticultural conditions (two vineyard locations, two grape varieties and two fruit maturities) and variable bottle ageing conditions (three oxygen availability regimes and four bottle ages) on red wine composition, with a particular focus on the production of aldehyde compounds and low molecular weight sulfur compounds

(LMWSC). After 24 months of ageing, the LMWSC concentrations increased in all wines. High oxygen availability treatments contained lower LMWSC concentrations compared to the low oxygen treatments. For volatile aldehyde compounds, generally, methional, 2-methylpropanal, 3-methylbutanal, 5-methylfurfural and furfural exhibited increased concentrations with time, while phenylacetaldehyde, benzaldehyde and hexanal showed decreased concentrations. Chemometrics analysis showed primary separation based on ageing and the viticultural conditions adopted. Regardless of the oxygen regimes or ageing time, the samples were able to be separated according to each of the viticultural conditions being investigated. This research is in the final stages and results to date have shown the importance of viticultural conditions of the grape on the ageing of wine, regardless of the extent of ageing or oxygen exposure.

Industry outcomes and relevance: this project will improve our understanding of how viticultural treatments applied in the vineyard influence the development of wine aged under different oxygen availability during bottle ageing, mainly focusing on the evolution of the reductive and oxidative off-flavour compounds. These results might be able to establish a primary bottle-ageing guideline indicating how wine volatile compounds will change based on the vineyard situations during the grape growing season.

Researcher/s students involved

Xinyi Zhang, PhD candidate
Dr Nikos Kontoudakis
Dr John Blackman
Dr Guillaume Antalick
Dr Katja Suklje
Dr Andrew Clark.

Time frame: April 2016 – Oct 2019.

Funding bodies and collaborators: Wine Australia and Charles Sturt University Postgraduate Research Scholarship and International Tuition Payment Scholarship.

Evaluating and demonstrating new disease-resistant red and white grapevine selections in cool and warm wine regions in NSW

Research aims: evaluating new grape varieties for their performance is crucial to determine their suitability for a region; assessing the resultant wines is equally important to validate market potential. Breeding grapevine varieties with disease resistance is a high priority, particularly

resistance to the two major diseases, downy mildew (*Plasmopara viticola*) and powdery mildew (*Erysiphe necator* syn. *Uncinula necator*). Downy mildew requires high humidity and rainfall to germinate and grow, whereas powdery mildew develops under a wide range of climatic conditions. The drivers for breeding disease-resistant winegrape varieties include lowering production costs by reducing spray applications and thus the need for labour, chemicals and fuel, improving the microbial activity of the soil in the vineyard by reducing the compaction caused by tractor usage, and to provide a healthier vineyard environment.

From the first generation crosses made by CSIRO, a total of 20 white and 20 red varieties exhibiting promising viticultural and winemaking characteristics have been selected and planted in diverse grape growing regions around Australia. NSW DPI evaluates these selections in the Orange and Riverina regions in New South Wales (South Eastern Australia) for productivity, grape composition and wine attributes. The most comprehensive results from the white selections growing in the Riverina region showed considerable differences in yield, yield parameters and must composition. Experimental wines made from these selections showed not only a considerable range in the overall scores, but also differences in aromas and attributes. These varieties will allow reduced production costs of wines exhibiting style characteristics similar to current major varieties.

Industry outcomes and relevance: this project will benefit a range of different stakeholders in the Australian wine industry. Growers will benefit from reduced fungicide requirements, which will lead to substantial savings during the growing season. The wineries will benefit from receiving grapes that have fewer residues, being potentially more marketable. Industry representatives, contractors, consultants and consumers should also benefit from the new information on the suitability of these resistant varieties that are evaluated in this project.

New knowledge on the performance and basic adaptation capacity of new red and white varieties for warm and cool climates will allow growers and winemakers to choose the most suitable variety for their production process. We will aim to determine growth characteristics, berry and wine composition (and style) for warm and cool grape growing regions and provide basic knowledge on these varieties in relation to yield and irrigation water use efficiency and capability to handle extreme weather conditions.

Researcher/s students involved

Dr Bruno Holzapfel
Di Hubbard
Darren Fahey
Adrian Englefield.

Time frame: July 2017–June 2022.

Funding bodies and collaborators: Wine Australia via the Commonwealth Scientific and Industrial Research Organisation (strategic alliance).

Aspergillus species associated with Australian wine grapes: implications of fumonisins for grapes and wine

Research aims

1. characterise *Aspergillus niger* and *Aspergillus welwitschiae* associated with Australian wine grapes for fumonisin production
2. examine the effects of temperature and water activity on fumonisin production by *Aspergillus* species
3. investigate the fate of fumonisins during the white wine vinification process
4. study the effects of fining agents in removing fumonisins from white wine.

Industry outcomes and relevance: the research findings will improve our understanding of how *Aspergillus* species influences grape and wine production.

Researcher/s students involved

Dilhani Perera, PhD candidate
Professor Christopher Steel
Associate Professor Sandra Savocchia
Associate Professor Paul Prenzler.

Time frame: 2016–2019.

Funding bodies and collaborators: NWGIC.

Producing volatile organic compounds with biocontrol properties by *Aureobasidium pullulans*

Research aims: increasing fungicide use restrictions means growers have to find alternative disease control methods. This project seeks to investigate the mode of action of *Aureobasidium pullulans*, a yeast-like fungus with known biocontrol properties. Reports in the literature indicate that *A. pullulans* produces a number of volatile organic compounds (VOCs) that are potentially antimicrobial. Using solid phase microextraction-gas chromatography-mass spectrometry (SPME-GC-MS), this research aims to identify VOCs produced by *A. pullulans*.

that are antimicrobial against *Alternaria solani* and *Botrytis cinerea*, two fungal pathogens of grapes and tomatoes. Further aims include determining the optimum culture conditions for VOC production along with elucidating how VOCs inhibit fungal growth.

Industry outcomes and relevance: lack of fungicide availability due to nil MRL restrictions in destination export countries means that many effective fungicides cannot be applied to wine grapes post véraison. This research will open new avenues for managing grapevine diseases without relying solely on fungicides.

Researcher/s students involved

Professor Christopher Steel

Professor Leigh Schmidtke

Dr Joanna Gambetta

Sashika Yalage Don, PhD candidate.

Time frame: 2017–2020.

Funding bodies and collaborators: The Australian Government Research Training Program scholarship from Charles Sturt University.

Building water use efficiency and resilience into future variation in water availability for winegrape production systems – a pilot water balance study of the Orange soils and vineyards

Research aims

1. to compile existing and new information on regional soil types in a spatial data format, expanding to include grapevine rooting depth and total transpirable soil water
2. at different vineyards representing regional soils and altitude ranges, characterise soil moisture dynamics, whole vine transpiration and other components of vineyard water balance across several seasons
3. compare measured soil and vine water use dynamics from field trials with existing vineyard water balance models
4. develop collaborations to expand the work to understand the effect of climate change on future risks and opportunities at a regional level.

Industry outcomes and relevance: if global temperatures continue to rise, cooler locations such as the high altitude Orange area in New South Wales offer opportunities for vineyard area expansion, thus helping to maintain the Australian wine industry's competitiveness in the cool climate wine market. However, while at an advantage

with higher rainfall and lower vine water demand, higher temperatures and long-term projected declines in rainfall will place increasing pressure on water resources. The overall objective of this study is to understand the components of water use in the vineyard, and the extent to which changes in the whole vineyard management system could allow wine grapes to be produced with reduced or no irrigation. Consideration will also be given for seasons with high rainfall, holistic vineyard management systems being resilient to variability in rainfall, as well as an underlying capacity for efficient water use.

Researcher/s students involved

Dr Jason Smith

Dr Bruno Holzapfel

Time frame: January 2019 – June 2023.

Funding bodies: Funded by Charles Sturt University and the New South Department of Primary Industries through the National Wine and Grape Industry Centre.

Collaborators and project advice: Peter Hedberg and Associates Vineyard Consulting, David McKenzie Soil Management Designs, Orange.

A special welcome to Dr Jason Smith

New senior research fellow for viticulture, Dr Jason Smith, is no stranger to the National Wine and Grape Industry Centre (NWGIC), having spent more than ten years in Wagga Wagga doing his PhD, postdoctoral research and then as a research fellow.

"To introduce myself, or to re-introduce myself to those familiar with the 'Postharvest vineyard management' and other carbohydrate-related seminars, I have recently returned to Australia after working in Germany since 2015," Dr Smith said.

"My new position is based in Orange, and I will be dividing my time between the NSW DPI Orange Agricultural Institute (OAI) site and Charles Sturt University's Wagga Wagga Campus."

Dr Smith is developing a pilot project in the Orange region on vineyard water use and water use efficiency to address longer-term research priorities identified by the wine industry. Given the advantage of a relatively cool climate with higher natural rainfall and diverse soil types, the underlying objective is to understand the scope for increasing vineyard resilience to a future of reduced water availability.

With other project developments, including trials of new CSIRO disease-resistant varieties



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and overlap with an open sensor network being developed by the NSW DPI climate group, there is a timely converge of research that can assist with the sustainability and longer-term climate adaptation of the wine industry.

"I have enjoyed previous cross-discipline projects and would be interested to pursue opportunities to link any future studies with fruit and wine composition research. In this respect, the Orange region will be a very interesting place to work as the combination of altitude, soil and rainfall provide diverse growing conditions in relatively close proximity," Dr Smith said.

In Germany, Dr Smith was employed as a viticulture lecturer and researcher at the Hochschule Geisenheim University, situated in the Rheingau region in the state of Hessen. This is a region famous worldwide for both its scenery and Riesling, with the university's involvement in viticulture and wine dating back to 1872 (Figure 2). His teaching involved viticulture and grapevine physiology for their English language International Wine Business degree and the European Vinifera Masters, as well as contributions to the German undergraduate viticulture and oenology program.

"The main part of my research was working on the university's grapevine free-air carbon dioxide enrichment (FACE; Figure 3) experiment looking at vine water use under near future climate conditions, and also supervising student projects across a range of general viticulture projects," Dr Smith said.

"Overall I was impressed by the university's long-term approach to viticulture data collection, which has proved very useful for documenting the effects of climate on phenology and fruit composition, and a valuable database for modelling applications. I was able to see a more holistic system approach to viticulture than I had been involved with previously, and would like to incorporate some of this experience in developing research projects here in Australia."

NWGIC Director Professor Leigh Schmidtke said, "We are delighted to welcome Jason back to the Centre and look forward to the contribution of his expertise and experience. Being based in Orange will allow Jason to work closely with other researchers and industry members in the NSW Central West expanding the capacity of our research in this area".



Figure 1. Dr Jason Smith.



Figure 2. Schloss Johannisberg, located north east of Geisenheim has over 900 years of viticulture and 300 years of Riesling. Photo: J Smith.



Figure 3. One of six carbon dioxide enrichment rings in the Hochschule Geisenheim University research vineyard. It is designed to increase CO₂ by 20% compared to ambient values, which at the time of construction in 2013 was 400 ppm. More details are at <https://www.hs-geisenheim.de/forschung/forschungsprofil-und-projekte/face/>. Photo: J Smith.

Acknowledgement

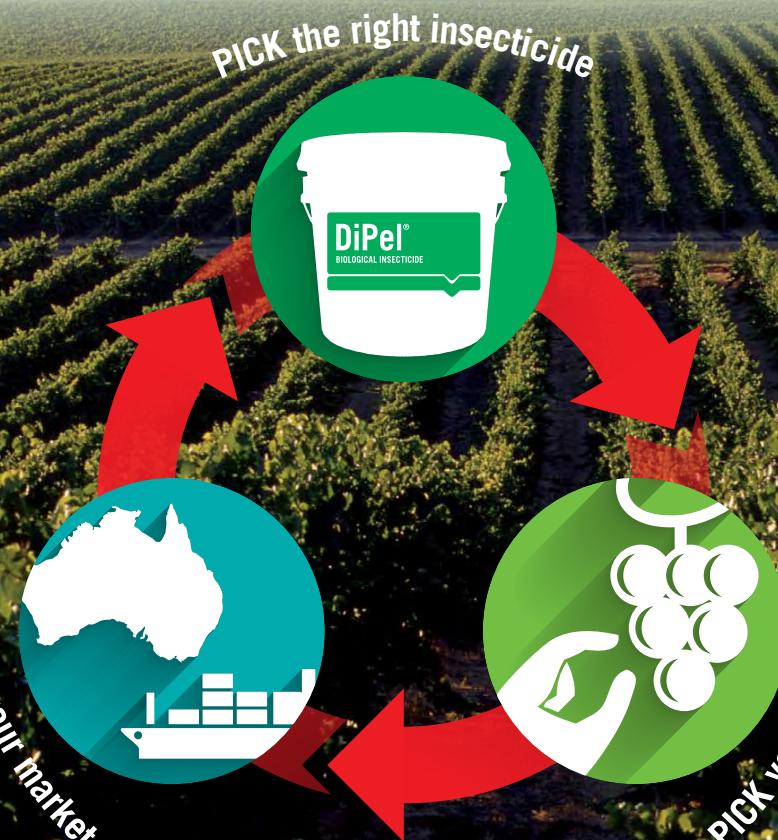
This is an expanded version of an article by Emily Malone that appeared in the February 2019 NWGIC newsletter.

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Monitoring and maintaining your drip irrigation system

Adrian Englefield; NSW DPI Development Officer – Viticulture

As an initiative of the 2018–19 Wine Australia Riverina regional program, Jeremy Giddings (Agriculture Victoria, Regional Manager – Irrigation) delivered a drip irrigation management workshop at the NSW DPI Griffith Research Station (Figure 4). Workshop attendees were introduced to key parameters for determining how efficiently a drip irrigation system is operating within design specifications.

This article outlines how to check and maintain a drip irrigation system and provides further drip irrigation resources.



Figure 4. Drip irrigation management workshop.

Drip system monitoring

Distribution uniformity (DU) is a measure of how evenly water is being delivered within an irrigation system. Poor uniformity can lead to over-watering and under-watering within the same vineyard block. To determine if irrigation is being applied evenly and within manufacturer's specifications, two simple measurements can be used to calculate dripper performance:

1. Dripper discharge: place a 50 mL measuring flask under a dripper (Figure 5) for 36 seconds and record the volume obtained.

$$\text{Dripper discharge in litres per hour (L/h)} = \frac{\text{volume (36 seconds)}}{36} \times 100$$



Figure 5. Measuring dripper discharge.

2. Operating pressure: this is measured with a pressure gauge attached to a brass adaptor (Figure 6) or equivalent, which are available at most irrigation suppliers. When measuring operating pressure, ensure drippers are not damaged through excessive force. Record the operating pressure in kilopascals (kPa).



Figure 6. Measuring operating pressure.

Measuring drip system uniformity

Take nine measurements (repeat three times and use the average; Table 1) within the irrigation shift at:

- the irrigation system extremities (sub-main and lateral)
- various elevations (high and low lying areas)
- low vigour (poor vine health) or constantly waterlogged areas.

Table 1. Calculate pressure and discharge variation.

Dripper	Discharge L/h (average discharge in 36 s × 100)	Pressure (kPa)
1		
2		
3		
4		
5		
6		
7		
8		
9		
Total discharge and pressure: add up all the discharge (L/h) and pressure (kPa) readings e.g. dripper 1 + 2 + 3...	Total discharge in L/h = _____	Total pressure in kPa = _____
Average discharge and pressure: divide total discharge (L/h) and pressure (kPa) by the number of drippers	Average = $\frac{\text{total discharge}}{\text{no. of drippers}}$ = _____ L/h	Average = $\frac{\text{total pressure}}{\text{no. of drippers}}$ = _____ kPa
Midpoint: select the maximum and minimum dripper measurements, add these and divide by two	Midpoint = $\frac{\text{max} + \text{min}}{2}$ = _____ L/h	Midpoint = $\frac{\text{max} + \text{min}}{2}$ = _____ kPa
Calculate variation: subtract the minimum from the midpoint dripper measurement and divide by the midpoint. Multiply by 100 to get a %.	Variation = $(\frac{\text{mid} - \text{min}}{\text{mid}}) \times 100$ = \pm _____ %	Variation = $(\frac{\text{mid} - \text{min}}{\text{mid}}) \times 100$ = \pm _____ %
Acceptable variation	< \pm 5%	< \pm 10%

After field testing a drip irrigation system, always compare the results with the manufacturer's and irrigation designer's specifications to ensure the system is meeting these specifications.

Drip system maintenance

Drip irrigation systems only operate to design specifications if they are monitored and maintained properly. Correct dripper care prevents clogging and component deterioration, leading to a decline in vine health and yield.

Three areas of drip system maintenance include:

1. flushing
2. chlorine or hydrogen peroxide injection (oxidation)
3. acid injection.

Flushing

Drip irrigation system flushing must include the filters and delivery system in the order of water flow:

1. mainline: with sub-main and lateral valves closed, flush for two minutes or until water is clear
2. sub-main: close the mainline valve and flush for two minutes or until water is clear
3. laterals (drip line): close sub-main, flush for two minutes or until water is clear.

When flushing laterals, often two sediment deposits are released. One is the material at the end of the lateral and the other will be the disturbed material along the lateral.

Flushing frequency can vary from weekly to six monthly, depending on water quality. Filtration systems stop material greater than 130 microns from entering the irrigation system. Silt (2–50 micron) and clay (< 2 micron) should pass through

the system (with proper maintenance). However, if allowed to build up, smaller particles bind together, then along with algae and bacteria, cause blockages and an uneven DU.

Determining the lateral flow rate for adequate flushing velocity

A minimum of 0.5 m/s flow velocity is recommended when flushing laterals to ensure all particles are dislodged and fully flushed

The required flow rate (L/min) for adequate flushing velocity for common lateral sizes is listed in Table 2.

With a bucket, measure the lateral flow rate for one minute. If the flow rate is less than that specified in Table 2, close a number of laterals to increase flushing velocity and re-measure until the flow rate corresponds with a velocity of 0.5 m/s.

Oxidation

Oxidation is a common term referring to injecting chemicals into a drip irrigation system to remove organic matter including algae and bacteria.

Chlorine and hydrogen peroxide are the most common oxidation agents. How frequently oxidation is required depends on water quality and checking of emitters.

Acid injection

Acid dissolves chemical deposits. Precipitated calcium salts appear as a white film inside the drip tube and outside the drippers. Generally, dilute solutions of hydrochloric or phosphoric acid are used to lower the pH to be between 2 and 4. Titrations are required to determine the required acid injection.

Note: acid should not be used with asbestos cement pipes as released fibres will block emitters.

Table 2. Flow rates required to achieve adequate flushing velocity for common lateral (drip line) sizes.

Lateral size (ID mm)	Required flow rate (L/min) for > 0.5 m/s
10.2	2.5
14.0	4.6
18.0	7.6
20.8	10.2

Calculations

Oxidation agent injection rate

$$\text{Injection rate (L/h)} = (\text{system flow rate (L/sec)} \times \text{required concentration (mg/L)} \times 0.36) / \text{active ingredient \%}$$

$$\text{Injection rate (L/h)} \div \text{_____ ha} = \text{L/h/ha.}$$

Check the flow rate via the water meter. If you are using chemicals such as chlorine and hydrogen peroxide, refer to the safety data sheets, label and irrigation designer recommendations.

Acid injection rate

1. Convert system (shift) flow rate to L/h:

$$\text{Shift flow rate: _____ L/sec (from your design)} \times 3,600 = \text{_____ L/h}$$

$$2. \text{ Acid required to drop pH to 3: _____ mL + 1,000 = _____}$$

$$3. \text{ _____ acid required (step 2) } \times \text{ _____ L/h (step 1)} = \text{ _____ L/h acid}$$

4. Adjust for injection time (e.g. 15 min or 0.25 of an hour)

$$\text{_____ L/h acid (step 3)} \times 0.25 = \text{_____ litre acid.}$$

Further reading

- Department of Jobs, Precincts and Regions. Testing your drip irrigation system: www.youtube.com/watch?v=qJAp1ZdRr84
- Irrigation Australia. Calculators: www.irrigationaustralia.com.au/certification/calculators
- Irrigation measuring and monitoring: www.tocal.nsw.edu.au/publications/list/farm-management/irrigation-measuring-and-monitoring
- Irrigation scheduling: www.tocal.nsw.edu.au/publications/list/farm-management/irrigation-scheduling
- Irrigation system and pump selection: www.tocal.nsw.edu.au/publications/list/farm-management/irrigation-system-and-pump-selection-agguide
- NSW DPI Irrigation management: www.dpi.nsw.gov.au/agriculture/irrigation
- NSW DPI PrimeFact: Maintaining a drip irrigation system for perennial horticulture: www.dpi.nsw.gov.au/agriculture/irrigation/irrigation/systems/maintaining-drip-irrigation-system
- Workshop attendees received copies of NSW DPI AgGuide water series, copies are available by emailing adrian.englefield@dpi.nsw.gov.au

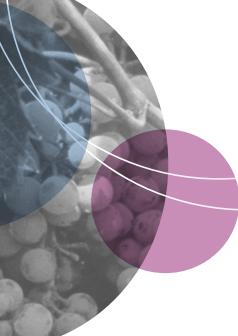


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Acknowledgements

Jeremy Giddings, Agriculture Victoria, Regional Manager Irrigation. Drip irrigation management workshop, Griffith Research Station, 23 October 2018.



Developing heatwave management strategies through grapevine phytomonitoring

Riverina vineyard sap flow and dendrometer demonstration

Adrian Englefield; NSW DPI Development Officer – Viticulture

Michael Forster; Edaphic Scientific and the University of Queensland

Introduction

In the NSW Riverina, vineyard irrigation and irrigation scheduling are critical considerations to maintain vine health, yield and winemaking specifications of wine grapes, especially during extreme heatwaves.

To record sap flow and dendrometer observations from two grapevine varieties, three vineyard

phytomonitoring sites were installed; two at the start of the 2017–18 growing season and another at the beginning of the 2018–19 growing season.

During the 2018–19 growing season, grapevine trunk diameter (measured by dendrometers) and sap flow were measured (Figure 7). During January 2019, the daily maximum temperature exceeded 40 °C on 17 days (Table 3) at the Griffith Airport Weather station Bureau of Meteorology (BoM station 075041). The variances in the data collected shows that dendrometers and sap flow meters are useful tools for assessing grapevine stress during heatwaves. They might also be useful for monitoring seasonal development and grapevine stress from causes other than heatwaves.

Table 3. Bureau of Meteorology Griffith Airport weather station data during 11–26 January 2019.

Date (January 2019)	Minimum air temperature (°C)	Maximum air temperature (°C)	9 am relative humidity (%)	3 pm relative humidity (%)
11	20.1	38.4	19	30
12	17.9	42.0	19	15
13	22.9	41.7	7	16
14	26.1	45.7	30	11
15	26.2	45.9	17	11
16	27.1	46.4	11	11
17	25.5	45.4	13	12
18	28.3	43.9	31	15
19	23.4	36.8	15	15
20	18.2	37.3	9	17
21	18.5	40.8	20	20
22	27.3	43.7	20	17
23	24.1	42.6	17	14
24	25.9	43.1	20	21
25	30.5	46.1	31	14
26	27.8	43.8	17	16



Figure 7. Dendrometer (side) and sap flow meter (middle) on a grapevine at the Griffith Research Station.

Seasonal trunk diameter changes

A typical grapevine trunk seasonal growth curve, measured with a dendrometer is shown in Figure 8. Key growth stages of budburst (EL 4), veraison (EL 35) and harvest (EL 38) are indicated by breakpoints, including rapid trunk growth (around two months) and slight trunk diameter shrinkage, followed by no change until harvest.

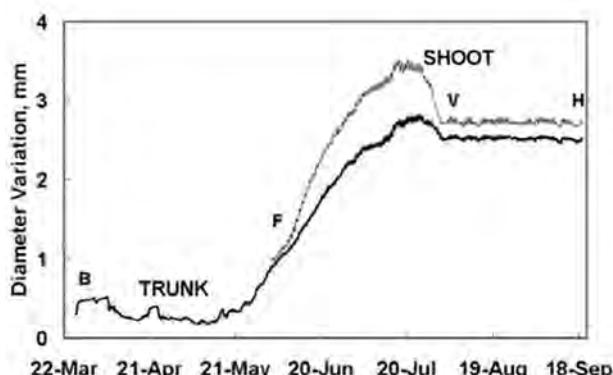


Figure 8. Typical seasonal trunk and shoot diameter curves, recorded from budburst to harvest. B = budburst, F = flowering, V = veraison and H = harvest. Source: Ton and Kopyt (2004). Note: the dates are from the Northern Hemisphere.

During the 2018–19 growing season, dendrometers measured seasonal trunk diameter growth on four varieties; Merlot, Shiraz, Cabernet Sauvignon and Chardonnay (Figure 9). Between 1 September and 15 October, trunk diameter contracted 0.1–0.3 millimetres (mm), except for Cabernet Sauvignon which expanded approximately 0.5 mm. Trunk diameter expanded by approximately 1 mm between mid-October and late December. The largest trunk diameter growth was recorded on the Chardonnay 3 vine, growing by approximately 3.5 mm. The dendrometer stopped recording after reaching the maximum measurement range. During

the last week of December to early January, grapevine trunk diameters contracted. The most pronounced was Merlot (0.4 mm). After this period there was little to no stem diameter change between January to the end of April.

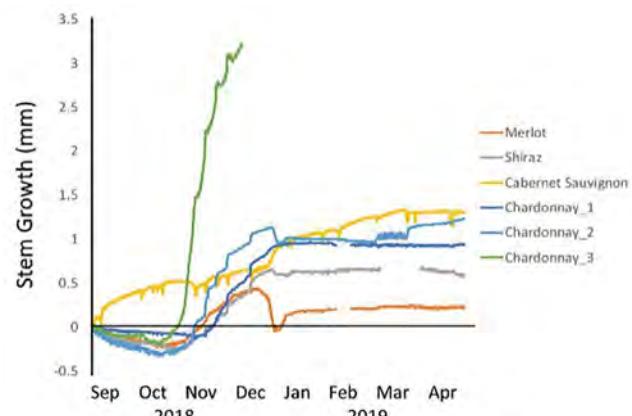


Figure 9. Seasonal trunk diameter curves, 2018–19 Riverina dendrometer demonstration.

Maximum daily shrinkage

The maximum daily shrinkage (MDS), which is the difference between the maximum and minimum stem diameter during one day, can be an indicator of grapevine water stress. Generally, larger MDS values indicate lower soil moisture availability as plants work harder to absorb moisture from the soil. Figure 10 and Figure 11 outline the Shiraz and Cabernet Sauvignon MDS, respectively, recorded during January 2019. Generally, the decreased MDS values suggested there was sufficient soil moisture. However, there were two MDS spikes on 8 and 29 January. Soil moisture was consistent during this period and the spikes corresponded with cooler weather and a decreased vapour-pressure deficit. More data and measurements are needed to understand why these MDS spikes occurred, but these patterns suggest the vines needed to work harder on cooler days to absorb available soil moisture.

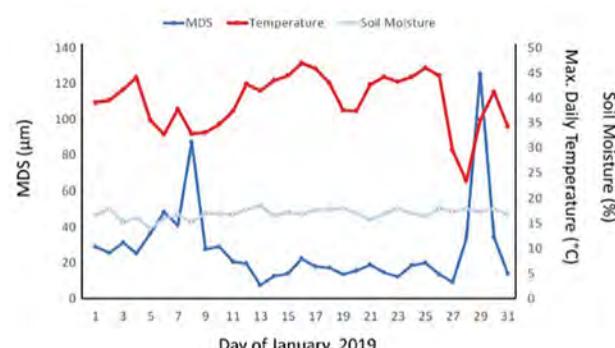


Figure 10. Maximum daily shrinkage (MDS, μm), air temperature ($^{\circ}\text{C}$), and volumetric soil water content (%) for a Riverina Shiraz grapevine during January 2019.

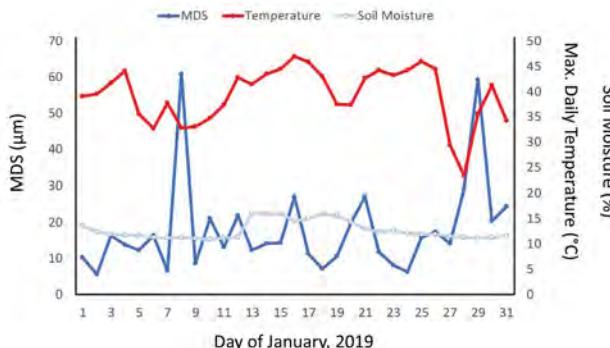


Figure 11. Maximum daily shrinkage (MDS, μm), air temperature ($^{\circ}\text{C}$), and volumetric soil water content (%) for a Riverina Cabernet Sauvignon grapevine during January 2019.

Sap flow

Grapevine sap flow (a combination of water, nutrients and plant hormones) is a synonymous measure of grapevine transpiration. Transpiration has a cooling effect within the canopy which increases canopy relative humidity. This might help grapevines to cope with extreme weather such as heatwaves. Daytime irrigation is another mechanism to decrease vineyard canopy temperatures and relative humidity. Irrigation during the 11–26 January 2019 heatwave at the Shiraz and Cabernet Sauvignon demonstration sites ensured increased evaporative cooling effects from grapevine transpiration.

There was a strong positive correlation between sap flow and maximum daily air temperature for Shiraz (Figure 12) and Cabernet Sauvignon (Figure 13). Sap flow was greater on hotter days than cooler days; the reduced sap flow recordings occurred on the two coldest January days (27–28) when the maximum temperatures were 27.9 $^{\circ}\text{C}$ and 25.5 $^{\circ}\text{C}$ respectively.

There was no relationship between sap flow and soil moisture in Cabernet Sauvignon (Figure 14) or Shiraz (Figure 15). If the Shiraz or Cabernet Sauvignon vines were under significant water stress during the 11–26 January heatwave, sap flow would reduce with extreme temperatures. This was seen during the 18–23 January 2018 heatwave (Figure 16 and Figure 17). Lower soil moisture in 2018 caused lower sap flow (transpiration) which, in turn, caused lower relative humidity, or a drier atmosphere inside the vine canopy (Figure 18). The drier atmosphere, coupled with extreme temperatures, caused physiological stress as exhibited by leaf and berry scorching.

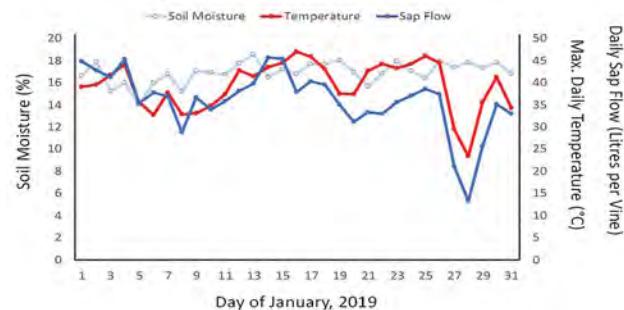


Figure 12. Sap flow (litres per day per vine) and air temperature ($^{\circ}\text{C}$) for a Riverina Shiraz vine during January 2019.

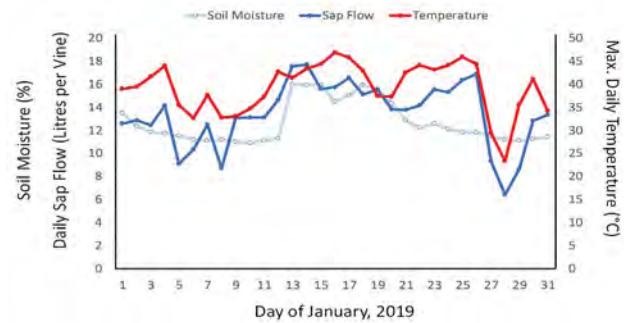


Figure 13. Sap flow (litres per day per vine) and air temperature ($^{\circ}\text{C}$) for a Riverina Cabernet Sauvignon grapevine during January 2019.

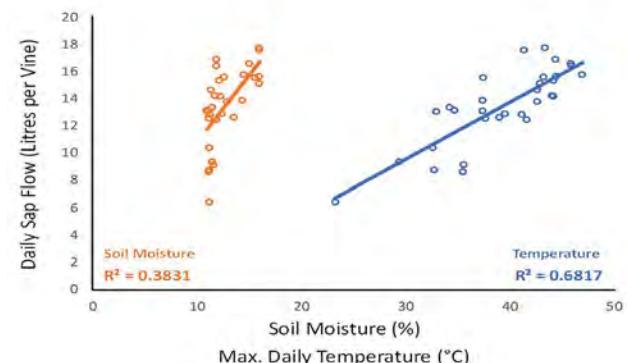


Figure 14. Volumetric soil water content (%) for a Riverina Cabernet Sauvignon grapevine during January 2019.

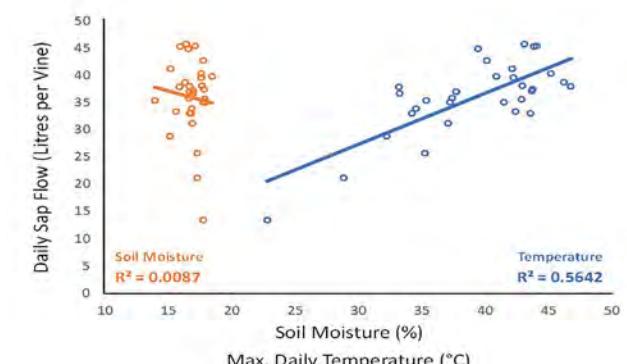


Figure 15. Volumetric soil water content (%) for a Riverina Shiraz vine during January 2019.

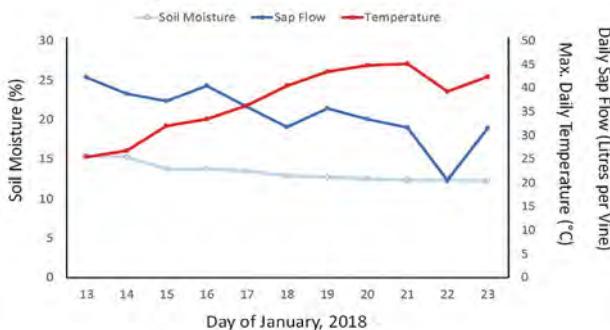


Figure 16. Soil moisture, sap flow and temperature recorded during heatwave conditions indicating Shiraz grapevine stress where insufficient soil moisture is limiting grapevine transpiration.

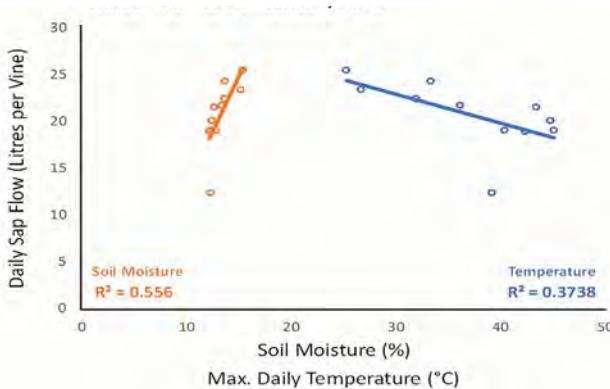


Figure 17. An example of parameters recorded indicating grapevine stress in a 2018 Shiraz where insufficient soil moisture is limiting grapevine transpiration during heatwave conditions.

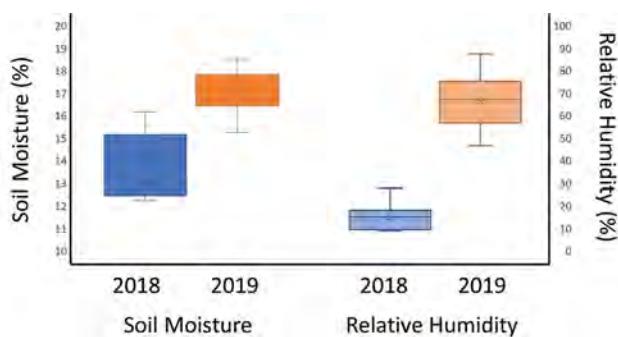


Figure 18. The effect of irrigation on soil moisture and the relative humidity inside a Shiraz canopy during the 2018 and 2019 heatwaves (days where the maximum temperature exceeded 40 °C).

Conclusion

During the 11–26 January 2019 heatwave, growers in the Riverina would have expected some level of grapevine stress due to the extreme temperatures, with 13 of the 16 days during this period recording a daily maximum temperature above 40 °C. However, the phytomonitoring data from the 2018–19 Riverina sap flow and dendrometer demonstration suggests the vines had ample soil moisture, with minimal discernible influence on grapevine trunk growth or sap flow measurements. Data was strongly coupled with ambient air temperature conditions.

The results from the 2017–18 and 2018–19 Riverina sap flow and dendrometer demonstration will be used to develop further phytomonitoring demonstrations. At the time of writing, proposals for the 2019–20 season include evaluating grapevine response to different irrigation schedules throughout the growing season.

Acknowledgements and further information

Dr Michael Forster, Edaphic Scientific Pty Ltd: www.edaphic.com.au

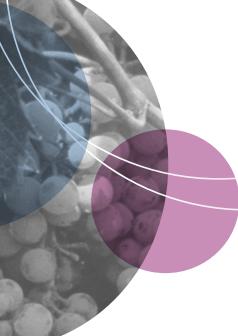
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Griffith Research Station LoRaWAN demonstration

Adrian Englefield; NSW DPI Development Officer – Viticulture

Dr Allen Benter; NSW DPI Technical Specialist – Climate Branch

Dr Michael Forster; Edaphic Scientific and the University of Queensland

Introduction

Numerous technology options are available to assist growers with implementing vineyard environmental monitoring systems. Many growers are asking for information on how to set up a sensor network and the reliability of this equipment. This article outlines the installation of a long-range wide area network (LoRaWAN) vineyard monitoring system at the Griffith Research Station, key considerations and where to find further information. Interested growers are welcome to visit the Griffith Research Station and discuss LoRaWAN technology with NSW DPI Development Officer Adrian Englefield.

What is LoRaWAN?

Since 2016, the NSW Department of Primary Industries (DPI) has been trialling the Internet of Things (IoT) as a sensor network for on-farm data capture and processing. The FarmDecisionTECH™ trial (a collaboration between NSW DPI and Bralca Pty Ltd, a commercial farming operation based at Molong) was developed to demonstrate viable options capable of resolving barriers to digital technology adoption on NSW farms.

The most common reason limiting the uptake of digital agriculture was poor internet connection, followed by limited access to new technology and lack of support (Cotton Australia Limited 2018). Lamb (2017) reviewed on-farm connectivity options and found that lack of internet coverage was a significant barrier to adoption affecting new AgTech enterprises. There was a distinction made between connectivity to the farm and across the farm. Most farms have some internet connection to the homestead, but away from this central location it is typically non-existent or requires expensive (in both cost and power) mobile networks.

An alternative approach to a ubiquitous internet-connected sensor network is to use a low power, long-range network to provide data transmission across the farm with a single connection point to

relay that to the internet. LoRa is a leading low power wide area network (LPWAN) for Internet of Things deployments. LoRa offers long-range data transmission for devices that do not need high speed or high bandwidth data rates and typically have low power consumption.

LoRaWAN is an open network protocol that operates on top of LoRa, defines the communications and network architecture, and provides inter-operability (the ability of computer systems or software to exchange and make use of information) between devices and manufacturers (LoRa 2015). LoRaWAN devices are typically associated with very small data packets, low-speed transmission, low power consumption and often only a small number of data packets per day. Adelantado et al. (2017) reported small LoRaWAN networks can deliver proper service to applications such as agriculture. A typical device on a farm would be a soil moisture sensor that sends a couple of bytes every hour and could therefore last up to 10 years in the field.

Data transmitted by a LoRaWAN device can be received by multiple gateways if available, each forwarding the data packet to the network server which can be in the cloud or a local network node. The network server then performs all redundancy and security checks before pushing the data to an application, such as a data storage, visualisation and analytics package (LoRa 2015).

FarmDecisionTECH™

An extension project to the FarmDecisionTECH™ trial was launched in 2018 to test the LoRaWAN across eight NSW DPI research stations for use in agricultural research. The project is nearing completion and will cover a number of key industries to NSW DPI research, including horticulture, viticulture, livestock and aquaculture.

A key outcome to date is that some of the issues raised by Cotton Australia Limited (2018) are still preventing technology uptake. Even though there is an increasing variety of commercial providers and open source, community-based networks, access to network equipment specialists in regional Australia is still limited. Similarly, access to sensors and the knowledge to install and interpret data is still hampering the greater adoption of IoT on farms.

Griffith Research Station LoRaWAN installation

As an initiative of the Wine Australia 2017–22 Riverina Regional Program, NSW DPI partnered with Edaphic Scientific to design and install a LoRaWAN vineyard environmental monitoring system at the Griffith Research Station. This system will demonstrate the benefits of LoRaWAN and IoT technologies and allow further viticulture environmental monitoring of projects and Riverina Regional Program activities at the Griffith Research Station.

Node installation (Figure 19) at seven Griffith Research Station sites (Figure 20) allows wireless sensor data communication up to 10 km from a gateway (1) receives the data and sends it to a secure cloud-based server via a modem or ethernet connection. Node 3 transmits weather station data from an ATMOS 41 weather station (Figure 21), while the remaining six nodes are connected to sensors measuring:

- leaf-wetness (Figure 22)
- temperature/humidity using an ATMOS 14 digital sensor (Figure 23)
- soil moisture and electrical conductivity (EC) using a Sentek Drill and Drop probe (Figure 24).



Figure 19. Node installation at the Griffith Research Station vineyard.



Figure 20. The location of the gateway (1) and the seven Griffith Research Station nodes.

The gateway is located in the farm manager's office and receives node signals through an aerial approximately 10 m in elevation. Design considerations include:

- the spreading factor: there is a trade-off between this and the communication range, where transmission is slower with a higher spreading factor. Communication range should be as small as possible to limit both the time on air and the subsequent off-period. In other words, the gateway must be close enough to the end devices.
- the number of channels must be carefully designed and accommodate the:
 - number of end-devices or sensors
 - maximum duty cycle: defined as the maximum percentage of time during which an end device can occupy a channel. The selection of the channel must implement pseudo-random channel hopping at each transmission and be compliant with the maximum duty cycle.



Figure 21. An ATMOS 41 weather station.



Figure 22. A leaf wetness sensor.



Figure 23. A temperature/humidity sensor.



Figure 24. A soil moisture probe ready to be installed.

Class B nodes were installed where data transmission from each node occurs at synchronised times to avoid all nodes communicating with the gateway at the same time. The LoRaWAN application is not applicable to industrial automation and critical infrastructure monitoring requiring real-time operation (industrial control loops may require response times around 1–100 m/s) (Adelantado et al. 2017).

Under ideal conditions, a node can communicate with a gateway up to 10 km away. However, growers must consider grapevine canopy density, topography, buildings or other factors affecting line-of-site. The node aerial at the Griffith site (Figure 19) is 2.1 m above the ground to accommodate an over-row fungicide spray cart. Signal strength was measured on 7 January 2019, with full canopy growth at different heights to demonstrate how fully grown grapevine canopies affect line-of-sight and signal strength (Table 4).

Table 4. LoRaWAN signal strength at seven Griffith Research Station nodes.

Node	Aerial height above ground level (m)	Signal strength (dBm)	Distance from gateway (m)
1 Gateway	10.0	N/A	N/A
2 Disease-resistant varieties (white)	2.1	-92	284
	1.2	-95	
	0.3	-99	
3 ATMOS 41 weather station	2.1	-72	77
4 Chardonnay_1	2.1	-90	203
	1.2	-96	
	0.3	-107	
5 Chardonnay_2	2.1	-73	128
	1.2	-99	
	0.3	-93	
6 Shiraz	2.1	-97	307
	1.2	-95	
	0.3	-108	
7 Chardonnay_3	2.1	-102	375
	1.2	-103	
	0.3	-104	
8 Durif	2.1	-104	484
	1.2	-103	
	0.3	-102	

dBm = decibel-milliwatts.

Typical signal strength values should range from between -50 to -120 dBm (Forster 2019). LoRaWAN nodes will usually operate at signal strengths down to -120 dBm. Once the signal strength reaches approximately -120 dBm, data transmission can be intermittent and unreliable. However, even a signal strength of -119 dBm is adequate to transmit the small data packets from a LoRa node. The highest observable signal strength is approximately -60 dBm.

Signal strength testing also occurred across the Griffith district (Table 5) using a mobile LoRa node where the aerial was located at approximately head-height (1.8 m above ground). The mobile LoRa node was moved to various locations and distances from the NSW DPI research station within the Griffith region. Depending on location, the LoRa node attempted transmission of data under non-ideal conditions and there was signal attenuation by numerous objects such as buildings, vegetation and hills. Regardless, the mobile LoRa node was still able to send a signal to the gateway from various locations around Griffith.

Table 5. Signal strength (dBm) at various Griffith region locations.

Location	Signal strength (dBm)	Distance from gateway
1 Griffith Research Station	-54	20.0 m
1 Yoogali Public School	-118	2.39 km
2 Cnr Murray and Hanwood Rds	-114	2.99 km
3 Hanwood Store	-121	3.72 km
4 Jack McWilliams Road	-117	4.30 km
5 Riverina Winegrape Growers Office	No signal	5.00 km
6 Hermit Hill lookout (Figure 25)	-114	5.44 km
7 Ted Scobie sports oval	-119	5.51 km
8 Cnr Rosetto and Gorman Rds	-120	6.8 km
9 De Bortoli Road	-121	7.87 km
10 Lake Wyangan Public School	No signal	9.27 km
11 Yenda	-121	15.72 km
12 MIA Vine Improvement Society	No signal	16.52 km
13 Nericon	No signal	19.70 km

Recommendations

Growers considering installing a LoRaWAN vineyard environmental monitoring system need to consult with specialists to design a sensor network for their individual requirements.

For adequate signal strength, install aerials as high as possible and with as few line-of-sight obstructions between the node and gateway as possible. For example, in Table 5, the signal at the Riverina Winegrape Grower's office is obscured by buildings and the signal at Lake Wyangan Public School is obscured by Scenic Hill. To improve signal strength at the Griffith Research Station, the LoRaWAN gateway line-of-site could be improved by increasing gateway–aerial height above the current 10 m level.

If nodes are located more than 10 km from a gateway, then additional gateways should be considered. On a larger scale, further gateways might be required depending on line-of-site considerations including topography and buildings.

It is also important to recognise that nodes and gateways are not data logging nor storage devices. The purpose of LoRaWAN is to provide real-time (or near real-time) data for management decisions. If the power supply at a node is disrupted, or if the gateway is inhibited, then most LoRaWAN systems will not record data and no other data can

be retrieved. If historical data is critical for your operation, then a data logging system, rather than LoRaWAN, might be more appropriate.

Some online platforms that display data from LoRaWAN devices have data storage capacity, but data storage is usually not a default setting and it is important that your LoRaWAN provider can offer this facility to you.

The Griffith Research Station LoRaWAN system operates on a time scale of one to several hours. It is ideal for hourly weather station or soil moisture probe information updates. However, if you need high-frequency data for critical management decisions, a modified version would be more appropriate.



Figure 25. Testing signal strength at Hermit Hill lookout.

If you are interested in visiting or for more information regarding the installation of the Griffith Research Station LoRaWAN network, please contact NSW DPI Development Officer Adrian Englefield:

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A demonstration [website](#) for the Griffith Research Station LoRaWAN network can be found at <https://portal.sensori.cloud/public/dashboards/195/token/3sKun>

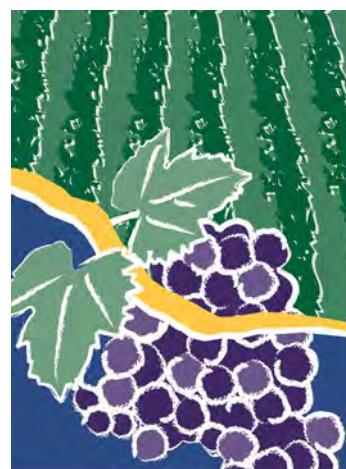
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Acknowledgements



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Decompressing your vintage

Using antitranspirants on Shiraz in the 2018–19 vintage

Darren Fahey; NSW DPI Development Officer – Viticulture

Increased temperatures and heatwave conditions are causing compressed vintages, creating challenges for winery logistics. Anecdotal evidence suggests that coating the berries with an antitranspirant could help manipulate berry ripening while maintaining yield.

Antitranspirants are a group of compounds that when applied to plants help reduce water loss from tissues, thus avoiding water stress and enabling normal metabolic and growth processes to continue. Film-forming antitranspirants can be synthetic (polyacrylamide, silicone oils or low viscosity waxes), inorganic compounds (kaolin clay and other silicates) or natural biopolymers (chitosan).

To assess the effects of applying a naturally derived film-forming polymer to berries, seven trial sites were established across different NSW wine regions during 2018 and 2019. Di-1-p menthene (Stress-Ex™) was applied to each treatment area at a 1% solution rate at pre-flowering (PF) in 2018 vintage only, with 2019 vintage applications at EL 29 (berries 3–5 mm), pre-veraison (PF) and at both pre-flowering and pre-veraison (PFPV). These were compared against a control (no antitranspirant) using a fully randomised and replicated complete block trial design.

Just before the commercial harvest date at each site, 20 randomly selected bunches were hand harvested with two 100-berry samples collected for weight measurements and berry quality analysis. Yield was calculated using bunch weight \times bunches/vine \times vines/ha. Return on investment was calculated using yield/ha less application costs, including extra harvest costs if weight exceeded the control.

Results

Berry weight

Berry weight was significantly increased by di-1-p menthene at four of the seven sites in 2018 and at three of the seven sites in 2019 with the PV and PFPV treatments.

Bunch weight

Applying the antitranspirant increased bunch weight at six of the seven sites in 2018. In 2019, bunch weight significantly increased at five of the seven sites, with the PFPV treatment being the most effective. Grape yield increased likewise (Figure 26 and Table 6).



Figure 26. Passing the bucket test: increased Shiraz yield at Orange with the combined replicates of the control on the left displaying 2.5 buckets of berries, followed by the PF, then PV and on the far right the dual treatment of PFPV with 3 full buckets.

Return on investment

The cost of applying di-1-p menthene per hectare was calculated to reach a net profit figure after all costs. Inclusions were the cost of product, tractor, fuel and labour (\$400/ha/treatment) along with the extra cost of harvesting fruit (@ \$50/t) above the control.

Grape price for Shiraz ranged from \$500/t in warm-hot climates to \$2,100/t in cool-warm climates (Table 7). This assessment only includes differences between the control and the PV and PFPV treatments at each site in both vintages. Only one site returned a loss and this occurred in the PFPV treatment in Mudgee in 2019 where little yield difference resulted between the control and the dual application treatment.

Grape quality

Grape quality for the 2018 vintage was tested at the NWGIC (Figure 27). Berry quality parameters such as pH and titratable acidity (TA) were unaffected by the antitranspirant application.

°Brix decreased at sites 3, 4 and 6 (Table 8) along

with anthocyanin readings at sites 1, 3 and 4 (Table 9) with the PV and PFPV treatments.

At the time of writing, the 2019 berry quality results are still being tested and will be published in next year's guide.

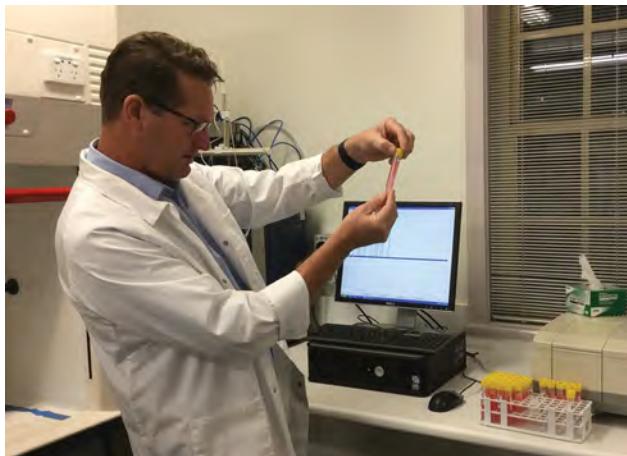


Figure 27. Grape quality testing at the NWGIC.

Wine quality

Experimental wines were made at the NWGIC from one site in 2018 (Figure 28). Shiraz wine pH increased and alcohol concentration decreased with antitranspirant use (Table 10). Total red pigments were significantly reduced with all treatments. The acetic acid concentration was decreased by the PV treatment, increased by the PFPV but not affected by the PF treatment. Applying the antitranspirant did not affect Shiraz TA or free, bound or total sulfur and phenolics.

Pivot profiling

Bottled experimental Shiraz wines (Figure 29) were assessed by a team of NWGIC staff. Pivot profiling was not able to separate the respective treatments of the Shiraz trial wines in a distinct and logical manner. However, the Shiraz control and the PF treatment wines were perceived as

pre-verasion (PV), at both pre-flowering and pre-veraison (PFPV) or left untreated (Control) during 2018-19.

Site	Location	Yield (t/ha)							
		2018				2019			
		Control	PF	PV	PFPV	Control	PF	PV	PFPV
1	Hunter Valley	9.7 c	11.4 b	11.3 b	12.3 a	11.7 c	11.7 c	13.2 b	15.0 a
2	Mudgee	13.2 c	14.6 b	16.4 a	14.3 b	14.3 ns	13.4 ns	15.0 ns	14.7 ns
3	Orange	7.6 d	8.8 c	9.8 b	11.0 a	11.4 ns	11.5 ns	12.7 ns	13.6 ns
4	Hilltops	11.3 c	11.4 c	12.7 b	14.5 a	8.7 b	9.2 b	10.0 a	10.6 a
5	Canberra	17.1 b	16.7 b	19.7 a	20.4 a	8.2 d	10.2 c	12.1 b	13.6 a
6	Griffith	16.6 b	17.7 b	19.7 a	19.1 a	16.8 c	18.6 b	20.5 a	21.3 a
7	Griffith	13.5 ns	13.5 ns	14.9 ns	15.9 ns	12.3 bc	13.0 b	13.6 b	15.6 a

Values with different letters in the same row are significantly different ($p<0.05$), ns = non-significant.

darker with more red and dark fruit, and were associated with higher alcohol. Wines from the PV and PFPV treatments were characterised by less ripe attributes, with PV in particular associated with herbaceous attributes and higher acidity (Figure 30).



Figure 28. Replicate experimental Shiraz wines being tested at the NWGIC.



Figure 29. Sensory testing of bottled experimental Shiraz wines was conducted at the NWGIC. Control wine on the left followed by the PF, then PV and on the far right the dual treatment PFPV wine.

Table 6. Yield (t/ha) differences in field grown Shiraz vines treated with antitranspirant at pre-flowering (PF),

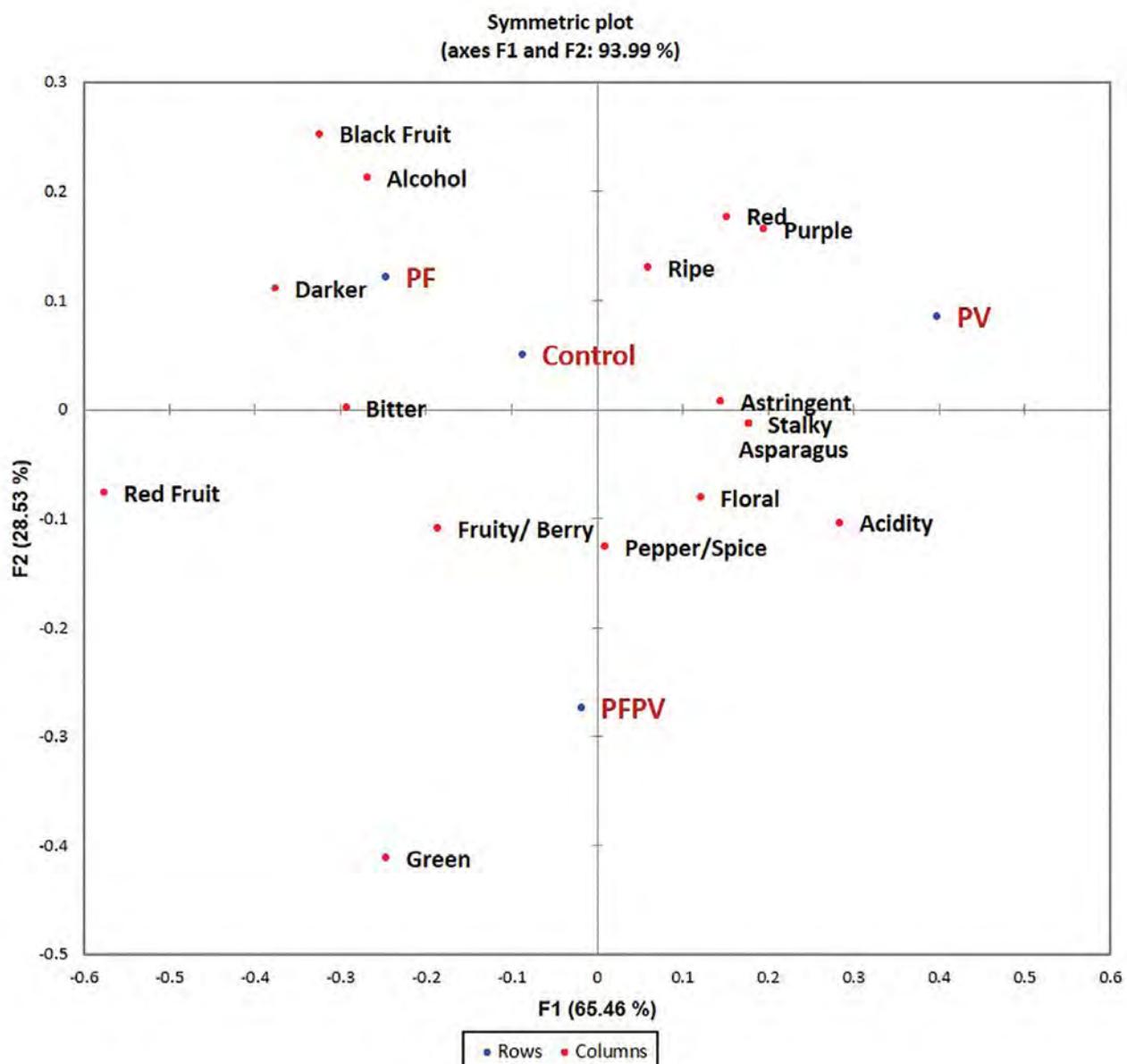


Figure 30. Shiraz wine pivot profile assessment, all treatment replicates combined.

Discussion

Applying a film-forming antitranspirant at a 1% solution rate can effectively manipulate berry ripening. Perhaps the most notable effect was on grape yield, with increases in berry size and bunch weight across both vintages at multiple sites. The lower rainfall and higher temperatures that occurred during both vintages would have caused stress to the berries during cell division and expansion, subsequently affecting berry growth and final size (Keller 2010). If the antitranspirant had not been applied, it is likely that the yield increases would not have occurred.

Increased berry size occurred more with the PV and PFPV treatments than with the PF treatment. This is in contrast to Palliotti et al. (2013), who indicated that PV antitranspirant applications had little chance of affecting berry size. The

antitranspirant application covered bunch structures where bunches were exposed within the canopy. The bunch weight increases might have eventuated from less desiccation of the rachis (Poni et al. 2001; Fahey and Rogiers 2018) or from greater turgor pressure (Matthews et al. 2009; Castelarrin et al. 2016), as berries treated with antitranspirants demonstrated less berry shrivel compared to untreated berries.

The effect of the antitranspirant on grape quality was less pronounced than grape yield. Overall, many sites had pH readings above 4.0, highlighting the effect of increased temperatures on winegrape growing (Sadras et al. 2013). This also affected TA readings (Escudier et al. 2014), which would be considered low overall, regardless of treatment.

Table 7. Net profit after using antitranspirant.

Site	Location and year	Treatment	Yield (t/ha)	Difference (t/ha)	Net profit (\$/ha)
1	Hunter Valley 2018	Control	9.7	–	–
		PV	11.3	1.7	2,857
		PFPV	12.3	2.6	4,290
1	Hunter Valley 2019	Control	11.7	–	–
		PV	13.2	1.5	2,525
		PFPV	15.0	3.3	5,655
2	Mudgee 2018	Control	13.2	–	–
		PV	16.4	3.2	2,960
		PFPV	14.3	1.1	355
2	Mudgee 2019	Control	14.3	–	–
		PV	15.0	0.7	623
		PFPV	14.8	0.4	-149
3	Orange 2018	Control	7.6	–	–
		PV	9.9	2.2	3,026
		PFPV	11.0	3.4	4,455
3	Orange 2019	Control	10.4	–	–
		PV	12.0	1.6	2,096
		PFPV	13.2	2.8	3,587
4	Hilltops 2018	Control	11.3	–	–
		PV	12.7	1.4	552
		PFPV	14.6	3.3	1,514
4	Hilltops 2019	Control	8.7	–	–
		PV	10.0	1.3	1,471
		PFPV	10.6	1.9	1,959
5	Canberra 2018	Control	17.1	–	–
		PV	19.7	2.6	5,012
		PFPV	20.4	3.3	5,986
5	Canberra 2019	Control	8.2	–	–
		PV	12.1	3.9	7,595
		PFPV	13.9	5.7	10,865
6	Griffith 2018	Control	16.6	–	–
		PV	19.7	3.1	1,037
		PFPV	19.1	2.5	369
6	Griffith 2019	Control	16.8	–	–
		PV	20.5	3.7	1,613
		PFPV	21.3	4.5	1,653
7	Griffith 2018	Control	13.5	–	–
		PV	14.9	1.4	240
		PFPV	15.9	2.4	316
7	Griffith 2019	Control	12.3	–	–
		PV	13.6	1.3	332
		PFPV	15.6	3.3	1,015

[°]Brix readings were significantly reduced in the PV and PFPV treatments. Similar reductions were reported on cv. Sangiovese (Palliotti et al. 2013), cv. Cabernet Sauvignon (Brillante et al. 2016) and cv. Barbera (Gatti et al. 2016). It is interesting to note that the reductions in this trial resulted from a lower antitranspirant application rate compared with the other studies mentioned.

The decrease in anthocyanin content in PV and PFPV treatments (at three sites) is similar to results reported by Palliotti et al. (2013). Moreover, all sites recorded significant increases in berry and bunch weight. Two separate variables may have elicited this result. Increased absolute berry temperature across the warmer drier vintage may have reduced anthocyanins (Spayd et al. 2002) as would a water deficit (Bucchetti et al. 2011), and this is known to inhibit berry growth (McCarthy 1997, 1999). Given that antitranspirants reduce transpiration (Palliotti et al. 2010), the enhanced berry size resulted in a lower skin to pulp ratio and therefore lower anthocyanin content.

Shiraz wine made from berries treated with the antitranspirant had lower alcohol concentration as the lower [°]Brix levels in the fruit led to less alcohol in the finished wines, a result that may fit well with a growing consumer trend based on

health and societal issues (Saliba et al. 2013). The lower alcohol percentage was also perceived in the pivot profile assessment with PV and PFPV treatments plotted further away from alcohol compared to the control and PF treatments. However, perception of green, herbaceous and high acidity attributes in both PV and PFPV wines supports the notion that these treatments were made with under-ripe fruit, especially given the aforementioned sugar levels, and not derived from the treatment itself.

All fruit for winemaking was picked based on commercial harvest dates and not against a determined sugar level. While the wine from this trial might be undesirable for some wineries, it demonstrates the potential of antitranspirants to mitigate vintage compression (Jarvis et al. 2018) in the vineyard. If treated fruit were allowed further hang time, enhanced flavour and aroma development could result. Furthermore, it provides an alternative to adding water to high sugar fruit in the winery (Schelezki and Jeffery 2018).

Despite the reduction in total red pigments which occurred in the Shiraz PV and PFPV treated wines, only the PFPV treatment was perceived to be less red/purple in the pivot profile assessment.

Table 8. Mean [°]Brix differences in field grown Shiraz vines treated with an antitranspirant at pre-flowering (PF), pre-verasion (PV), at both times of pre-flowering and pre-verasion (PFPV) or left untreated (C).

Site	Location	[°] Brix			
		C	PF	PV	PFPV
1	Hunter Valley	20.59 ns	20.74 ns	19.66 ns	19.19 ns
2	Mudgee	23.83 ns	23.65 ns	23.09 ns	23.62 ns
3	Orange	24.80 a	24.73 a	23.11 b	22.14 c
4	Hilltops	25.02 a	25.02 a	24.12 b	24.12 b
5	Canberra	21.78 ns	22.14 ns	21.96 ns	21.96 ns
6	Griffith	22.93 a	22.97 a	22.25 b	21.85 c
7	Griffith	25.45 ns	25.31 ns	25.34 ns	25.20 ns

Values with different letters in the same row are significantly different ($p < 0.05$), ns = non-significant.

Table 9. Mean anthocyanins per gram of berry weight (mg/g) in field grown Shiraz vines treated with antitranspirant at pre-flowering (PF), pre-verasion (PV), at both times of pre-flowering and pre-verasion (PFPV) or left untreated (C).

Site	Location	Anthocyanins per gram berry weight (mg/g)			
		C	PF	PV	PFPV
1	Hunter Valley	1.15 a	1.12 a	0.96 b	0.94 b
2	Mudgee	1.42 ns	1.45 ns	1.32 ns	1.31 ns
3	Orange	1.70 a	1.69 a	1.40 b	1.43 b
4	Hilltops	1.55 a	1.56 a	1.45 b	1.39 b
5	Canberra	1.33 ns	1.42 ns	1.32 ns	1.33 ns
6	Griffith	0.80 ns	0.78 ns	0.76 ns	0.61 ns
7	Griffith	1.07 ns	1.01 ns	0.97 ns	0.98 ns

Values with different letters in the same row are significantly different ($p < 0.05$), ns = non-significant.

Table 10. Mean wine composition parameters recorded from Shiraz (Site 6) treated with an antitranspirant at pre-flowering (PF), pre-veraison (PV), at both times of pre-flowering and pre-veraison (PFPV) or left untreated (C).

Location and variety	Treatment	pH	Titratable acidity (g/L)	Alcohol % (w/v)	Total red pigments (a.u.)	Acetic acid (g/L)
Site 6 Shiraz	C	3.54 c	5.53 ns	12.2 a	11.35 a	0.34 b
	PF	3.56 b	5.37 ns	12.0 b	10.50 b	0.34 b
	PV	3.56 b	5.37 ns	11.8 c	8.92 c	0.33 c
	PFPV	3.57 a	5.33 ns	11.8 c	8.92 c	0.38 a

Values with different letters in the same column are significantly different ($p < 0.05$), ns = non-significant.

Conclusions

All antitranspirant treatments significantly increased wine pH and reduced TA in Shiraz, and all results were well within winery specifications. Therefore, using an antitranspirant will enhance yield, decompress vintage and still result in acceptable wine. The treatment effect of the PF application on its own was negligible and, on reflection, even when applied at the later EL stage of peppercorn or pea size berries in 2019, still elicited minimal effects. Therefore, if you are considering applying an antitranspirant to your grapes, perhaps consider not using it at PF stage.

Using a film-forming antitranspirant (di-1-p menthene) at a 1% application rate can manipulate winegrape production in field conditions across different viticultural climatic zones of NSW. Applying the antitranspirant:

- increased yield at 6 of the 7 sites in 2018 and 5 of the 7 sites in 2019.
- reduced °Brix at 4 of the 9 sites in 2018 (2019 results yet to be analysed)
- reduced anthocyanins at 3 of the 9 sites in 2018 (2019 results yet to be analysed)
- produced lower alcohol wine
- provided a tool to mitigate vintage compression.

Acknowledgements

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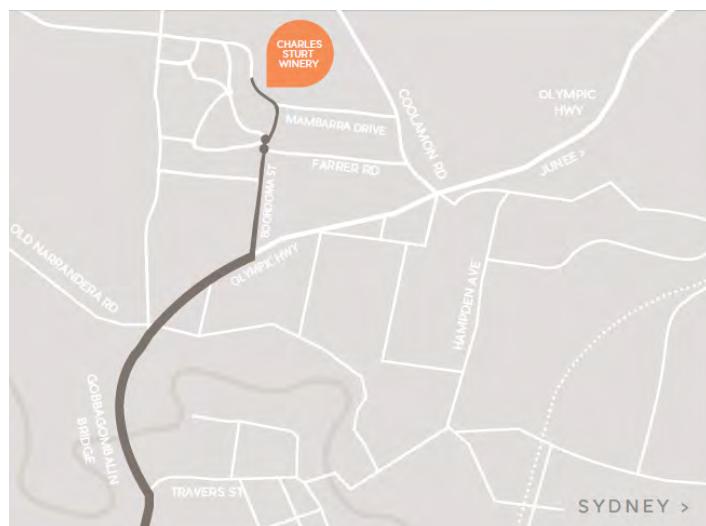
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Charles Sturt
University



Hail and severe storms

Dr Aude Gourieroux; National Wine and Grape Industry Centre, Wagga Wagga

Introduction

Storms are usually short, localised, destructive and mostly unpredictable; a storm can destroy a crop in a few minutes. The latter is the main problem for vineyard managers, as once a storm is detected, it can often be too late to protect the vineyard. Most storms can be accompanied by hail. Hailstone size (Figure 31) and the effect on the vineyard, will depend on different factors including elevation, lower freezing zones, wind shear and the developmental stages of the grapevines and bunches when the storm occurs.



Figure 31. Hailstone size will influence the severity of the damage to grapevines. Photo: Kevin Dodds.

Hail damage and the effect on grape berries and wine

Much information exists on how hail affects grapevines in the current and following seasons (Dry 1986), although it may take a couple of years to assess the total impact. Most of the information is about the reduced crop that occurs after hail, and thus the loss of income in the winery (Spellman 1999; Grainger and Tattersall 2008). However, the information relating to berry damage is usually brief.

Hail can affect the whole vineyard (Krstic et al. 2014) including leaves (Figure 32), fruit, shoots (Figure 33) and trunks, and damage can range from total crop destruction (Figure 34) to minor berry damage (Figure 35).



Figure 32. Hail can strip leaves from the vines. Photo: Darren Fahey.



Figure 33. Hail-damaged shoots. Photo: Darren Fahey.

Some storm damage, including split trunks and arms, can provide the ideal entry point for *Agrobacterium*, the bacteria inducing crown gall. These bacteria are always present but stay latent until suitable conditions arise. It generates tumours that destroy the vine's vascular system and can induce grapevine death, especially in younger plants. The only solution is to eliminate and burn the affected organs (Bonal, 1984).



Figure 34. Hail can cause total crop destruction. Photo: Dr Bob Emmett.



Figure 35. Hail might only cause minor berry damage. Photo: Dr Aude Gourieroux.

Storm damage before flowering

Plants receiving damage at inflorescence usually recover by growing laterals that might bear fruit at a later stage (Figure 36). Fruit quality is likely to be reduced because of the delayed development, lack of nutrients from the damaged leaves, and possibly a loss in yield, due to a lower rate of fruit set and other issues that can arise from the 'second cropping'.

Storm damage before veraison

Storm damage before veraison will affect the whole plant, including the developing berries. Usually, the berries will either dry or drop (they will not be present at harvest) or heal by themselves (Fiola and DeMarsay 2013). For those that heal, they will have an uneven shape but will follow the normal development and ripening processes. Apart from the reduction in yield, the important thing with storms before veraison is to keep the canopy dry to avoid the inception of diseases such as mildew and rots.

Storm damage after veraison

A storm during berry ripening will most likely cause the berries to suffer skin splitting (Figure 37). This is caused by two main factors:

1. mechanical injury from a hailstone

2. a sharp increase in berry moisture

Skin splitting increases the risk of infection by Botrytis and other rots. There are different vineyard techniques for 'drying' the berries and avoiding or controlling these infections, however, the critical success factor is timing; if the damage occurs during the weeks before harvest, some growers might recommend sequencing harvest. This means to pick the damaged bunches before infection occurs, even though they have not quite reached the expected maturity. Then at the estimated harvest time, pick the remaining 'healthy' bunches as usual.

After veraison, if the berries do not drop, the split skin will release some of the sugary pulp and juice which might increase the risk of infection, especially Botrytis, ripe, sour or bitter rot (Fiola and DeMarsay 2013).



Figure 36. Hail-damaged plants recover by growing laterals that might bear fruit at a later stage. Photo: Darren Fahey.

Limiting the damage

Several prevention methods such as anti-hail bombs, canons and rockets have been implemented over the years, but they do not completely protect the vineyard from damage (Bonal, 1984). In some locations, generators of silver iodine crystals have been used to reduce the size of hailstones.

A more effective method is using nets to slow down the hailstones before they reach the vines. Netting will not completely prevent the damage but will reduce it. However, it is labour intensive to set the net over the rows just in case the storm comes and it is always possible that the nets might not be set on the right block.



Figure 37. Hail can cause skin splitting and this increases the risk of infection. Photo: Darren Fahey.

Microbiome

Microbiome is a term that includes all the microorganisms (yeasts, bacteria, fungi) in a particular environment. Another term is microbiota, which corresponds to the microorganisms of a particular site, habitat or geological period.

Wine grapes are known to host a wide range of microorganisms (Barata et al. 2012) that are dependent on their growing environment. Many of these organisms are recognised for their role in grapevine health and wine quality. They contribute to the terroir that is essential for grape growing and winemaking, although the terroir is mainly influenced by the region or site, cultivar and climate where the grapes are grown (Bokulich et al. 2014), as well as the health status of the grapevine (Barata et al. 2012).

Wet and cooler weather after a storm is generally ideal for the majority of 'bad' microorganisms and these are the ones to keep an eye on. If the weather conditions are not favourable for their growth, the damage to the berries should be confined. It is important to note that the perceived expression of the terroir in the wines still needs to be experimentally tested using sensory methods.

Take home messages

Before doing anything, assess the extent of the damage and check with your insurance company.

Before veraison

After a storm, assessing the damage and removing the injured shoots and buds will tidy the vines, keep the undamaged bunches clear of infection and can promote some new growth. Applying a fungicide will reduce the occurrence of bunch rots and help damaged stem tissue heal.

After veraison

Unfortunately, there is not much that can be applied after veraison to prevent bunch rots. It might still be possible to harvest the grapes, as long as the weather remains dry, and thus slows down the inception of *Botrytis* or *Aspergillus* (most commonly found). Removing damaged bunches will also help reduce infection spread.

If the storm happens within a couple of weeks of scheduled harvest, some people would recommend to sequence harvest.

At the winery

Once the grapes have arrived at the winery, there is not much that can be done. The grapes should be sorted to remove as much of the obviously damaged berries/bunches as possible to ensure a better quality final product, i.e. wine. Test for the presence of *Botrytis* or *Aspergillus*, and then process the grapes as you would normally do with any 'infected' wine.

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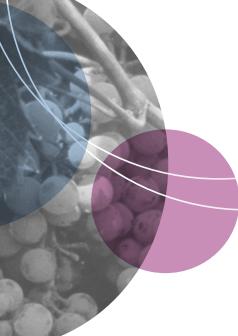
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Grapevine biosecurity: a how to guide

Pip Cotter, Acting Plant Biosecurity Officer

The process of creating and implementing a farm biosecurity plan can be quite daunting. By now, primary producers should understand the term 'biosecurity' and its importance, but this does not necessarily provide you with the knowledge to put together a biosecurity plan.

The aim of this guide is to help you gain a better understanding of:

- the general biosecurity duty
- why we need biosecurity plans
- how to create a farm biosecurity plan
- some of the risks to look out for.

Biosecurity – a legal responsibility

Everyone has an active role to play in managing biosecurity risks under their control. The Biosecurity Act 2015 supports sharing the responsibility of biosecurity amongst government, industry and the community.

The General Biosecurity Duty in NSW makes it more important than ever to be aware of biosecurity risks on your own property and to take action to mitigate these risks.

Farm biosecurity planning

Quick and simple measures can easily be built into everyday practices that will help protect your farm and your future from biosecurity threats. A Farm Biosecurity Plan is an easy way to help you identify biosecurity risks on your farm and provide guidance on how to address them. By developing a biosecurity plan you will be able to identify and prioritise biosecurity practices relevant to your property.

One strategy might not suit all and the actual management practices you choose to use will vary depending on the parameters of your property(s). To start or improve your own farm biosecurity plan, visit www.farmbiosecurity.com.au.

There are a variety of tools and resources available to help you start building your plan today.

On-farm biosecurity risks

Biosecurity risks on-farm can generally fall into one of six essential categories. Actions identified in your farm biosecurity plan will help to improve biosecurity in these fundamental areas.

1. **Farm inputs:** anything moved onto your property can be a source of pests and diseases. Monitor plant materials that enter the property as well as sources of water and fertilisers.
2. **Farm outputs:** responsibility for biosecurity does not end when the produce leaves the farm gate. The measures in place on your property support biosecurity in your region.
3. **People, vehicles and equipment:** if it can move, it can carry diseases, pests and weeds. Hence people, vehicles and equipment pose a high biosecurity risk and should be managed accordingly. Biosecurity signage alerts visitors to protect your property.
4. **Production practices:** good on-farm hygiene reduces the risk of spreading pests and diseases. Implementing simple hygiene practices for water, product packaging, storage facilities, waste materials and plant propagation activities is essential.
5. **Weeds:** these are a continuous biosecurity threat. Ensure you monitor and manage these widespread risks to your business.
6. **Train, plan and record:** ensure staff are well trained, that you can trace where plants have come from and where they go, and keep records of purchases, sales and movements.

Look out for *Xylella fastidiosa*

Xylella fastidiosa is an exotic plant pest that is not currently in Australia. If you suspect this disease in your vineyard, you should report it immediately.

Description: *Xylella fastidiosa*, also known as Pierce's disease, is a bacterial plant pathogen that can affect a wide range of ornamental and commercial plant species.

Damage: *Xylella fastidiosa* grows within the xylem, clogging the water flow, causing dehydration and eventually plant death.

Symptoms: scorched leaves (Figure 39 and Figure 38), browning, loss of leaves, fruit and shoot stunting and plant dieback, eventually leading to plant death.

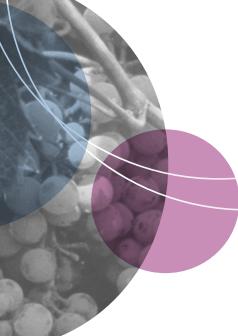
Suspected notifiable pests or diseases must be reported within 24 hours to the Exotic Plant Pest Hotline on 1800 084 881. Early detection means we have a greater chance of eradicating a pest before it becomes established.



Figure 38. Close up of bacterial leaf scorch from *Xylella fastidiosa*. Photo: Elizabeth Bush, Virginia Polytechnic Institute and State University, Bugwood.org.



Figure 39. Bacterial leaf scorch from *Xylella fastidiosa*. Photo: Alex H Purcell, University of California – Berkeley, Bugwood.org.



Disease-resistant grapevine cultivars in the Riverina

Adrian Englefield; NSW DPI Development Officer – Viticulture

Could the future of Riverina winegrape production include cultivars resistant to powdery mildew (*Erysiphe necator*) and downy mildew (*Plasmopora viticola*)? This is the question being asked through the Wine Australia Riverina Regional Program 2017–22.

Background

Since 2013, NSW DPI Senior Research Scientist, Dr Bruno Holzapfel, has evaluated 20 white and 20 red CSIRO-bred grapevine cultivars with resistance to powdery mildew and reduced susceptibility to downy mildew at the National Wine and Grape Industry Centre (NWGIC), Wagga Wagga. The 20 white disease-resistant cultivars are crosses of eight common selections and a parental line (BC5:3294-R23) derived from a back-crossing program involving the North American grape species *Muscadinia rotundifolia*, which contains genes with resistance to powdery mildew and downy mildew.

Apart from early-season sulfur sprays for mite control, the vines received no powdery or downy mildew preventative or curative sprays. This enabled pathogen level resistance evaluation as well as the suitability of these cultivars to a warm, inland irrigated region to be assessed.

The NWGIC vineyard planting consists of 2.25 m spacing between vines and 3 m between rows, with a planting density of 1,481 vines per hectare. The vines are spur-pruned on a bilateral cordon to approximately 20 spurs or 40 buds. Approximately 3 ML of irrigation water and 50 kg of nitrogen was applied per hectare during the 2016–17 and 2017–18 growing seasons. Monthly rainfall and average temperatures for these growing seasons are shown in Figure 40 and Figure 41.

Evaluation at the NWGIC

Despite strong disease pressure, especially for powdery mildew, no powdery or downy mildew development was observed on any of the cultivars. Grape quality and seasonal development were monitored every two weeks from veraison (EL 35) to ensure each selection was harvested at the pre-determined ripeness of 22 °Brix.

Yield and pruning weight (canopy size) varied between the two growing seasons (Table 11), possibly from exhausted internal reserves in the young vines after a larger crop the previous season. Pruning weight ranged from 0.5–2.0 kg per vine in 2016–17 to 0.4–1.5 kg per vine during 2017–18.

Cultivar 18 had the lowest pruning weight and increased bunch exposure in both seasons (Figure 42 and Figure 43) and this trend appears to be continuing. Final pruning weights will be determined during winter 2019.

Two ferments of each cultivar (approximately 50 kg) in each vintage were assessed after bottling for sensory attributes including tropical and floral aromas, citrus, stone fruit and mouthfeel, length of flavour, acidity and bitterness. Overall scores, based on a 100 point scale, were assessed by Riverina winemakers, with average values ranging from 83.5–87.4 (2016–17; Figure 44) and 82.9–91.7 (2017–18; Figure 45).

Balancing the viticulture, winemaking and sensory assessments (Table 11, Table 12, Figure 44 and Figure 45), the white cultivars selected for planting at the Griffith Research Station are 1, 2, 7, 16 and 18.

Table 11. Bunches per vine, bunch weight, berries per bunch and berry weights from the 2016–17 and 2017–18 harvests of disease-resistant cultivars selected for planting at the NSW DPI Griffith Research Station.

Cultivar	Bunches per vine		Bunch weight (g)		Berries per bunch		Berry weight (g)		Yield (tonnes per hectare)	
	2017	2018	2017	2018	2017	2018	2017	2018	2016–17	2017–18
1	118	62	121	109	97	70	1.25	1.60	21.00	10.00
2	90	75	187	173	105	75	1.78	2.31	24.92	18.96
7	73	41	276	280	133	100	2.08	2.79	29.84	17.00
16	88	54	147	138	131	98	1.12	1.40	19.16	11.04
18	105	72	75	88	95	89	0.79	0.99	11.66	9.38

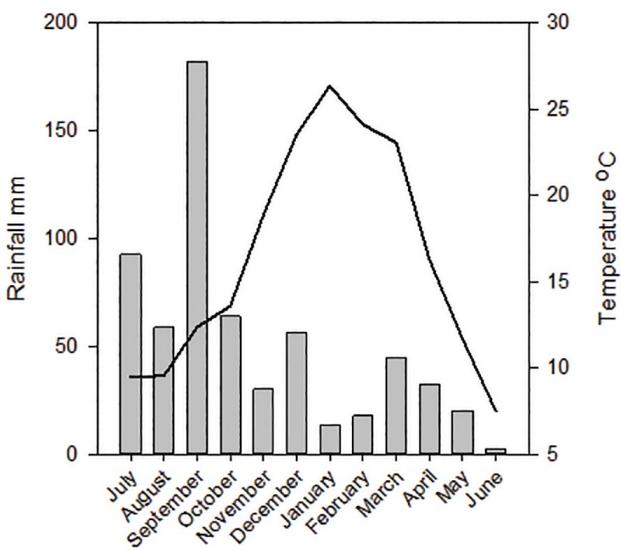


Figure 40. Monthly rainfall and average monthly temperatures in Wagga Wagga for the 2016–17 growing season. Source: Holzapfel et al. 2019.

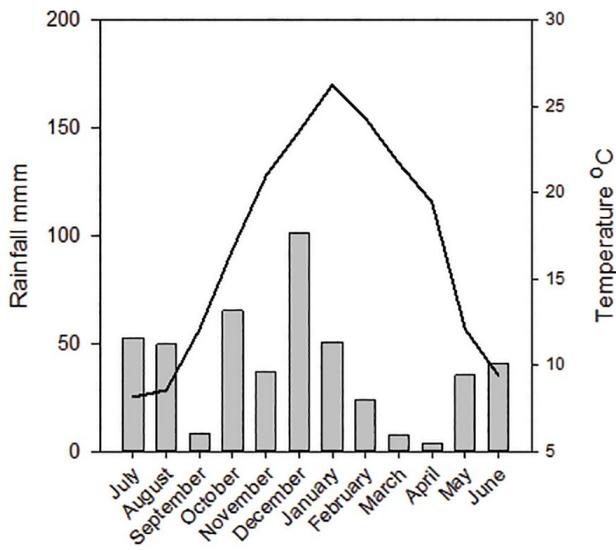


Figure 41. Monthly rainfall and average monthly temperatures in Wagga Wagga for the 2017–18 growing season. Source: Holzapfel et al. 2019.



Figure 42. Increased bunch exposure in Cultivar 18.



Figure 43. Canopy growth in Cultivar 18.

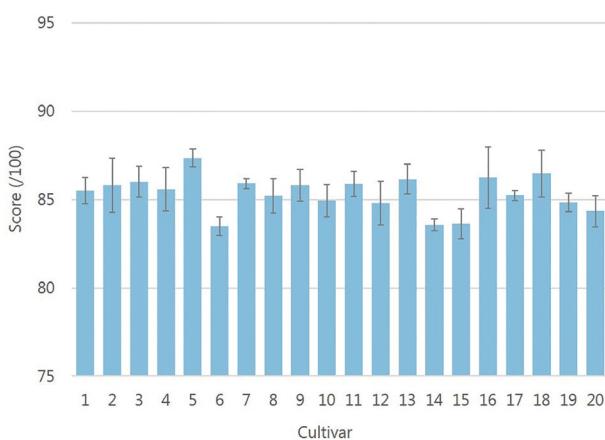


Figure 44. Overall wine scores of 20 white selections evaluated at the NWGIC during 2016–17. Bars represent standard error (n=5). Source: Holzapfel et al. 2019.

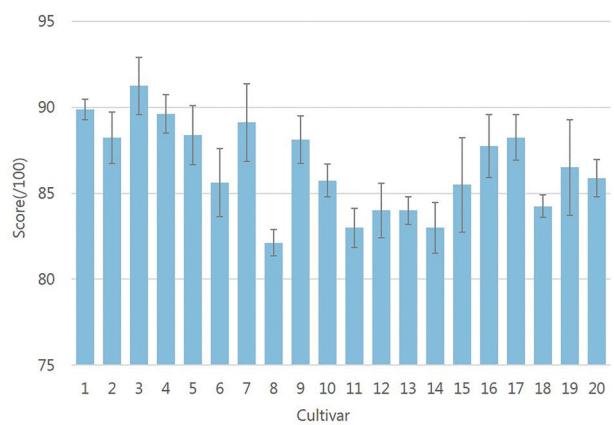


Figure 45. Overall wine scores of 20 white selections evaluated at the NWGIC during 2017–18. Bars represent standard error (n=5). Source: Holzapfel et al. 2019.

Table 12. Total soluble solids (TSS), sugar per berry, juice pH and titratable acidity (TA) from the 2016–17 and 2017–18 harvests of disease-resistant cultivars selected for planting at the NSW DPI Griffith Research Station.

Cultivar	Total soluble solids ($^{\circ}$ Brix)		Sugar per berry (mg)		Juice pH		Titratable acidity (g/L)	
	2017	2018	2017	2018	2017	2018	2017	2018
1	21.3	21.5	266	343	3.43	3.31	4.61	7.16
2	21.7	22.5	385	520	3.65	3.54	3.65	3.97
7	21.5	22.2	446	621	3.40	3.45	4.21	4.19
16	21.5	22.6	241	317	3.44	3.17	4.49	5.88
18	21.1	21.8	166	215	3.17	3.07	6.87	6.30

NSW DPI Griffith Research Station planting

In spring 2018, as an initiative of the Riverina Regional Program 2017–22, a one-hectare demonstration vineyard (Figure 46) comprising white cultivars 1, 2, 7 (Figure 47 and Figure 48), 16 and 18 was developed. Approximately one-third of the block comprises the selections on their own roots, with one-third on Ramsey rootstock and the remaining third on Paulsen rootstock.

The disease-resistant cultivars and rootstocks were planted as callused cuttings. In winter 2019, the rootlings will be cut back to two buds and replacement vines planted where callused cuttings failed to establish in spring 2018. Field grafting the white selections onto Ramsey and Paulsen rootstock will occur in spring 2019.

Only 9 of 140 vines successfully established for cultivar 18. Coupled with decreased canopy growth and increased fruit exposure, this cultivar will be replanted in spring 2019 with a yet to be determined cultivar.

A further 0.5-hectare development of red disease-resistant cultivars is planned for spring 2019. Sensory results from the 2019 vintage will help determine the five most appropriate cultivars.

This initiative aims to give Riverina viticulturists and winemakers the ability to further assess market suitability of these cultivars for fast-tracking market adoption. The vineyard development will demonstrate and assess a number of viticulture and winemaking techniques. If you are interested in visiting the disease-resistant cultivar sites at the NWGIC or NSW DPI Griffith Research Station, or would like further information, please contact NSW DPI Development Officer, Adrian Englefield at adrian.englefield@dpi.nsw.gov.au



Figure 46. NSW DPI Griffith Research Station disease-resistant cultivar vineyard block.



Figure 47. Cultivar 7 leaf.



Figure 48. Cultivar 7 bunch.

Reference

Holzapfel B, Rossouw G, Dry I and Thomas M. 2019. Productivity and wine assessment of new disease-resistant cultivars in Australia. *In press.*

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Integrated pest management in vineyards

New native predatory mite for grapevine mite pests

Doreen (*Typhlodromus doreenae*; Figure 49) is an Australian native predatory mite that feeds on rust mite, bud mite, blister mite and bunch mite in winegrapes (Figure 50), bryobia mite in almonds and pomefruit, and other eriophyid mites in a range of crops.

Field research between 1988 and 1994 showed this predator to be common in these crops throughout south-eastern Australia.



Figure 49. *Typhlodromus doreenae* feeding on grapevine rust mites.

With modern advancements in predator rearing, the Biological Services team says it is now possible for them to offer Doreen to commercial growers to promote healthier crops.

To learn more about Doreen or how integrated pest management can help reduce the risk of chemical resistance among crop pests, contact Biological Services on 08 8584 6977 or info@biologicaleservices.com.au.



Figure 50. Grapevine rust mite damage.



European wasp pilot control program

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Adrian Englefield; NSW DPI Development Officer – Viticulture

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In September 2018, the Australian Pesticides and Veterinary Medicines Authority (APVMA) approved a permit ([PER86492](#)) for controlling European wasps in orchards, vineyards and berry farms with the active ingredient non-repellent fipronil (100 g/L).

European wasp identification

European wasps (Figure 51) are identified by:

- black and yellow body
- yellow legs
- triangular markings on the abdomen
- black antennae



Figure 51. European wasp.

Vineyard and cellar door pests

European wasps are scavengers. Attracted to meat and sweet foods (including grapes), they are commonly a nuisance around winery cellar doors and vineyards as berry-sugar increases.

The European wasp is not aggressive to humans or other animals if left alone. However, if disturbed, individual European wasps can sting multiple times and if nests are threatened the wasps release a chemical, which triggers the colony to attack.

European wasp life cycle

Winter: cold weather kills worker wasps. Mated queens overwinter alone in protected sights including wood heaps, under bark, in clothing left outside and buildings such as sheds and garages.

Spring: the queen leaves the protected site once daytime temperatures exceed 12 °C, seeking a nest location and sugary-food sources. Queens lay eggs and raise the first worker population for the season.

Summer: hive population increases. Once the queen has produced a number of workers she remains in the hive. By mid-December, numbers start to increase rapidly, peaking in late summer and autumn. This is the key time for non-repellent fipronil baiting.

Autumn: as the weather cools, hive activity slows. New queens mate and prepare to leave the hive and seek shelter over winter.

Reducing risk

To discourage European wasps from your property:

- avoid leaving fallen fruit or food scraps exposed
- avoid leaving uneaten pet food outside or in locations where wasps can feed
- ensure rubbish bins are sealed
- keep compost covered at all times
- cover exposed food at barbeques and outdoor events
- check drink cans or bottles before drinking and use clear containers.

Fipronil baiting

APVMA permit [PER86492](#), valid from 14 September 2018 to 30 September 2023, outlines the requirements for controlling European wasps in NSW with the active ingredient 100 g/L non-repellent fipronil.

Baiting technique

1. Start with 85 g of non-poisoned bait. This can be a non-oily cat food or ground liver
2. Place non-poisoned bait into an EnvironSafe™ fly trap (available at retail outlets such as Bunnings) and install the traps following permit instructions

3. Ensure traps are less than 150 m apart. European wasps have been sighted up to 500 m from their hive but prefer to forage within 100–150 m
4. European wasps will generally collect the bait and fly back to feed the nest
5. Monitor traps until 3–5 wasps are feeding during the warmest part of the day. The wasps will smell food on other wasps returning to the nest and follow their co-workers back to the food source
6. Once 3–5 wasps are identified feeding on non-poisoned baits and there is no risk to native or non-target pests, remove non-poisoned bait
7. Replace the non-poisoned bait with a poisoned bait by adding 3–4 drops of the 100 g/L non-repellent fipronil to the 85 g of bait (17.5 mg fipronil; Figure 52) and reinstall into the EnvironSafe™ fly trap
8. If more than 4 drops are used, the European wasps will die before returning to the nest and will therefore not kill the remaining wasps
9. When the worker wasp returns to the nest with poisoned bait, it passes the bait to both wasps and larvae
10. Allow 3–7 days for the nest to be killed.

Warning: fipronil is highly toxic to bees. However, bees only source plant-based foods and are not attracted to meat-based products.

End of the baiting program

At the finish of the baiting program all poisoned baits are to be buried 500 mm below ground and containers must be taken to an approved management facility for appropriate disposal.

Record keeping

Records required as per APVMA [PER86492](#) include:

- date and location of bait placement
- amount of product used
- name and address of person doing the baiting
- pre-baiting non-target monitoring and observations.

First aid

If someone is stung by a European wasp, apply ice or a cold pack to reduce swelling.

Stings to the face or neck, or multiple stings, can cause severe swelling or allergic reaction.

Seek immediate medical advice or call 000 in emergency situation.

If poisoning occurs, contact a doctor or call the Poisons Information Centre 13 11 26.

Baiting trial

Funded by the NSW DPI Viticulture Skills Development Program 2015–19, members of the NSW DPI Biosecurity team conducted a pilot baiting program on ten vineyard and orchard sites in the Orange region, including the NSW DPI sponsored Food Week Forage site.

Early baiting results from the trial sites in November–December revealed the wasps were avoiding the baits containing cat food, possibly because of the vegetable oil in the product; therefore, the trials on the vineyard sites were paused.

An amendment to the permit was sought and approved by the APVMA to introduce ground liver as the protein source. This was highly successful with wasps eradicated at the monitoring site on the Orange Agricultural Institute.

In February 2019, non-poisoned sheep liver baits were re-hung at the ten vineyard sites, checked and replaced with poisoned baits if wasps were present. Wasp numbers declined to zero within two weeks or less in every site where poisoned baits were placed.

As grape berry sugar increased and harvest started in the Orange region, baiting continued as required. The traps were removed and discarded at the start of April.

This pilot trial showed that fipronil, when used as per instructions in [PER86492](#), reduced European wasp numbers at vineyard trial sites and at a food and wine event involving approximately 1,500 members of the public.



Figure 52. Cat food tins with four drops of fipronil, ready to be distributed at the trial sites.



PERMIT TO ALLOW MINOR USE OF AN AGVET CHEMICAL PRODUCT

**FOR CONTROL OF EUROPEAN WASPS IN ORCHARDS, VINEYARDS AND
BERRY FARMS**

PERMIT NUMBER – PER86492

This permit is issued to the Permit Holder in response to an application granted by the APVMA under section 112 of the Agvet Codes of the jurisdictions set out below. This permit allows a person, as stipulated below, to use the product in the manner specified in this permit in the designated jurisdictions. This permit also allows any person to claim that the product can be used in the manner specified in this permit.

THIS PERMIT IS IN FORCE FROM 14 SEPTEMBER 2018 to 30 SEPTEMBER 2023

Permit Holder:

NSW DEPARTMENT OF PRIMARY INDUSTRIES
161 Kite Street
ORANGE NSW 2800

Persons who can use the product under this permit:

Government and council employees, farmers and their employees, apiarists, and pest control operators who are suitably qualified and are experienced in the application of agricultural chemicals.

CONDITIONS OF USE

Product to be used:

An UNREGISTERED BAIT prepared by applying 3-4 drops of MONARCH 100 INSECTICIDE [APVMA No. 84558] or another registered liquid concentrate product containing 100 g/L FIPRONIL as the only active constituent to an 85 g can of prepared cat food (seafood or ground liver) and mixed thoroughly prior to placement into suitable trap/feeding device. Bait to contain: 0.23 g/kg FIPRONIL as its only active constituent.

Directions for Use:

Situation	Insect Pest	Application Rate
ORCHARDS, VINEYARDS AND BERRY FARMS	EUROPEAN WASP (<i>Vespula germanica</i>) COMMON WASP (<i>Vespula vulgaris</i>)	Apply 3 – 4 drops of fipronil product (\approx 17.5 mg fipronil) to 85 g of prepared bait (contained in pet food can) per bait station

Critical Use Comments:

- Monitor European wasp population by free-feeding with non-toxic bait prior to baiting with toxicant.
- Substitute non-toxic bait with toxic bait when baits constantly attract 3 - 5 European wasps feeding during the warmer part of the day. Toxic bait must only be used when monitoring indicates that non-target insects are not feeding on the bait substrate.
- DO NOT use toxic bait if non-target species are observed feeding on untreated bait substrate.
- Contain bait in suitable trap/feeding device¹ and label the trap in accordance with the label contained as Attachment 1.

Jurisdiction:

ALL STATES

Additional Conditions:

Selection of Baiting Sites:

Pre-bait with non-toxic bait before using fipronil treated baits (toxic baits). Baiting with toxic baits can only be carried out if non-toxic baits constantly attract 3 - 5 European wasps feeding during the warmer part of the day. Pre-baiting establishes European wasp foraging pattern and will also determine if native species are at risk. If native species are at risk, treated bait must not be used until a location can be found that precludes native species.

Preparation and Storage of Baits:

The bait must be prepared in the open or in a well-ventilated area wearing appropriate PPE as required on the approved product label. Wear PVC gloves when handling and placing the prepared baits into traps. Wash hands after use.

1. Commercially available fly trap marketed by EnvironSafe™ will be modified to contain the fipronil bait. Wasps will be able to access treated bait via holes (approx. 23 mm diameter) formed on adjacent sides of the trap body. The small size of the holes will exclude access to treated bait by birds and other large non-target species.

Bait Stations:

Bait stations must be used and labelled with the label as contained in Attachment 1. Suspend the bait station using string or other material at a minimum 1.5 m above the ground and in areas out of reach of children and animals. Keep baits free of ant infestation (e.g. apply sticky barrier where practicable). If ants are observed during the non-toxic baiting period relocate bait station to another location.

Completion of Baiting Program:

Upon completion of the baiting program, bait must not be left in any bait station. All users must ensure removal of any remaining bait and bait stations following cessation of the baiting program. Dispose of remaining toxic bait in accordance with the labels at Attachments 1.

Record keeping:

Users of fipronil treated baits are required to maintain records of all treatments performed under this permit. Specifically details must include the date and locations where baits were placed, total amount of product used and the names and addresses of the persons undertaking the use. Details must also be recorded for the pre-baiting non-target monitoring including non-target observations. These details must be maintained for a minimum period of two years from the date of expiry of this permit and must be made available to the APVMA upon request.

Issued by the Australian Pesticides and Veterinary Medicines Authority

Note:

04/10/2018. Apiarists included under persons who can use the product under this permit. Issued as version 2.

12/02/2019. Jurisdiction amended to include all states. *Vespula vulgaris* (common wasp) added to permit.

Issued as version 3.

Attachment 1 – Label for bait station

Caution

**KEEP OUT OF REACH OF CHILDREN
READ SAFETY DIRECTION BEFORE OPENING AND USING**

EUROPEAN WASP BAIT

Active ingredient: 0.23 g fipronil / kg bait substrate

This product is not registered

APVMA Permit PER86492

DO NOT HANDLE OR DISTURB THIS BAIT STATION

First Aid:

If poisoning occurs, contact a doctor or Poisons Information Centre 131 126.

Safety Directions:

May irritate the eyes and skin. Avoid contact with eyes and skin. Wear PVC gloves when handling and placing fipronil treated bait into traps. Wash gloves and hands after use.

Storage and Disposal:

Dispose of unused treated baits by burial at least 50 cm below ground.

Contact Officer Name:

Address:

Telephone:

Deterring birds from vineyards

Zihao Wang; University of Sydney
Andrew Lucas; Agent Oriented Software
Andrea S Griffin; University of Sydney
KC Wong; University of Newcastle

Introduction

Birds can cause significant damage to crops, including vineyards. Using unmanned aerial vehicles (UAVs, more commonly known as drones) is one of the emerging approaches to tackle this problem. Typically, these drones are designed to closely resemble natural predators. However, birds will habituate to scaring methods without the presence of a real threat. Therefore, we used a different approach in our research by trying to make the birds learn that the drone is a new predator in their community rather than an existing natural predator.

Methods

Bird behaviour research shows that birds learn about novel threats by seeing them at the same time as hearing alarm responses from other birds. To capitalise on this way of learning, the prototype drone is equipped with a horn tweeter and a crow taxidermy (Figure 53). The crow taxidermy is hanging upside down from the undercarriage of the drone, giving the impression that the drone has just caught the crow. The coinciding distress call coming from the horn tweeter signals to onlooking birds that the crow taxidermy is in real danger; an experience that should trigger social learning.

The drone was tested in four New South Wales vineyards in 2018 and successfully deterred birds from the immediate area (Wang et al. 2019). This year, the drone was compared with two common bird scaring methods i.e. netting and reflective objects (Figure 54) in three vineyards located in the Hunter Valley, Young and Orange, NSW. Each treatment was applied to an individual block within the vineyard; each block was approximately 0.2 hectares. The three blocks were as close to each other as possible with a sufficient

buffer area to isolate the effects of different methods. The blocks contained the same grape varieties and had evidence of pest bird activity before testing started.

The treatments were deployed two weeks before harvest. Netting and reflective objects were manually installed and they were left unattended for seven days as per usage instructions. The drone was flown manually between sunrise and sunset during the seven days with a minimum frequency of one flight every hour. If bird activity was observed, the drone was flown more frequently to target the birds. Each flight lasted at least three minutes.



Figure 53. The unmanned aerial vehicle equipped with a horn tweeter (top left) and a crow taxidermy (bottom).

To determine the effectiveness of the treatments, the damage to the vines was assessed before and after the interventions and compared within and between treatments. Three bunches were randomly selected and tagged from each vine within each block and the bird damage in these bunches was visually estimated.

Results

In the Hunter Valley vineyard, the drone performed slightly better than netting and significantly better than reflective objects, whereas in Orange the netting outperformed the drone by a small margin, and the reflective objects almost had no effect. However, the results from Young showed that the reflective objects performed slightly better than the drone, but netting was the most effective deterrent. It is possible the drone outperformed the reflective objects in the Hunter Valley and Orange but not in Young because the primary pest bird species in Young was Silveryeyes. Their smaller body size was difficult for the drone to target. Results might improve if the drone was flown more frequently, especially as previous research suggests silveryeye activity decreases significantly in the 15-minutes following the drone flight (Wang et al. 2019).

Conclusion

Incorporating bird behaviour theory and drone technology is a viable solution to the pest bird problem in vineyards. The results indicated the drone was more effective than reflective objects when used with large-bodied birds. The effectiveness of the drone against small-bodied birds may improve if the drone was flown more frequently and/or if taxidermy mounts and vocalisations were more closely related to the target species used (e.g. a silveryeye rather than a crow). In addition to such adjustments, future research will focus on developing autonomous technologies, so that more frequent flights and more precise targeting become possible.



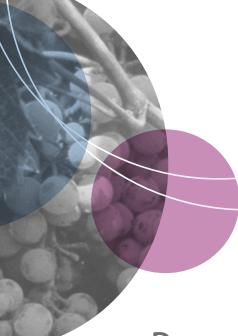
Figure 54. The reflective bird scaring objects used in the experiments.

Reference

- Wang Z, Griffin AS, Lucas A and Wong KC. 2019. Psychological warfare in the vineyard: using drones and bird psychology to control bird damage to wine grapes. *Crop Protection*, 120: 163–170.

Acknowledgement

This work was funded by the Wine Australia Regional Program, University of Sydney and Agent Oriented Software.



Alternative weed control measures for vineyards

Darren Fahey; DPI Development Officer – Viticulture

Key messages

- A combination of chemical, mechanical, biological and cultural practices could provide more effective long-term weed control than continually using only one method
- The timing of any spray application in relation to plant life cycle, air temperature and humidity is critical to achieving the best results
- A cover crop in the midrow or undervine area can help suppress weeds
- Strategic tillage will suppress weed germination
- Monitor weed populations and prevent weeds from setting seed
- Use label rates and rotate between herbicide groups to reduce resistance developing in weed populations.

Introduction

Managing undervine weeds is an intensive ongoing task and the ease of using glyphosate products is fast becoming a tool that may become obsolete in conventional vineyards. Additionally, if your vineyard is certified organic, you need to consider non-chemical options available to effectively control weeds.

With these limitations in mind, the Greater NSW/ACT regional program (funded by Wine Australia) facilitated three demonstration trials to be established in Mudgee, Orange and Hilltops during 2018–19 to evaluate alternative weed control measures in undervine areas of both conventional (Hilltops) and organic vineyards (Orange and Mudgee) compared to current practices at each site.

Methods

Commencing at budburst in early spring, the following treatments were applied within adjacent rows and along single rows within the same panel areas across each site:

1. **Flame:** applied using a handheld Butane gas weed wand until leaves, stems and crown structures were completely burnt off (Orange site only due to fire restrictions).

2. **Steam:** applied using an SW2800 unit with water set at 120 °C and 20 psi pressure, travelling at 1 km/h with a 30 L/min water output rate using 17 L/h of diesel. Hilltops received two steam treatments, one in November and another 4 weeks later in December, whereas Orange and Mudgee received 3 treatments 4 weeks apart in early October, November and December at the aforementioned rates.
 3. Active constituent 790 g/L **acetic acid** (Contact Organics FarmSafe™) applied at a 1:20 ratio of formulation or 50 mL/L and Organics FarmSafe™ Boost at a 1:40 ratio or 25 mL/L with a water rate of 600 L/ha to run-off for complete coverage.
 4. Active constituent 224 g/L **sodium chloride** (Nontox®) applied as a pre-mixed solution at a water rate of 600 L/ha to run-off for complete coverage.
 5. Active constituent 680 g/L **pine oil** (Bioweed™) applied at a rate of 100 mL/L in a water rate of 600 L/ha to run-off for complete coverage.
 6. Active constituent 525 g/L **nonanoic acid** (Slasher®) applied at a rate of 70 mL/L with a water rate of 900 L/ha to run-off for complete coverage.
 7. **Recycled mulch** (Australian Native Landscapes AS4454-2012) applied as an 80/20 blend of coarse mulch and compost at a rate of 153 m³/ha (banded 60 cm width x 7.5 cm depth undervine). The mulch was applied to previously cultivated soil in Orange, and pre-sprayed (with Slasher®) grass surfaces in Mudgee. At Hilltops, the mulch was applied to both pre-sprayed (see Hilltops current practice below) and non-sprayed areas.
 8. **Straw:** applied as banded 60 cm widths x ~5–7 cm depth undervine (applied at Hilltops site only on both pre-sprayed and non-sprayed areas).
- All sprays were applied using a 60 psi pressurised 15 L backpack with a solid cone nozzle set to coarse.
- Weed populations and diversity varied at each site, but all included selections of annual and

perennial grasses and broadleaf weed species. The most problematic weeds at Orange and Mudgee were grass species including paspalum (*Paspalum dilatatum*), perennial ryegrass (*Lolium perenne*), ribwort plantain (*Plantago lanceolata*), Scotch thistle (*Onopordum acanthium*) and couch (*Cynodon dactylon*) whereas at Hilltops, wild oats (*Avena fatua*), mallow (*Malva neglecta*) and Paterson's curse (*Echium plantagineum*) were dominant.

Current weed control practices at each site were as follows:

Mudgee: grazing sheep between harvest and budburst with midrow slashing when required. No specific undervine practices throughout the growing season, with weed management relying on high temperatures and dry conditions to suppress weed growth during summer.

Orange: grazing sheep between harvest and budburst with undervine cultivation around budburst to allow ryegrass to outcompete broadleaf weeds and grow toward cordon height. A second cultivation occurred at flowering to provide a cover of decaying material to suppress weeds during summer. Herbicide (Slasher[®]) was used to spot spray blackberries undervines where necessary.

Hilltops: undervine herbicide spraying in early October with a mixture of 570 g/L glyphosate (Roundup ULTRA[®] MAX) at 1.9 L/ha plus 45 mL of 400 g/L carfentrazone-ethyl (Hammer[®]) and 350 g/L soyal phospholipids, 350 g/L propionic acid (SP700 surfactant) at 1 L/ha in 200 L/ha water rate. This was applied again on 1 January, with the addition of 500 g of ammonium sulphate. This combination is used to attain superior weed kill, less drift, and pH buffering under adverse environmental conditions.

The effectiveness of treatments against the current practice at each site can be observed in the normalised difference vegetation index (NDVI) scores recorded in January 2019. NDVI was measured using GreenSeeker[™] technology to determine the amount of living or dead vegetative matter.

Soils were collected at a 10 cm depth from the Orange and Hilltops sites before and after treatments to determine if any of the applied treatments changed soil parameters.

Results and discussion

Due to fire restrictions and drought conditions, the flame treatment could only be applied at Orange. While this method does offer some control, it can be problematic and might not be a practical option.

All non-selective contact desiccant sprays (treatments 3, 4, 5 and 6) affected broadleaf weeds within hours of spraying (Figure 55), although a delayed response occurred with grass species (Figure 56). Within seven days, the desiccant sprayed areas looked like a typical herbicide treated bare undervine area (Figure 57). However, weed control was short-lived, with weeds re-emerging through decayed material and new weeds growing on bare soil in all desiccant treatments.



Figure 55. Broadleaf weeds within one hour of treatment.

As desiccant labels suggest, they are designed to control young broadleaf weeds and suppress established and perennial weed populations, therefore the timing of applications is paramount. This was evident at the Orange site where a single desiccant spray later in spring (November) was more effective than two separate applications in early spring (October). This suggests that environmental conditions such as increased temperature and rainfall might have influenced weed control with the later spray.

Steam treatments resulted in minimal visual effects directly after application, but provided good weed suppression at the Orange

and Hilltops sites (Figure 58) where weed management previously involved cultivation or spraying. However, this technology requires further work to suit vineyard operations if the undervine area is not clean initially. While steam is effective, the labour costs to cover large areas may render this application prohibitive as it took 3.5 hours using 5,940 L water and 56.1 L of diesel to cover one hectare.



Figure 56. Grass species showed a delayed response to desiccant sprays and complete clump kill was difficult to achieve with one application at the label rate.



Figure 57. One week after spraying with acetic acid showing a complete kill of undervine weeds.

Mulch was one of the better performing treatments at Orange, with NDVI suggesting reduced vegetation regrowing after treatment (Figure 59). Applying straw, both sprayed and unsprayed, resulted in the lowest NDVI scores at Hilltops (Figure 60). None of the treatments seemed to be effective at Mudgee (Figure 61), with all treatments scoring slightly higher NDVI readings than current practice, despite the visual effects in the weeks after treatment.

The costs involved with some of these treatments could mean that using alternative methods to manage weeds might not be economically viable (Table 13), therefore the efficacy of each treatment and its duration must be considered. A combination of chemical, mechanical, biological and cultural practices might be more effective in the long term, rather than the continual use of only one method to control weeds.

Various soil chemistry parameters were influenced by the treatments (Table 14). Applying pine oil changed the soil from alkaline to acidic, while applying mulch increased calcium and potassium.



Figure 58. Steam treated undervine area at Hilltops, highlighting the treatment zone with weeds growing outside the edge of the treatment toward the midrow.

Table 13. Cost of products when applied at label rates used in the trial.

Input	Input cost	Cost/ha (input only)
224 g/L sodium chloride (Nontox®)	\$240/20 L	\$238
525 g/L nonanoic acid (Slasher®)	\$286/20 L	\$298
680 g/L pine oil (Bioweed™)	\$330/15 L	\$436
790 g/L acetic acid (Contact Organics™)	\$220/20 L	\$163
Flame	\$15.95	\$579
Mulch	\$33/m³ delivered	\$5,049 (~\$1,683/ha/yr)
Steam SW2800	\$39,600/unit	~\$87.00 water and diesel
Straw	\$70/4 x 4 round bale delivered	\$3,500 (~\$1,166/ha/yr)

Table 14. Soil chemistry parameters with different treatments to manage weeds.

Site	Analysis	Units	Treatment	Before treatment	After treatment
Orange	Sodium (Na)	(mg/kg)	Sodium chloride	11.2 very low	220 high
	pH (CaCl₂)	pH unit	Pine oil	7.54 slightly alkaline	6.2 slightly acid
	Potassium (K)	(mg/kg)	Mulch	299	538
	Calcium (Ca)	(mg/kg)	Mulch	2,480	6,230
	eCEC	(cmol(+)/kg)	Mulch	14.5 moderate	34.3 high
Young	Sodium (Na)	(mg/kg)	Straw	30.4 very low	298 high
	Sodium (Na)	(mg/kg)	Nonanoic acid	30.4 very low	269 high
	pH (CaCl₂)	pH unit	Nonanoic acid	7.15 neutral	6.44 slight acidity
	Potassium (K)	(mg/kg)	Mulch	187	560
	Potassium (K)	(mg/kg)	Straw	187	566
	Sulfur (S)	(mg/kg)	Straw	7.8	65

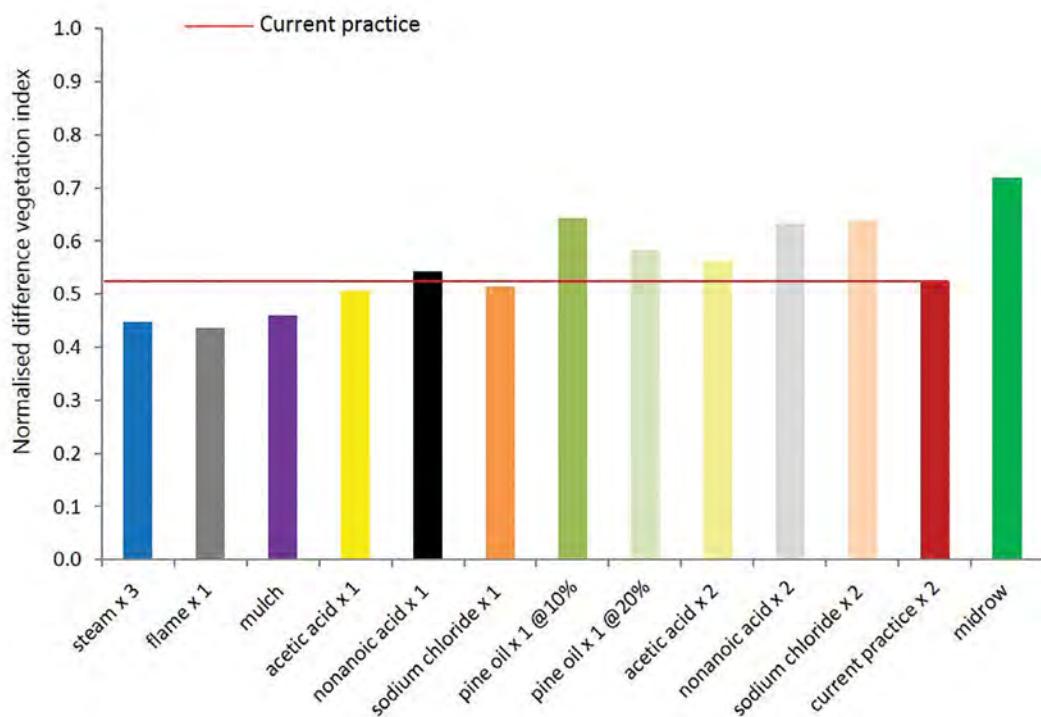


Figure 59. NDVI differences at the Orange site on 10 January 2019.

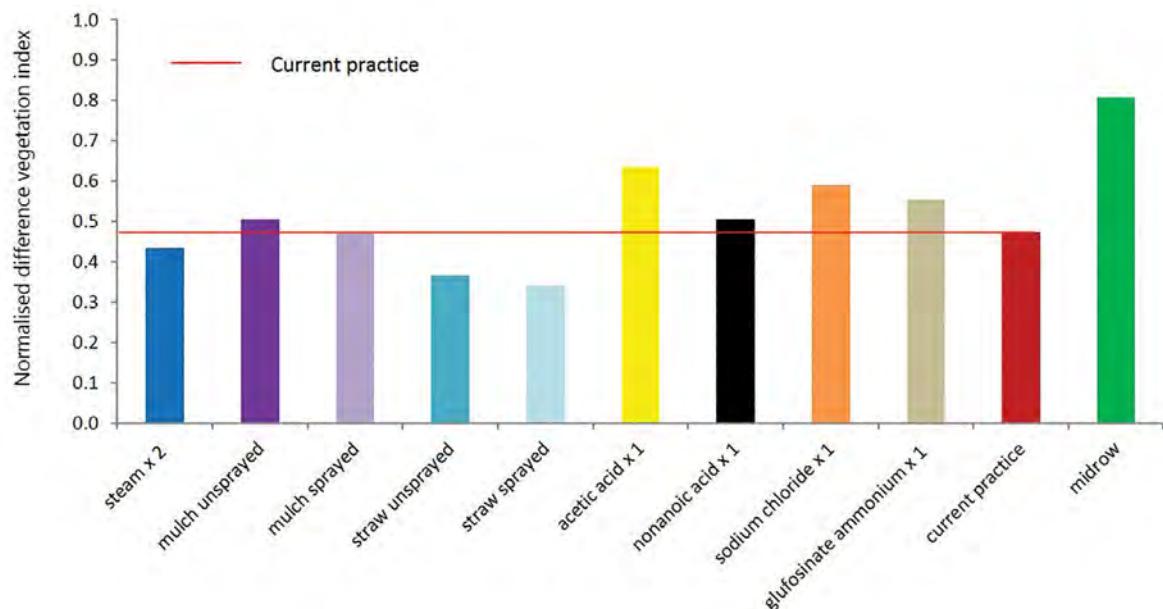


Figure 60. NDVI differences at the Hilltops site on 17 January 2019.

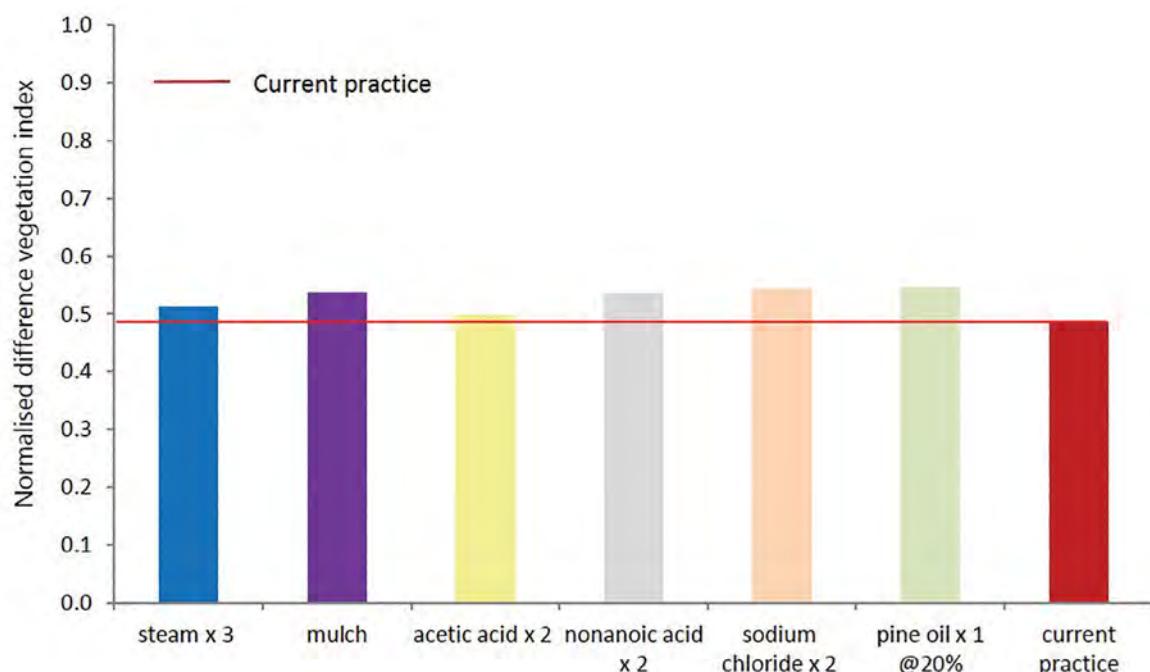


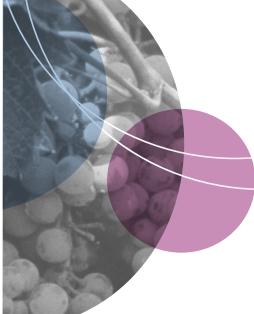
Figure 61. NDVI differences at the Mudgee site on 14 January 2019.

Acknowledgements

This work was funded through the Wine Australia Regional Program. The following people contributed to the project: Clayton Kiely (Tamburlaine Organic Wines), Will Sneddon (Hudson Vineyard) and Dr Tim White (Thistle Hill) provided vineyard sites, equipment and assistance in the trial. Weed Technics undertook all steam applications. Nontox® and Contact Organics FarmSafe™ are acknowledged for supplying products free for use in this trial, all other products were purchased.

Further information

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VineWatch

Adrian Englefield
NSW DPI Development Officer – Viticulture

What is VineWatch?

VineWatch is the NSW Department of Primary Industries' (DPI) news bulletin for viticulturists, winemakers and wine industry representatives. VineWatch:

- is regularly emailed directly to your inbox
- is published fortnightly during the growing season and monthly during the rest of the year
- includes regional reports from locals with insights into regional issues and seasonal developments.

VineWatch regional reports

VineWatch reports from 11 NSW wine regions:

- Canberra district
- Cowra–Canowindra
- Hilltops
- Hunter Valley
- Mudgee
- Murray Valley
- New England
- Orange
- Riverina
- Southern Highlands
- Tumbarumba.

What information is in VineWatch?

Each VineWatch issue covers:

- pest and disease alerts
- regional viticultural tips and information
- vineyard weather observations from the DPI viticulture weather stations network (www.dpi.nsw.gov.au/agriculture/horticulture/grapes/weather-stations-network/wsn)
- short-term and long-range weather forecasts

and information from the NSW DPI and the Bureau of Meteorology (BOM)

- NSW DPI and wine industry factsheets and resources providing pest, disease and vineyard management information
- NSW DPI viticulture and wine industry news and events.

How do I subscribe to VineWatch?

- by visiting the NSW DPI grapes website (www.dpi.nsw.gov.au/agriculture/horticulture/grapes)
- scroll down to the VineWatch subscribe link (nsw.us11.list-manage.com/subscribe?u=59ba43482b8c913efe7355823&id=d179b42dac)
- fill in your email address and regions for which you wish to receive VineWatch reports.

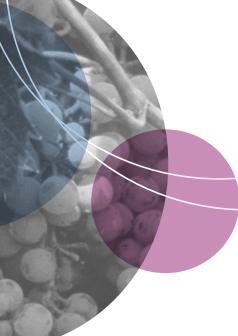
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For updates go to www.dpi.nsw.gov.au/factsheets



NSW DPI Development Officers – Viticulture (left) Darren Fahey and (right) Adrian Englefield.



Fourier transform infrared spectroscopy: measuring grapevine nutrient status

Adrian Englefield; NSW DPI Development Officer – Viticulture

Opportunity for an alternative nutrient sampling method

Vineyard petiole analysis at 80% flowering (EL 25) is widely used to estimate grapevine nutrient status. Collecting a representative vineyard nutrition sample can assist with determining seasonal fertiliser requirements and managing long-term mineral deficiencies or toxicities.

Traditional commercial laboratory analysis requires approximately 100 petioles. In 2014, researchers at the National Wine and Grape Industry Centre (NWGIC) developed an alternative method for determining grapevine nutritional status using attenuated total reflectance Fourier transform infrared (ATR–FT–IR) spectroscopy. For this method, petioles are collected from the basal leaf opposite the flowering cluster (Figure 62), similar to samples sent to commercial laboratories. However, the ATR–FT–IR method is a rapid technique, reducing sample size and possibly reducing reporting turnaround.



Figure 62. Collecting petioles from the basal leaf opposite the flowering cluster.

As an initiative of the NSW DPI Viticulture Skills Development Program 2014–19, early-stage prototype software development is underway at the NWGIC to create an interface for the ATR–FT–IR spectrometer. The software will convert spectra results (Figure 63) into quantifiable

figures for comparison against grapevine petiole nutrient standards. NSW DPI will demonstrate the software interface and ATR–FT–IR capability at the 2019 NSW DPI Spring Vine Health Field Days for industry feedback and validation.

Sampling and sample preparation

In Spring 2018, petiole samples were collected (at 80% flowering) from one Canberra district and two Tumbarumba vineyards. Five replicates were collected from Pinot Noir, Chardonnay (two samples), Shiraz and Riesling varieties (total 25 samples).

Each replicate comprised 100 vines and three petioles were collected from each vine (from the basal leaf opposite a flowering bunch). One petiole from each vine (100 petiole sample) was analysed at a commercial laboratory. Two petioles from each vine (200 petiole sample) were collected for comparison and analysed using ATR–FT–IR at the NWGIC.

Commercial laboratory samples were prepared according to the sample submission instructions. Samples for analysis via the ATR–FT–IR method were washed twice in water and further with phosphate-free detergent (Figure 64). After cleaning, the samples were oven dried at 60 °C. After three days, daily weighing of samples occurred until the sample weights were stable (Table 15). Once dry, petioles were ground using a coffee grinder (Figure 65) for 30 seconds.



Figure 63. Washed samples ready for drying.

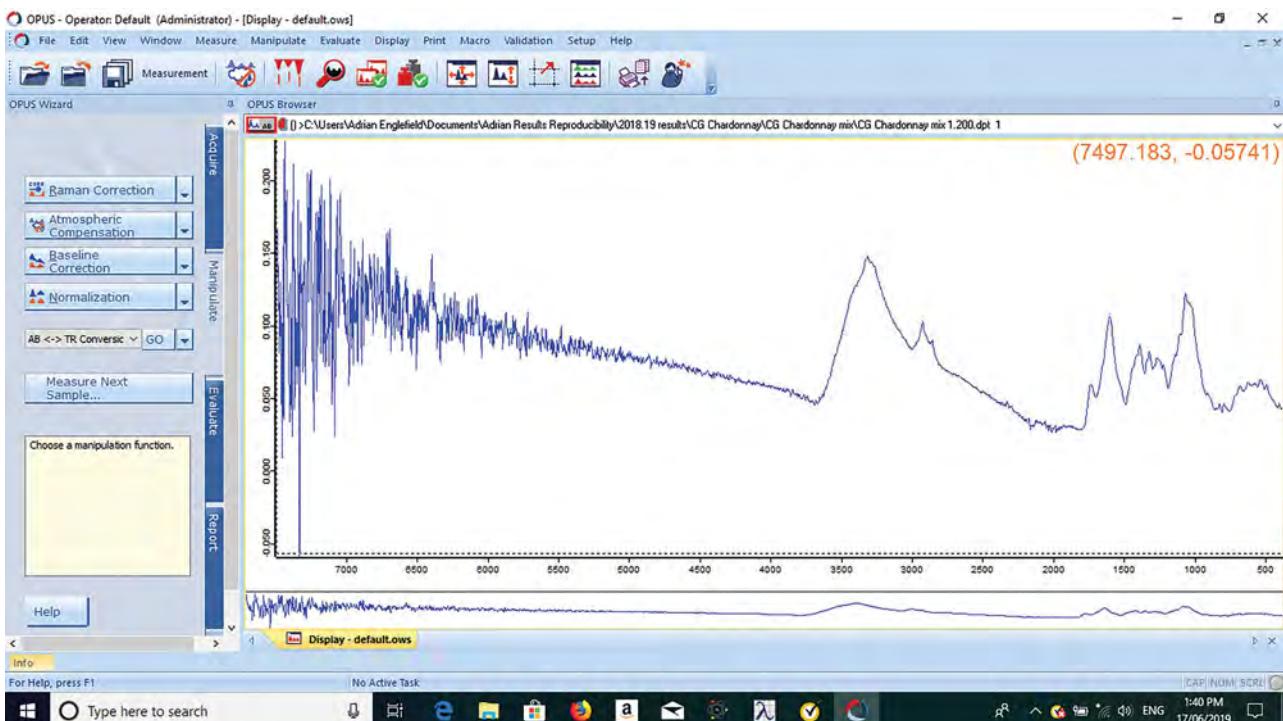


Figure 64. An example of spectra results that will be converted into quantifiable figures for comparison against grapevine petiole nutrient standards.



Figure 65. A coffee grinder for grinding dry petioles.

Table 15. Average petiole weights before and after drying.

Variety	Average weight (g) 200 petioles	Average weight (g) dried sample
Chardonnay (sample 1)	148.73	25.04
Chardonnay (sample 2)	140.32	24.08
Pinot Noir	116.48	18.50
Riesling	114.04	21.14
Shiraz	157.10	24.98

Results

Analysis of the 25 dried samples was conducted using Opus software and the ATR-FT-IR spectrophotometer at the NWGIC. The diamond internal reflection element was set at 40 °C and a background scan against air was conducted

every 10 scans. ATR spectra for each sample were prepared by averaging 64 scans on each sample over the wavenumber range of 375–7,500 cm⁻¹. Potential exists to measure 1–2 petiole samples. The ATR-FT-IR requires a sample size of approximately 0.1 gram, allowing for a much smaller sample size and precision vineyard sampling compared to commercial laboratory sampling. However, with a small sample, homogeneity (being representative of the total sample) must be considered.

Further work

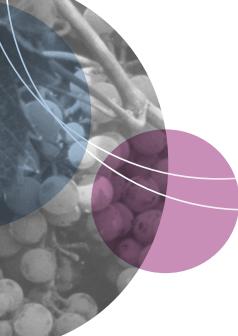
Calibration of the software interface and ATR-FT-IR progression modelling is planned. Further work is required to fully assess the suitability and accuracy of this method as an alternative to commercial laboratory analysis. However, updates and demonstration of petiole sampling capability using the ATR-FT-IR technique will be held at the 2019 NSW DPI Spring Vine Health Field Days.

Acknowledgements

Alex Oczkowski; Technical Officer – Programmer,
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Further reading

Smith JP, Schmidtke LM, Muller MC and Holzapfel BP. 2014. Measurement of the concentration of nutrients in grapevine petioles by attenuated total reflectance Fourier transform infrared spectroscopy and chemometrics. *Australian Journal of Grape and Wine Research*, 20: 299–309.



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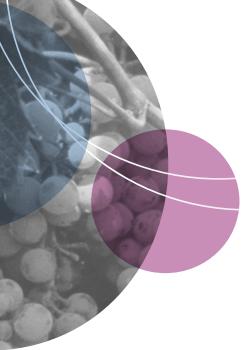
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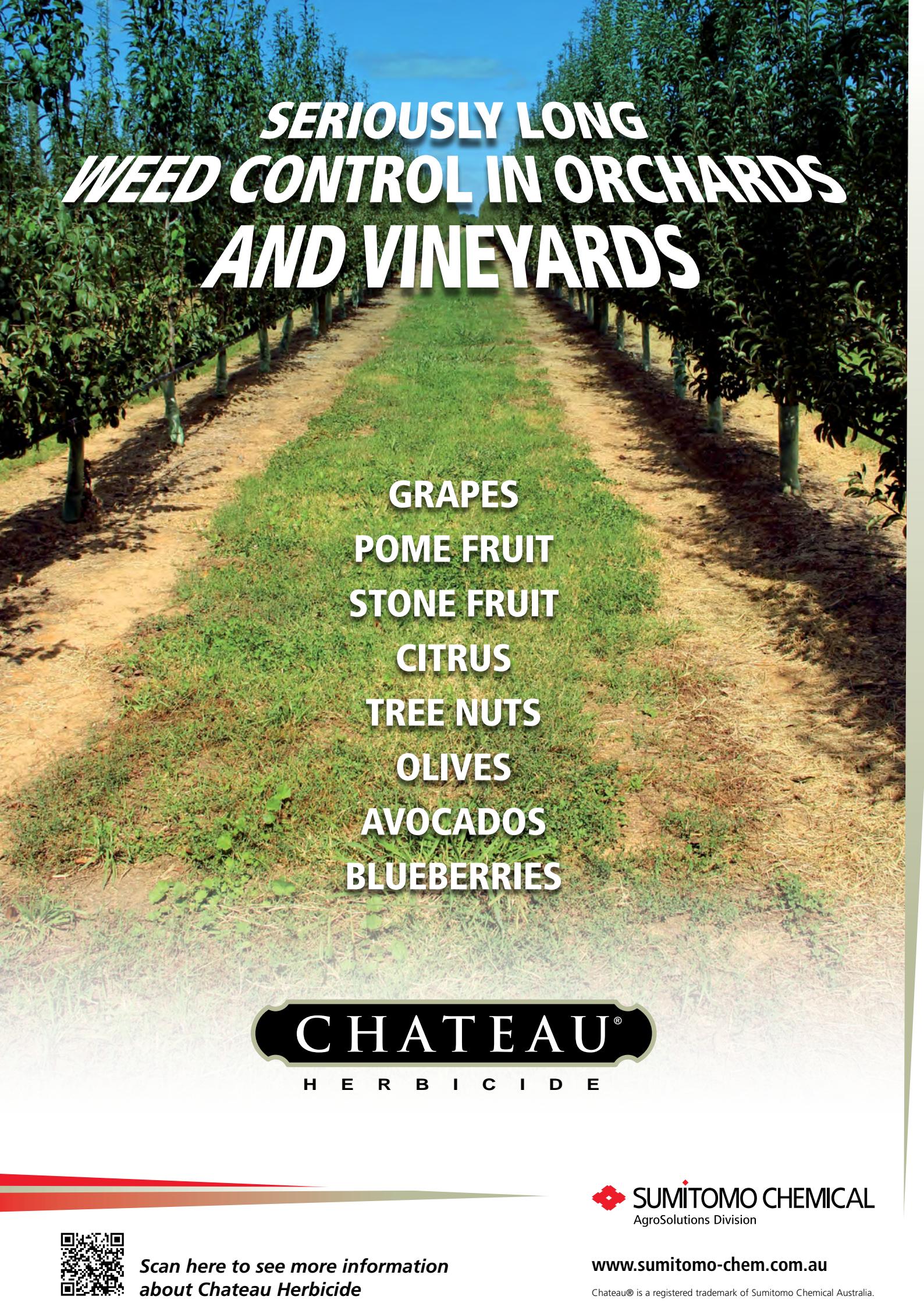
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Notes



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