NEW ZEALAND WINE
PURE DISCOVERY

RESEARCH SUPPLEMENT

Information and Updates on NZ Winegrowers Research Programmes.
Editor: Dr Simon Hooker, General Manager Research and Innovation

A regular feature at the back of each issue of WineGrower to inform industry people about research projects being undertaken for their benefit. Newly approved projects (when available) are briefly summarised in the first section 'Introducing New Projects'. Longer reports in the section headed 'Progress Reports', will describe what has been achieved so far. Scientists in charge of each project have been asked to make these reports reader-friendly rather than to follow the usual format of scientific papers. When completed, each project will be reported in full detail, with references, on the website: **www.nzwine.com/members/research**

LIST OF PROJECTS

Quality Wine Styles for Existing and Developing Markets

The pathway of volatile sulphur compounds in wine yeast
The Bragato Trust and NZW Scholarship, University of Auckland
(Dr Bruno Fedrizzi - student Matias Kinzurk)

Lifestyle Wine (PGP)
University of Auckland and Plant and Food Research
(Various)
Jointly funded by NZW and MPI Primary Growth Partnership (PGP) fund.

Literature review of calcium tartrate stability of wines
Lincoln University
(B Tian)

Evaluation of the efficacy of a range of commercial bentonites on New Zealand Sauvignon blanc wine
Hills Laboratory
(K Creasy)

Bentonite literature review
Lincoln University
(B Tian)

High-throughput genotyping of transposon-induced mutations in vines
Lincoln University
(C Winefield)

Population genomics of the wine spoilage yeast Brettanomyces bruxellensis
Auckland University
(M Goddard)

Pests and Disease

Grapevine Trunk Disease; young vine ecology, diagnostics and preventative treatments
New Zealand Viticulture Nursery Association Incorporated
(VINA)(N Hoskins)

Leafroll virus and mealybug monitoring in Marlborough, 2015 to 2017
Plant and Food Research
(V Bell)

Virus diversity in New Zealand grapevines: sequence, ecology and impact – The Rod Bonfiglioli Scholarship
Plant and Food Research
(R MacDiarmid - student A Blouin)

Sustaining vineyards through practical management of grapevine trunk diseases
South Australian Research & Development Institute
(M Sosnowski)
Supported by MPI Sustainable Farming Fund

Developing Powdery Mildew Best Practise (Year Two)
Lewis Wright Valuation & Consultancy Ltd
(T Lupton)

Grape botrytis resistance to AP and SDHI fungicides
Plant and Food Research
(R Beresford)

Grape powdery mildew monitoring
Plant and Food Research
(D Mundy)

Developing Powdery Mildew Best Practise in New Zealand Vineyards
Lewis Wright Valuation & Consultancy Ltd
(T Lupton)
Supported by MPI Sustainable Farming Fund

Sustainability/Organics

Pinot noir wine composition and sensory characteristics as affected by soil type and irrigation in the Waipara region
Lincoln University
(G Creasy)

Vineyard Ecosystems Programme
University of Auckland and Plant and Food Research
(Various)
Jointly funded by NZW and MBIE

Risk Assessment of Nutrient Losses from New Zealand's Vineyard by Mechanistic Modelling
Plant and Food Research
(B Clothier)

Sector weather data licence & tools
HortPlus (NZ) Ltd.

Effects of undervine vegetation management on grape quality, wine sensory properties, vine performance, grape composition, weed ecology, and soil chemical and physical properties.
Thoughtful Viticulture
(M Krasnow)

Cost efficient optimisation of weed management in vineyards
Thoughtful Viticulture
(M Krasnow)

Cost Reduction/ Increased Profitability

Grapevine growth stage monitoring for prediction of key phenological events
Plant and Food Research
(R Agnew)
Supported by MPI Sustainable Farming Fund

Sulphur for powdery mildew control: It's all about coverage

15-100

Sulphur is the main powdery mildew fungicide used in New Zealand and accounts for approximately 60% of powdery mildew fungicide applications. Sulphur label rates (80% ai product) in New Zealand are 150g and 300g per 100 litres of spray mixture for dilute spraying to runoff. This label was developed when the industry was based on 3 metre rows and water rates of 1,000 litres per hectare, giving sulphur rates of 1.5 to 3.0 kg/Ha. In response to increasing powdery mildew problems, and in line with Australian practices, sulphur rates in many NZ vineyards have increased to 4-5 kg/ per application in recent years. Typical Australian sulphur product labels allow between 200g to 600g of product per 100 litres, and many Australian vineyards now receive sulphur sprays at 6kg per hectare per application. Sulphur is also generally applied with a wetting agent, although this is not recommended on sulphur labels.

During spring and summer of 2015/16 NZ Winegrowers funded two powdery mildew control trials in commercial chardonnay vineyards in Gisborne and Marlborough. Key questions in these trials were:

Do higher rates of sulphur improve control?

Does sulphur plus a wetting agent improve control?

Is sulphur at higher rates crop safe?

Is sulphur plus a wetting agent crop safe?

What is the best sulphur based programme?

The trial sites had powdery mildew in the crop in 2014/15, so were expected to have high levels of powdery mildew pressure in 2015-16. The grower sprayed the trial sites up to pre flowering, trial applications then commenced and continued at 10-14 day intervals until veraison.

			Critical Period for Bunch Infection						
Growth Stage	2 weeks pre flowering	pre flowering	35% cap fall	100% cap fall	berries pea size	pre bunch closure	bunch closure	pre veraison	early veraison
1. Untreated for Powdery Mildew	-	-	-	-	-	-	-	-	-
2.Kumulus DF at 3.0kg/ha	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF
3.Kumulus DF at 4.0kg/ha	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF
4.Kumulus DF at 5.0kg/ha	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF
5.Kumulus DF at 6.0kg/ha	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF
6.Kumulus DF at 10.0kg/ha	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF	Kumulus DF
7.Kumulus DF at 3.0kg/ha + Actiwett 75ml/100L	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett
8. Kumulus DF at 4.0 kg/ha + Actiwett 75ml/100L	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett
9. Kumulus DF at 6.0 kg/ha + Actiwett 75ml/100L	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett
10. Organic Programme Kumulus at 5.0kg/ha Protector @ 0.5%	Kumulus DF HML 32 Nordox	Kumulus DF HML 32 Nordox	Kumulus DF Protector	Kumulus DF Protector	Kumulus DF Protector	Kumulus DF HML 32 Nordox	Kumulus DF Protector	Kumulus DF HML 32 Nordox	Kumulus DF Protector
11. Conventional Programme Kumulus at 5.0kg/ha	Kumulus DF Actiwett	Impulse	Kumulus DF Actiwett	Talendo	Kumulus DF Actiwett	Flute	Kumulus DF Actiwett	Kumulus DF Actiwett	Kumulus DF Actiwett

Trial applications were made at water rates of 500-700 litres per hectare with motorised knapsacks to plots containing two vines. The experimental design at both sites was randomised complete blocks with four replicate plots of each treatment.

Product rates per hectare in this report refer to vines planted on three metre row spacings. To convert these rates for vineyards planted with row widths of less than three metres, rates should be adjusted proportionately to row width. For example 3kg/ha sulphur on a three metre row spacing is equivalent to 3.75kg/ha on a 2.4m row spacing or 4.5kg/ha on a two metre row width.

Eleven different spray programme treatments were applied. The following table sets out treatments and application timings. Kumulus DF was chosen as it the most commonly used sulphur product used in grapes. Treatments 2-6 examined the effect of increasing rates per hectare of Kumulus DF. Treatment 6, Kumulus DF at 10kg/ha was included to check plant safety at high Kumulus DF rates.

Treatments 7-9 examined the effect of adding Actiwett, a non-ionic wetting agent to Kumulus DF. Actiwett is a wetting agent suited to the relatively high water rates used in this study.

Treatment 10 represented an organic programme for powdery mildew control and was based on input from viticulturists managing organic vineyards.

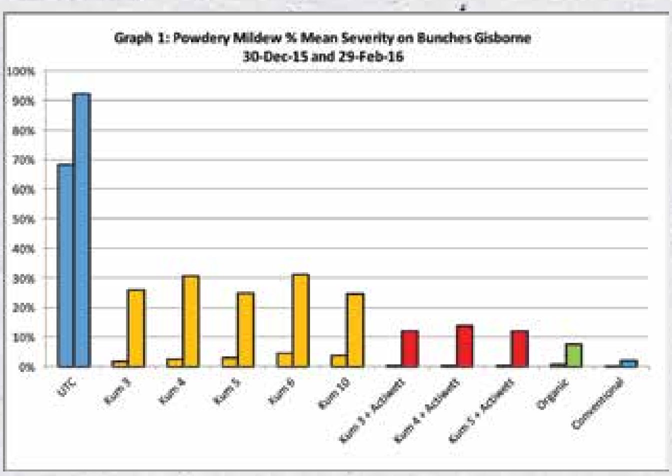
Treatment 11 was a conventional programme that incorporated single site fungicides in alternation with Kumulus DF. This programme meets the guidelines of the fungicide Resistance Management Strategy for Grapevine Powdery Mildew (*Erysiphe necator*) in New Zealand (Beresford et al 2015).

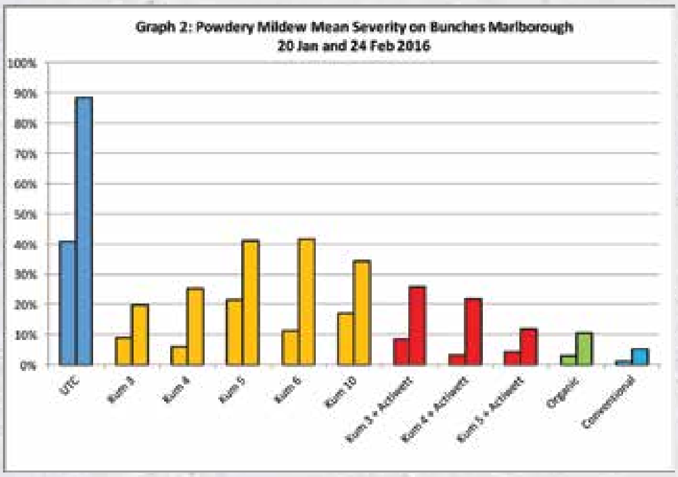
Applications at 10-14 day intervals were slightly extended compared with those currently recommended as best practice. This was done to increase disease pressure to detect differences between Kumulus DF treatments where the application rate differences were relatively small, eg Kumulus DF at 3, 4, 5 and 6 kg/ha.

Canopy Density and Coverage Assessments

The canopy at the Gisborne trial site was relatively open and good coverage was achieved with 700 litres per hectare at late flowering. At this time the canopy was at its most dense with no trimming or leaf removal having occurred. Coverage was assessed with water sensitive papers as 80% adequate. Well setup vineyard sprayers typically achieve 75%+ adequate coverage.

Visually the Marlborough canopy was denser than Gisborne with more leaf layers. There was also more leaf on leaf and bunch-on-bunch congestion. Spray coverage was assessed with water sensitive papers as 70-75% adequate. This assessment was made on 29 December 2015 at berries pea size, after trimming and leaf removal. Subsequently the grower thinned out the heads of the vines and de-lateralled. This improved spray coverage into the bunch zone. However by then bunch infections were established and continued to be expressed. As





in the Gisborne trial bunch-on-bunch congestion was the major site of infection in bunches.

Assessments

In both the Gisborne and Marlborough trial sites high levels of powdery mildew developed in untreated leaves and bunches - indicating high disease pressure. Assessments of 50-100 leaves or bunches per plot were conducted to determine the mean severity of powdery mildew. Mean severity is the average area of leaf or bunch infected for each treatment – in bunches this is a measure of total crop loss.

Results

Do increased rates of sulphur improve powdery mildew control?

In both Gisborne and Marlborough increasing rates of Kumulus DF above 3kg/ha did not significantly improve control on leaves or fruit during the main part of the season. This result was a little surprising.The explanation for these results is likely to be due to sprayer coverage and resulting chemical dose. Water sensitive papers from the Marlborough trial site show adjacent areas of good and poor coverage and chemical dose

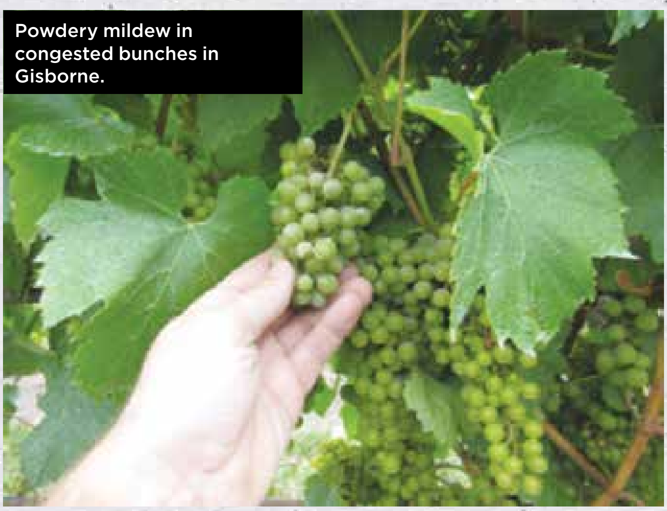
The left side of these papers could represent the exposed side of external bunches while the right side represents the inward facing surface of the bunch. To obtain good coverage of the inner surface the spray plume must penetrate through the canopy. Where the inner bunch surface is obscured by another bunch or leaves, this surface will be under dosed. In areas of poor coverage there are too few spray droplets to deliver an acceptable dose or for sufficient wetting agent to be deposited to provide improved coverage.

One of the most commonly observed areas of under-dosing in NZ wine grape canopies are areas of congestion above crowns of vines with too many shoots and points where shoots from canes ends overlap along rows. Other points of potential under-dosing result from tucking wires causing congestion in the foliage zone.

Does the addition of a wetting agent wetting agent to sulphur improve control of powdery mildew?

The addition of the wetting agent Actiwett to Kumulus DF reduced powdery mildew mean severity on bunches but not on leaves. In the following graph data from both Gisborne and Marlborough trials was used. Each data point represents a result from powdery mildew assessments of bunch infection within a plot, paired for each rate and timing. For example Kumulus DF at 3kg/ha was paired with Kumulus DF at 3kg/ha+ Actiwett. If there was

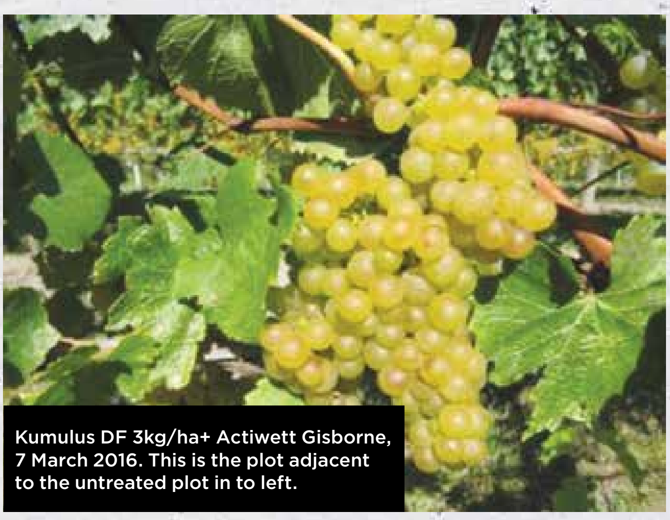

Bunch on bunch congestion in Gisborne where canes have been butted together on the cropping wire.


Powdery mildew in congested bunches in Gisborne.

Marlborough vines showing congested canopy where canes from adjacent vines meet and above the head of the vine with open canopy between.

Powdery mildew in congested bunches in Marlborough .

Powdery mildew infection of untreated bunches Gisborne, 7 March 2016.



Kumulus DF 3kg/ha+ Actiwett Gisborne, 7 March 2016. This is the plot adjacent to the untreated plot in to left.

no response to the addition of Actiwett to Kumulus DF the data points would be expected to fall on the solid blue line. The dotted blue line indicates a highly significant trend ($P < 0.05$) to lower powdery mildew mean severity where the wetting agent Actiwett has been added to Kumulus DF.

There was no significant wetting agent effect apparent on powdery mildew on leaves, which are an easier spraying target than bunches.

2. Is the addition of a wetting agent safe to the crop?

In Gisborne, a light russet was observed on sun exposed berries in bunches exposed to the sun following application of Kumulus DF plus Actiwett. This was only seen when temperatures following application approached 30°C. The russet did not appear to result in any deterioration in the affected berries at harvest. It would be prudent to avoid the use of Kumulus DF and Actiwett mixtures when high (>28°C?) temperatures are expected following application. This may apply to other sulphur formulations and wetting agent combinations.

3. Are higher sulphur rates safe to the crop?

There were no adverse effects observed in vines receiving the higher Kumulus DF rates.

4. What does a best practice sulphur based programme look like?

The best protection of bunches was provided by the conventional programme with single site fungicides (Impulse, Talendo and Flute) alternating with Kumulus DF + Actiwett during the critical flowering to pre bunch closure period.

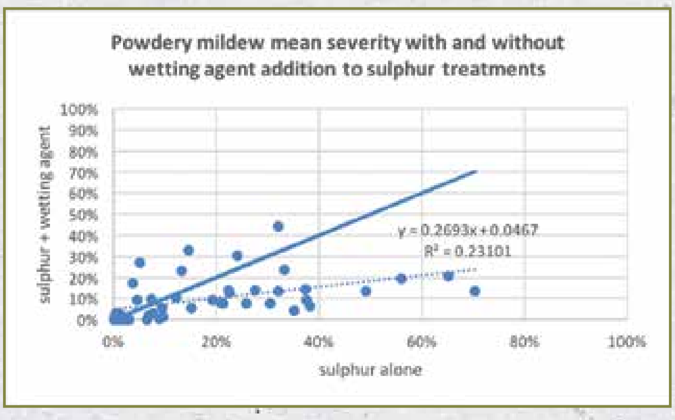
The organic programme provided the next best level of control. In this programme Kumulus DF + Protector (as a wetting agent) formed the basis of the programme with Kumulus DF + HML 32 + Nordox 75WG applied at key timings to provide some additional curative activity. Control in the organic programme could likely be improved by closer spray intervals.

The conventional and organic programmes provided similar levels of control on leaves, apart from the final assessment in Gisborne where the organic programme was superior. The organic programme included two mid-summer applications of HML32 + sulphur + copper which may have had a curative effect on leaf powdery mildew.

Summary

These studies demonstrated the importance of achieving good spray coverage of bunches and leaves. Increasing rates of sulphur above 3kg/ha did not improve powdery mildew control, even when sulphur at 6 or 10kg/ha was applied.

The explanation appears to be that if adequate coverage is not achieved areas of poor coverage will result in too few spray droplets to deliver an acceptable sulphur dose or for sufficient wetting agent to be deposited to provide improve coverage. Increasing sulphur rates does not compensate for poor spray coverage.



The importance of good canopy management was the other key finding from these trials. Powdery mildew was typically found in areas of bunch and leaf congestion. Avoiding bunch on bunch congestion and areas of dense foliage is critical to ensuring adequate spray coverage. Management of this starts with winter pruning to ensure there are not excessive numbers of growth points in the heads of the vines and that shoot and bunch congestion does not occur where adjacent vines meet.

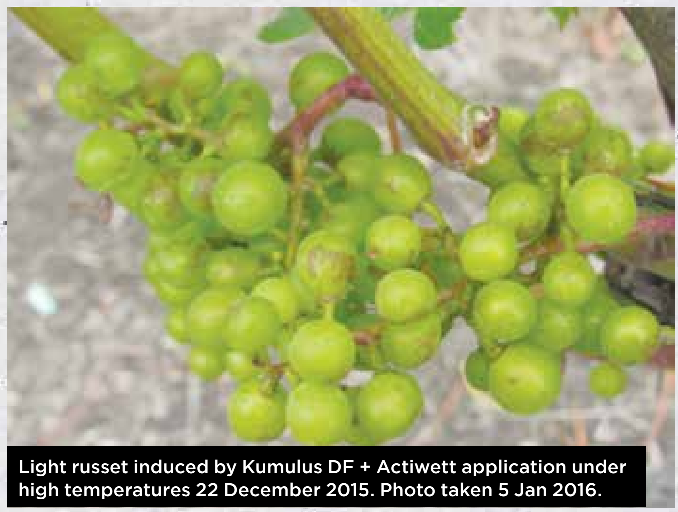
Grape bunches are highly susceptible from flowering to around bunch closure. It is important that spray coverage of bunches is monitored during this period of active canopy growth. Water sensitive papers folded in half and pinned to shoots adjacent to bunches are a simple method of checking bunch coverage. Spray intervals should also be closed up during this period and it is important to alternate the direction of spraying between applications to fill in any under-sprayed areas.

Row widths in New Zealand vineyards now average 2.4 metres. Ensure that rates per hectare have been adjusted to reflect additional row length per hectare where closer row spacings are in use.

Reference

Beresford R, Follas G, Hagerty G, Manson P, Manktelow D, Lupton T, 2015 Fungicide Resistance Management Strategy for Grapevine Powdery Mildew (*Erysiphe necator*) in New Zealand, New Zealand Committee on Pesticide Resistance August 2015.

Powdery mildew infection untreated bunches 5 Jan 2016.



Light russet induced by Kumulus DF + Actiwett application under high temperatures 22 December 2015. Photo taken 5 Jan 2016.

The vines are mutating. What does that mean for our industry?

15- 109

Darrell Lizamore, Lincoln University

Co-funding from New Zealand Wine, Plant and Food Research and Lincoln University has made possible research into a previously unknown type of genetic differences among the elite clones grown by the NZ wine industry. This is has established the foundation for a rapid clonal identity test and the production of New Zealand's own population of locally-developed Sauvignon blanc and Pinot noir clones.

The venerable grapevine can reveal a lot about how the DNA of a species changes over time. If the average person thinks about genetics at all, it is likely to be in a multi-generational context: "He has his mother's eyes" and "surely Chihuahuas aren't really be descendant from wolves?" Yet within a single lifetime, an individual will undergo a surprising amount of genetic change. New growth and even tissue maintenance, such as replacing skin cells, requires the total complement of the individual's DNA to be copied continuously. Though infrequent, small mistakes start to add up. What is more, we now know that parts of the genetic code, known as transposons, can rearrange themselves, altering the code. These natural DNA changes (a.k.a. mutations) are the cause of birthmarks, cancers and plant bud sports such as white grape varieties.

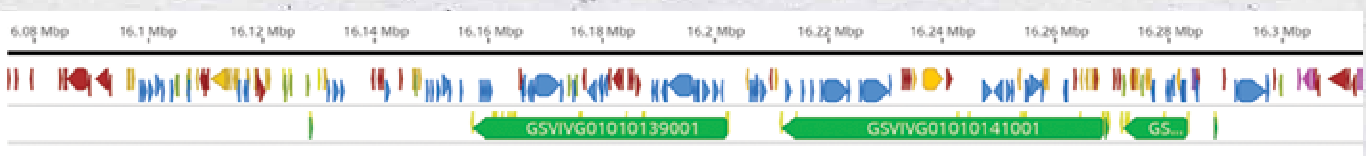


Figure 1: A short sample region (approx. 0.04%) of the grapevine genome with genes indicated in green and transposons indicated by other colours. The profusion of transposons within and around genes complicates the challenge of identifying new mutations.

In most species, the changes are contained by generational boundaries. Although a mutation in your liver might lead to terminal cancer, it won't be passed on to your descendants. Grapevines are different. Unlike species in which all genetic information is reduced to a few cells (sperm / pollen & ova) every few years or decades, grapevines are propagated by cuttings and have been for centuries. Varieties such as Cabernet Sauvignon are believed to have existed for up to 500 years without sexual crossing. As a result, mutations that occur in the vegetative material (termed 'somatic' mutations) become a permanent feature of future plantings. In fact, grapevines offer a unique opportunity to study the affect of the accumulated genetic changes on a species. By studying the DNA of farmed vines, we can gain insight into the rates, effects and causes of somatic mutations.

Spot the missing star

Robert Evans, an amateur astronomer in Hazelbrook, Australia searches the sky every night for supernovae, the melodramatic death of a star. To make a positive identification, he must spot one new star in a splendid desert night sky, a task that has been likened to noticing one new grain on one of fifteen hundred tables randomly scattered with salt. In spite of the seemingly overwhelming task, he has already identified and named more than 40 supernovae. Likewise, novel genetic mutations appear against a background of perfect uniformity. Due to their historical activity, we need to check the position of around 70,000 transposon sequences in the DNA to identify a single new mutation in a single vine (Fig. 1). Lacking an Aussie savant, our research group has developed computer algorithms that rapidly map the positions of each transposon.

Large-scale DNA sequencing projects start by breaking the DNA from many cells into short fragments and then sequencing both ends of those fragments. Our process then takes this data and searches it for fragments where one end is within a transposable element and the other is not (i.e. the fragment spans one end of a transposon). We then take all of the sequences that are next to a transposon and locate these on the grapevine DNA reference sequence. The output is a set of locations that indicates where in the genetic code transposons can be found. By comparing all of these locations among different samples, we can spot the new mutations.

Mapping mutations in a new population of clones

The knowledge that transposon mutations account for a majority of the genetic variation among clones of the same variety has been taken a step further by a collaborative effort between New Zealand Wine, Lincoln University and Plant and Food Research. Over the past few years by our research group has shown that the natural rate of transposon mutations can in fact be increased, so that we are able to produce a population of new clonal diversity. To date, we have planted a collection of 200 Pinot noir vines produced by this technique from the Pinot noir clone UCD5 (Fig. 2) and have another 2,000 vines (Pinot noir and Sauvignon blanc) that will be added to the vineyard shortly. Among these vines we are already starting to see indications of physical differences such as altered leaf morphology, timing of dormancy and susceptibility to mildew infection (Fig. 3).

Figure 2: A population of 200 young vines growing in the Lincoln University vineyard. These vines were regenerated from cell cultures in the lab, to accelerate the natural rate of transposon-based mutations.

A better type of marker

Our new protocol allows us to track which transposons are moving about within the genome, and identify the genes that are affected by their changes. Furthermore, it provides a new type of genetic marker. Genetic markers are currently the preferred method for identifying grapevine varieties, since environmental factors can have a large effect on physical trait markers such as leaf morphology. But since the DNA of a single grapevine cell contains approximately half a billion letters of code, most of which never vary, it is rarely practical or economical to compare the entire sequence of two vines. Instead, we only test the most informative locations in the DNA. Just the as the trait of leaf morphology is selected for its utility in discriminating varieties, so too do we select DNA locations that are highly variable for comparison.

The copy-error types of mutations have so far been useful in identifying grapevine varieties, but do not generally vary among different clones of the same variety. In contrast, we have seen that genetic markers based on transposons can discriminate different Pinot noir clones. Developing this technique into a tool to discriminate genetically among clones (including rootstocks) could prevent costly errors by growers and nurseries and even allow those who are selecting their own clones with a way to characterise and protect their investment.

Into the future

Our colleagues at Plant and Food Research, led by Ross Bicknell, have made great improvements to our grapevine tissue culture protocols, which means they are now producing new vines in batches of thousands rather

Figure 3: Variation in leaf morphology among vines regenerated from tissue culture. All vines came from the same parental tissue.

than hundreds. To keep pace with the arrival of new plants, we are now working on ways to run genetic tests on vines more rapidly and economically. We have started using a liquid-handling robot to run automated DNA extractions on 96 samples at a time and by using customised DNA probes, we have managed to reduce the amount of DNA that needs to be sequenced per test by 100-fold, reducing the cost proportionately. Together these advances mean that we are now well on our way to establishing a population of well-characterised vines, each with isolated and unique genetic changes, as if it were possible to collect several thousand new bud sports all at once.

One advantage of DNA testing is that it only requires one small piece of leaf. We can therefore test the vines long before they are old enough to deliver fruit.

Our goal for the next five years is to focus on the production and genetic characterisation of new vines. As the first of these vines get old enough (three years from now), we will begin to roll out a phenotyping program across the vines, to describe and record the trait diversity caused by the genetic changes. Starting about five to seven years from now, cuttings will be taken from individual vines that show new traits of potential value, to study their performance in replicated field trials.

This means that we can expect the first well-characterised new clones to be made available to growers about 10 years from now.

The work we are doing today establishes the tools and procedures we will need to reach the next generation of grapevine clones. This continually growing set of local clones offers a resource of genetic diversity that will serve to protect and enhance the premium position of New Zealand wine for decades to come. With wine research centres from other countries now proposing similar projects, we are fortunate to have a 4-5 year lead that should be exploited to establish a future advantage of our industry.

An upcoming review of leafroll virus management in New Zealand vineyards

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Vaughn Bell[1] and Nick Hoskins[2], the New Zealand Institute for Plant & Food Research Limited, Havelock North[1], and Vine Managers Limited, Masterton[2]

In 2009, New Zealand Winegrowers embarked upon an ambitious research programme to monitor the incidence and spread of grapevine leafroll virus.

In what became known as the Virus Elimination project, this world-leading programme initially focused on vineyards in Hawke's Bay, and was extended in 2012 to include a further 17 vineyards in Marlborough.

Hence, multiple aspects related to leafroll virus and mealybugs - the virus vectors, were being monitored in 30 separate vineyards in two regions.

With that project concluding in mid-2015, monitoring all but ceased. Fortunately, New Zealand Winegrowers continued to fund monitoring in four of the Marlborough vineyards where, after three years, it was unclear if the practical virus management initiatives would successfully contain disease spread.

Therefore, in March and April 2016, we continued to monitor virus incidence and the patterns of virus spread in each of the four blocks. By extending monitoring for another 12 months, we aimed to improve the comparisons between Marlborough and Hawke's Bay, to determine if any regional variation existed, say, in respect of the patterns of virus spread.

Later this year, the Hawke's Bay and Marlborough virus results will be reviewed in New Zealand Winegrower. We will look at the changes to virus incidence and the patterns of virus spread in both regions, and how the effectiveness, or otherwise, of mealybug control has influenced virus management outcomes.

Hence, with datasets spanning multiple years, we will highlight the differences and/or similarities that exist between leafroll virus management in two wine-producing regions.

From a practical perspective, if no regional variability is apparent, virus management recommendations will reflect that lack of difference. Conversely, if variation is detected, it will have to be reflected in the technology transfer pathway.

Either way, the new knowledge gained from this research will help end-users confidently adopt those recommendations, irrespective of where they live in New Zealand.

Grapevine growth stage monitoring for prediction of key phenological events

14 - 100

Agnew R, Raw V, Grab F, Horner R, Sorensen I, Marshall R, Wood P, Stanley J, Gandell M, Parker T, Smith J.
The New Zealand Institute for Plant & Food Research Limited
Corresponding author rob.agnew@plantandfood.co.nz

VineFacts is a New Zealand Winegrowers (NZW) project supported by the Sustainable Farming Fund for the three years from July 2014 to June 2017. The project has now completed two years of phenology data collection in Gisborne, Hawke's Bay, Marlborough, Waipara Valley and Central Otago for five grape varieties (Chardonnay, Merlot, Pinot Gris, Sauvignon Blanc and Pinot Noir).

VineFacts newsletter has previously only been available to Marlborough subscribers and covering Sauvignon Blanc. The purpose of this National Phenology and VineFacts project is to extend the phenology monitoring to also include Gisborne, Hawke's Bay, Waipara Valley and Central Otago; to cover other varieties; and to make VineFacts available to any winegrower nationwide. A previous article in Issue 89 of New Zealand Winegrower explained the background to this project and Issue 93 presented the growing degree-days for the five New Zealand wine regions for the 2014-15 growing season.

Phenology data summary for the five New Zealand wine regions

The timing of the main phenological stages (budburst, flowering, and maturity from pre-véraison to harvest) are being monitored on each of the 28 vineyards in the five wine regions. These data are summarised weekly and reported to subscribers of VineFacts newsletter. This information allows them to compare the timing of a phenological stage in the current season with those in previous seasons, and to adjust management decisions within a season if necessary.

The duration of time between two phenological stages is referred to as a phenophase, e.g. the number of days from 50% budburst to 50% flowering, from 50% flowering to 8 °Brix, and from 8 °Brix to 21.5 °Brix. We are using the date of 8 °Brix as a surrogate for the date of 50% véraison and the date of 21.5 °Brix as a standard maturity point close to harvest.

Table 1 (right) demonstrates the difference in the length of each phenophase between the 2014-15 and 2015-16 growing seasons on each of the 28 phenology vineyards. A negative value indicates that the phenophase was shorter in 2015-16 than in 2014-15. In some instances data are missing e.g. the Hawke's Bay Merlot at Bridge Pa was severely frosted soon after flowering in 2014.

The values in the 'budburst to flowering' column in Table 1 are all negative. This clearly indicates that at all vineyards and in all regions the budburst to flowering interval in the 2015-16 season was shorter than that in the 2014-15 season. The 'flowering to 8 °Brix' values are all positive, indicating that this interval was longer in the 2015-16 season. These consistent differences in phenophase duration across all blocks from budburst to flowering and from flowering to 8°Brix are because temperature is the main driver of

Table 2: Total seasonal rainfall (mm) for five New Zealand wine regions for the 2014-15 and 2015-16 seasons compared with the long-term average (LTA).

	Long-term average	2014-15	% of LTA	2015-16	% of LTA
Gisborne	594.9	553.8	93%	678.6	114%
Hawke's Bay	457.3	402.1	88%	509.5	111%
Marlborough	395.7	220.8	56%	240.2	61%
Waipara	393.2	222.3	56%	288.8	73%
Central Otago	297.6	187.6	63%	179.0	60%

Table 3: Total Seasonal Growing Degree-Days for five New Zealand wine Regions for the 2014-15 and 2015-16 seasons compared with the long-term average (LTA)

	Long-term average	2014-15	% of LTA	2015-16	% of LTA
Gisborne	1544	1520	98%	1616	105%
Hawke's Bay	1320	1311	98%	1328	101%
Marlborough	1240	1349	109%	1377	111%
Waipara	1117	1251	112%	1273	114%
Central Otago	1036	1118	108%	1221	118%

Table 1: Difference in the duration (days) of the main grapevine phenophases for the 2015-16 growing season in relation to the 2014-15 growing season (BB - Budburst, FL - Flowering)

Vineyard Region	Grape Variety	Phenology Location Name	BB- FL	FL - 8° Brix	8°Brix - 21.5 °Brix
Gisborne	Chardonnay	Hexton	-4	+4	-1
Gisborne	Chardonnay	Patutahi	-3	+9	-13
Hawke's Bay	Chardonnay	Te Awanga	-16	+8	-1
Hawke's Bay	Chardonnay	Crownthorpe	-15	+9	+1
Hawke's Bay	Merlot	Ngakirikiri	-5	+5	-10
Hawke's Bay	Merlot	Bridge Pa	No data	No data	No data
Hawke's Bay	Pinot gris	Maraekakaho	-11	+10	+7
Hawke's Bay	Sauvignon blanc	Bridge Pa	-7	+3	-8
Marlborough	Chardonnay	Western Wairau	-9	+9	-6
Marlborough	Chardonnay	Awatere Dashwood	-4	+6	-3
Marlborough	Pinot gris	Rapaura	-10	+7	-12
Marlborough	Pinot gris	Awatere Seaview	-5	+7	-1
Marlborough	Sauvignon blanc	Rarangi	-4	+11	+3
Marlborough	Sauvignon blanc	Brancott	-7	+12	-5
Marlborough	Sauvignon blanc	Rapaura	-4	+8	+5
Marlborough	Sauvignon blanc	Western Wairau	-10	+8	-1
Marlborough	Sauvignon blanc	Upper Wairau	-7	+13	No data
Marlborough	Sauvignon blanc	Awatere Seaview	-4	+7	-5
Marlborough	Sauvignon blanc	Mid Awatere	-2	+12	-12
Marlborough	Sauvignon blanc	Upper Awatere	-5	+10	+3
Marlborough	Pinot noir	Brancott	-9	+11	-2
Marlborough	Pinot noir	Awatere Seaview	-5	+9	+4
Waipara	Sauvignon blanc	Waipara Glasneven	-6	+7	No data
Waipara	Pinot noir	Waipara Glasneven	-11	No data	No data
Central Otago	Pinot noir	Bannockburn	-7	+9	+1
Central Otago	Pinot noir	Pisa	-4	+7	+1
Central Otago	Pinot noir	Alexandra	-3	+7	+3
Central Otago	Pinot noir	Gibbston	-7	+7	-13

the early-season phenology. These data are also an indication that all the wine regions generally experience below- or above-average temperatures at similar times in the season.

Comparisons of the differences in duration of the '8 to 21.5 °Brix' phenophase indicate that there is no clear trend for all vineyards and regions. The length of this phenophase is still influenced by temperature. However, the yield that the vine is carrying also has a major bearing on the duration of the '8 to 21.5 °Brix' phenophase.

Climate summary for the 2014-15 and 2015-16 seasons compared with the long-term average

The rainfall data (Table 2, left) indicate that Gisborne and Hawke's Bay experienced slightly below-average rainfall in the 2014-15 season, followed by above-average rainfall in 2015-16. Marlborough, Waipara and Central Otago experienced one of the driest seasons on record in 2014-15, followed by another very dry season in 2015-16.

Table 3 (left) indicates that Gisborne and Hawke's Bay recorded slightly below-average growing degree-days (GDDs) in the 2014-15 season. In the 2015-16 season, Gisborne recorded slightly above-average GDDs and Hawke's Bay recorded average GDDs. Marlborough, Waipara Valley and Central Otago recorded well above-average GDDs in both seasons.

Acknowledgements:

We wish to acknowledge the large number of wine companies, vineyard and weather station owners supporting this project and without whose ongoing valuable assistance this project would not be possible.

We acknowledge the valuable financial support for the project being received from New Zealand Winegrowers, the Ministry for Primary Industries Sustainable Farming Fund, and the Marlborough Research Centre Trust.

• *For the full 2015-16 annual report on this research project, visit the NZW members' research pages.*

Sustaining vineyards through practical management of grapevine trunk diseases

13-100

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Introduction

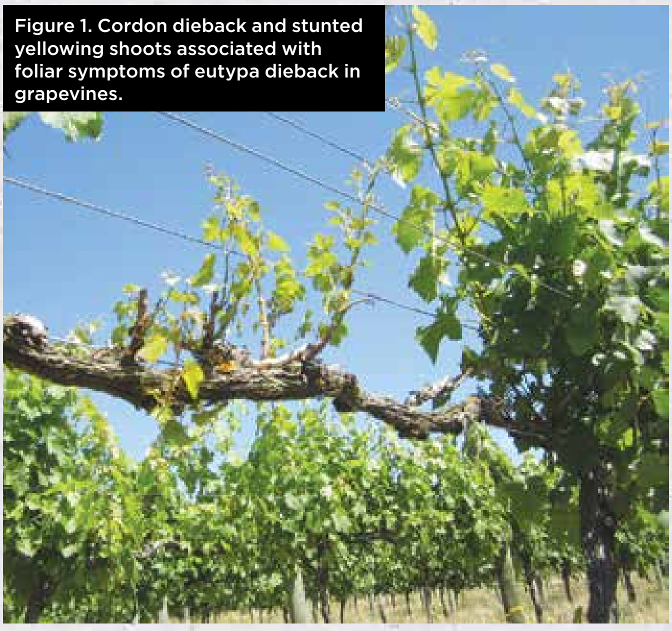
Eutypa and botryosphaeria dieback are emerging as major trunk diseases of grapevines in New Zealand, threatening the long-term sustainability of the wine industry. These diseases occur worldwide, causing significant economic losses. Caused by fungal species of the Diatrypaceae and Botryosphaeriaceae families, they infect vines through pruning wounds, colonise wood tissue, cause dieback of cordons and trunks (Figures 1 & 2), and eventually kill vines. Nine species of the Botryosphaeriaceae have been identified associated with botryosphaeria dieback on grapevines in New Zealand, with the most prominent and pathogenic being Neofusicoccum parvum. In the case of eutypa dieback (caused by Eutypa lata), symptoms also include stunted yellowing shoots and leaf distortion.

A New Zealand Winegrowers project (NZW 13-100), which concluded recently, has determined the extent of grapevine trunk diseases in New Zealand and has begun to develop practical management strategies to control the diseases and sustain vineyards. Fungicides and alternative natural treatments were evaluated for control of eutypa and botryosphaeria dieback, and strategies for cost-effective spray application of pruning wound treatments were demonstrated. Economic analysis was undertaken to determine the cost/benefit of managing grapevine trunk diseases and provide decision support for the industry.

Vineyard surveys

In December 2013, surveys recorded the incidence of trunk diseases in Hawke's Bay and Marlborough vineyards. In total, 697 vineyard blocks were surveyed, consisting of 22 varieties, ranging from 4 to 33 years of age. The youngest vines observed with dieback and foliar symptoms were 4 and 7 years old, respectively (Figure 3). Disease incidence increased with age and varied between varieties and regions. The greatest incidence of dieback (88%) and foliar symptoms (10.5%) were recorded in 19- to 21-year-old Cabernet Sauvignon vineyards in Hawke's Bay. Incidence of symptoms increased considerably in vines over 15 years of age, which was also reported in Australian surveys. Mean incidence of trunk disease was relatively low in Sauvignon Blanc, probably because of

Figure 1. Cordon dieback and stunted yellowing shoots associated with foliar symptoms of eutypa dieback in grapevines.



the young average age of vines (11 years) and the predominant use of cane-pruning for this variety. For most varieties in the survey, cordon-pruned vines had greater incidence of dieback than cane-pruned vines, confirming previous French research findings that young cordon-pruned vines expressed more symptoms, but cane-pruned vines resulted in greater mortality as vines matured. According to Australian research, Sauvignon Blanc was reported to be highly susceptible to trunk disease, so this serves as a significant warning to the Sauvignon Blanc-dominated industry as vineyards mature. Correlation between vine age, variety and trunk disease was low, indicating that variables other than these factors may also account for disease incidence. Vines grafted onto Millardet 101-14, Riparia Gloire and Couderc 3309 had consistently lower incidence of dieback than vines on other rootstocks. Clones with the least incidence of dieback included AM 10/5 (Pinot Noir), B

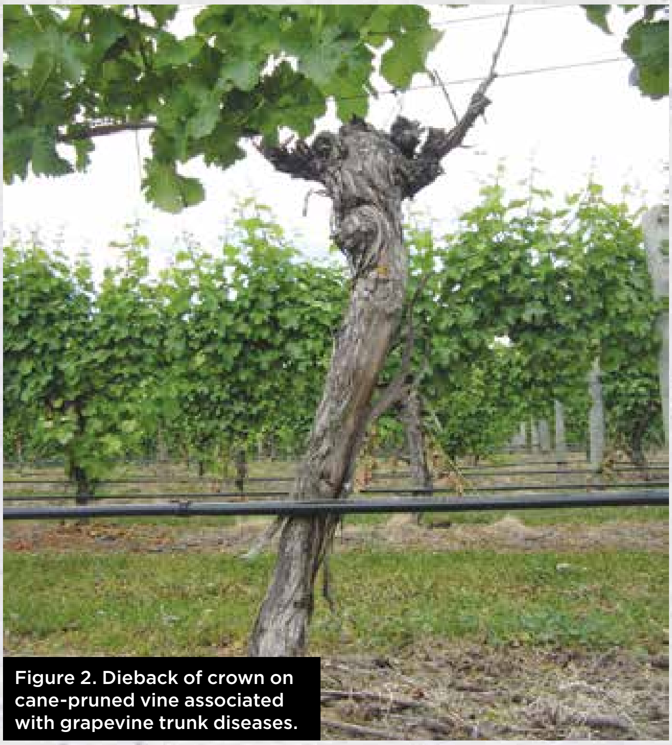


Figure 2. Dieback of crown on cane-pruned vine associated with grapevine trunk diseases.

95 and UCD 15 (Chardonnay), and BDX 481 (Merlot). These observations need to be confirmed by greenhouse experiments and may provide valuable information to assist decision making for future new plantings.

In December 2015, a survey in Central Otago targeted the oldest vineyards in the region. In general, the incidence of dieback symptoms in Central Otago was lower than those reported in Marlborough and Hawke's Bay (Figure 3), which are dominated by the susceptible varieties Sauvignon Blanc and, to a lesser extent, Cabernet Sauvignon. Central Otago vineyards are predominately planted with the less susceptible Pinot Noir. The lower incidence of dieback symptoms observed in Central Otago may also be due to the lower annual rainfall of 359 mm, compared with 711 and 785 mm in Marlborough and Hawke's Bay, respectively. Winter dominant rain patterns occur in the higher rainfall regions, compared with summer dominant rainfall in Central Otago (Figure 4); as pruning is conducted largely in winter and infection of wounds occurs during rainfall, there are fewer infection periods during pruning in Central Otago than in the other regions.

Pruning wound protection

The fungicides: Folicur® (tebuconazole), Chief® (carbendazim), Gem® (fluazinam), Dithane™ (mancozeb) and Megastar™ (flusilazole), chosen based on previously shown efficacy, were evaluated for control of eutypa and botryosphaeria dieback in Sauvignon Blanc, using detached cane assays (DCAs) in the laboratory and in vineyard trials in Marlborough. All fungicides, when applied at varying rates with a paintbrush, were effective at reducing wound infection by pathogens of both diseases compared with untreated controls, providing good disease control (Figure 5). Data from vineyard and laboratory experiments have been provided to agrochemical companies to apply for label registration with Agricultural Compounds & Veterinary Medicines (ACVM).

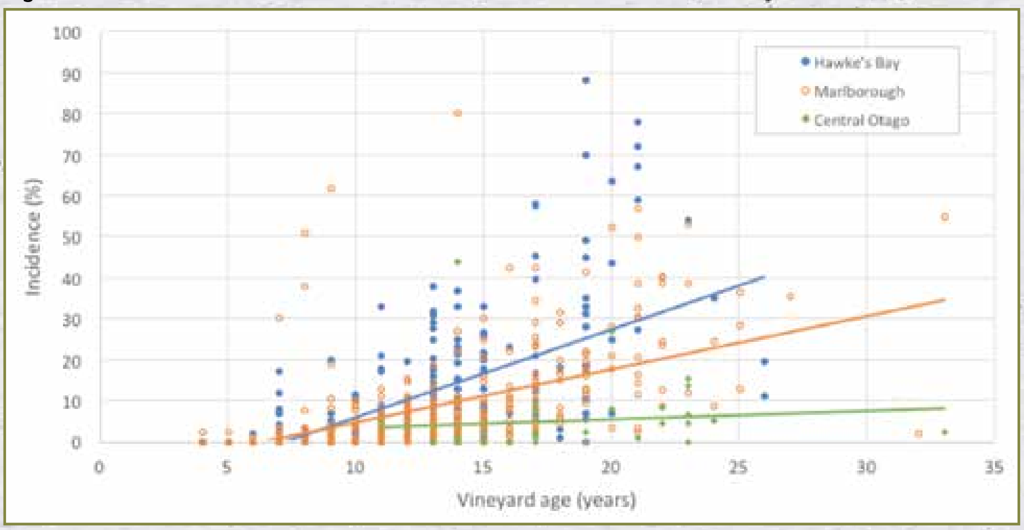
To date, application of pruning wound protectants on the day of pruning has been evaluated. This study also investigated the curative and preventative properties of fungicides using a detached cane assay. This involved delaying treatment application for up to a week after pruning, and once treatment was applied, determining the length of time for which treatments remained effective. DCA experiments were established by inoculating wounds with eutypa and botryosphaeria dieback pathogens, followed by application of Folicur or Chief, 1, 3 or 6 days after pruning and inoculation. Both fungicides significantly reduced infection by both pathogens at all application times. In a separate experiment, wounds were treated with Folicur or Chief on the day of pruning and then inoculated with *E. lata* 1, 7 or 14 days after inoculation. Both fungicides still actively reduced infection after 14 days. Therefore, the window of protection for wounds for Chief and Folicur could be at least 3 weeks, meaning only one application might be necessary per pruning season. Validation of these results in the vineyard is proposed for future research, along with evaluating other fungicides likely to be registered for wound protection.

Alternative natural product-based treatments were also evaluated using DCA only, and when applied neat (Biorepel®; garlic extract and HML 32™; potassium bicarbonate) or at 100 g/L (TriD25™; *Trichoderma* sp.), provided varying degrees of control of pruning wound infection by eutypa and botryosphaeria dieback pathogens. Further research is required to evaluate these products in the field and to determine the optimal timing of application.

Spray application

Recycle, air-shear and tangential sprayers, along with a modified weed sprayer, were evaluated

Figure 3. The relationship between vine age and incidence of grapevine trunk disease dieback symptoms in Marlborough (orange; 441 vineyard blocks) and Hawke's Bay (blue; 256 vineyard blocks), surveyed in 2013 and Central Otago (green; 39 vineyard blocks), surveyed in 2015. Linear trendlines are indicated for each region.



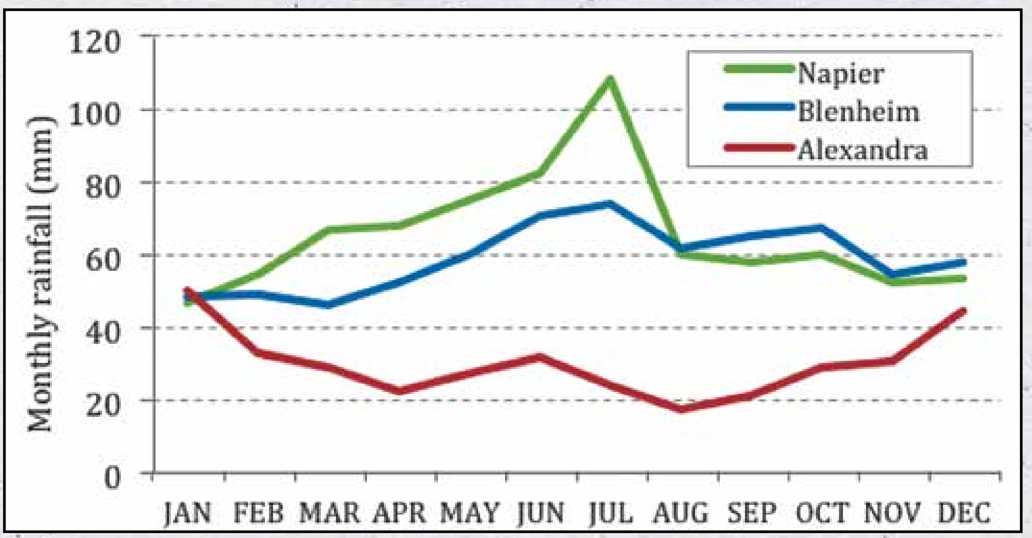


Figure 4. Mean monthly rainfall data for Napier (Hawke's Bay), Blenheim (Marlborough) and Alexandra (Central Otago). Data are mean monthly values for the 1981–2010 period (www.niwa.co.nz).

in both Hawke's Bay (on cordon-pruned Cabernet Sauvignon) and Marlborough (on cane-pruned Sauvignon blanc).

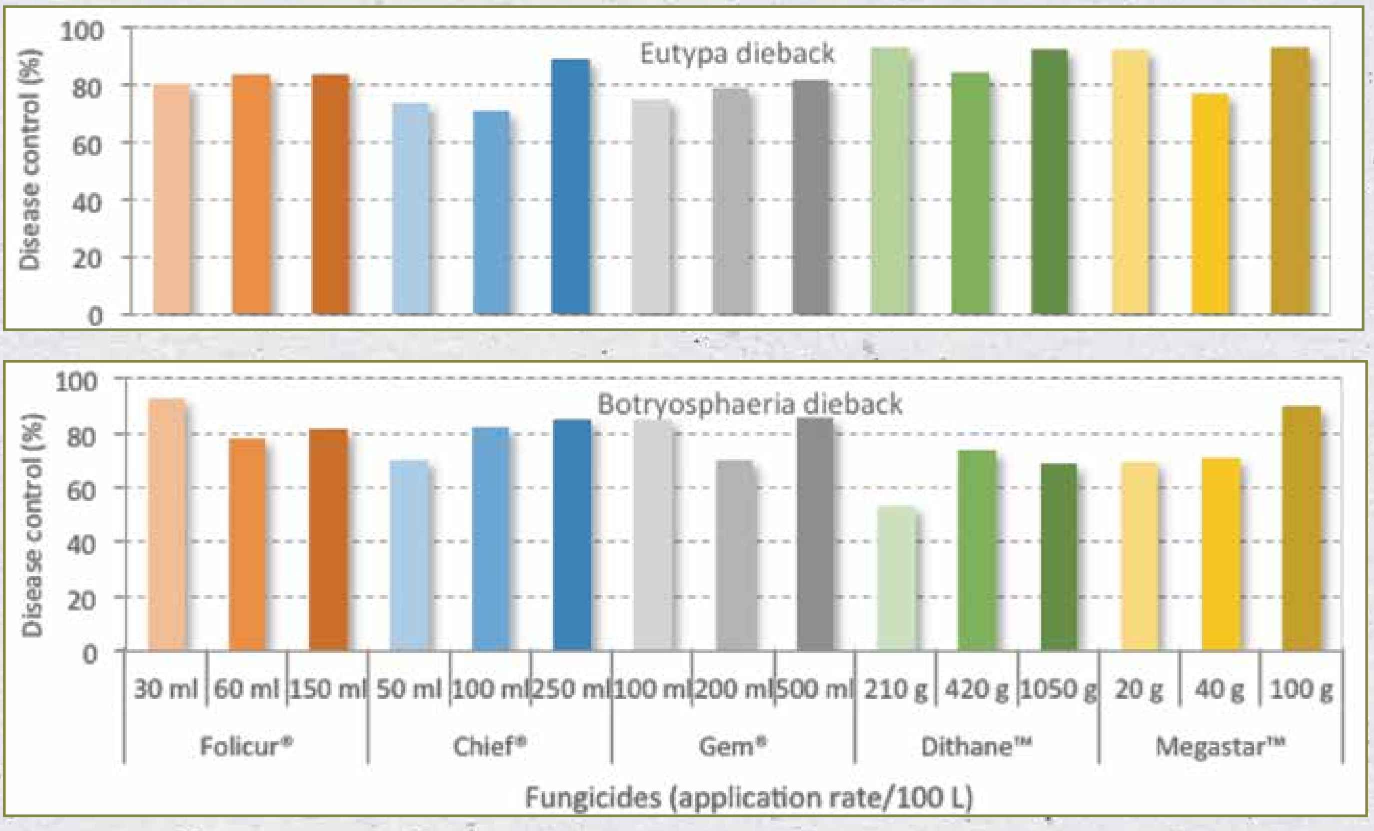
Sprayers were able to deliver sufficient fungicide (Chief) for applying fungicide with water volume rates between 100 and 900 L/ha (Figure 6)., with some nozzle adjustments to focus on the pruning wound zone, all to wounds, as demonstrated with water sensitive papers (Figure 7), to control eutypa and botryosphaeria dieback (Figures 8 & 9).

Field trials were established in Marlborough on Sauvignon Blanc over two years to investigate the susceptibility of wounds throughout the winter. Wounds were susceptible to infection by eutypa and botryosphaeria dieback pathogens throughout the pruning season, but there was some evidence of reduced susceptibility during late pruning in September, which may also be associated with faster wound healing in higher temperatures.

Natural infection rates of *E. lata* were correlated to rainfall before pruning.

The application of Chief fungicide reduced infection by both pathogens in at least one of the two trials at each pruning time, with the greatest reductions following application at the middle pruning time of early August. Future proposed research aims to determine the duration of wound susceptibility following pruning at different times, which along with spore trapping, will assist decision making for the optimal timing of wound protection.

Figure 5 Mean percentage disease control of eutypa and botryosphaeria dieback pathogens compared with untreated controls on treated Sauvignon Blanc grapevine wounds in a Marlborough vineyard. Fungicides were applied at varying rates with a paintbrush.



Economic analysis

Cost/benefit analysis was performed, based on results from the 2013 surveys in Hawke's Bay and Marlborough, as well as results of spray application of fungicide wound treatments, to provide decision support for managing grapevine trunk diseases. Early adoption of preventative wound treatments will minimise the cost of trunk diseases, providing up to NZ$700/ha/annum net present value (NPV) future benefit over the life of a vineyard when pruning wound treatments are applied with a tractor-driven sprayer. If preventative treatment does not commence until after trunk disease is evident, there will be costs for future crop losses and remediating or replacing vines. The cost of remediating vines by reworking or regrafting will be less than the cost of replacing vines. The sooner the remediation treatment is commenced, the greater the NPV future benefit. Wholesale remediation or replacement of a vineyard will be more cost-effective than treating symptomatic vines only once at least 80% of vines are symptomatic. The current potential "national" value of an effective annual spray treatment to the industry is estimated to be at least $20M per annum increasing by a further $20M per annum when combined with remediation treatments.


Figure 6. Recycle sprayer applying fungicides to pruning wounds in the Marlborough vineyard trial.

Acknowledgements

This project was made possible by funding from New Zealand Winegrowers and the New Zealand Ministry for Primary Industries Sustainable Farming Fund. The authors acknowledge technical support from Matthew Ayres (SARDI) and Pratap Vanga (PFR). Thanks also to Pernod Ricard NZ and Villa Maria for assistance with vineyard trials, the many companies that allowed access to vineyards for surveys, and the agrochemical companies which have committed to registering successful products for control of trunk diseases.


Figure 7. Spray coverage indicated on water sensitive paper.

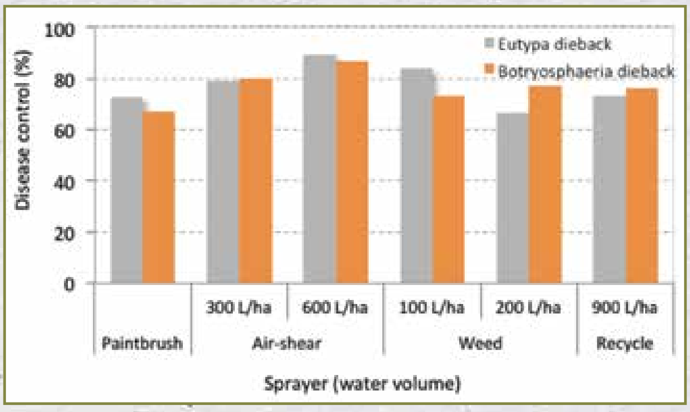


Figure 8. Mean percentage disease control of eutypa and botryosphaeria dieback pathogens compared with untreated controls on treated Cabernet Sauvignon grapevine wounds in Hawke's Bay. Chief® was applied with three different sprayers at various water spray volumes or with a paintbrush for comparison.

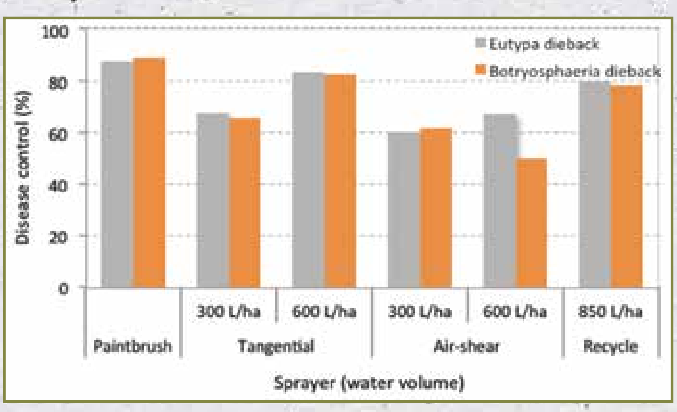


Figure 9. Mean percentage disease control of eutypa and botryosphaeria dieback pathogens compared with untreated controls on treated Cabernet Sauvignon grapevine wounds in Hawke's Bay. Chief® was applied with three different sprayers at various water spray volumes or with a paintbrush for comparison.

Spy Valley:
PHOTO SPY VALLEY WINES MARLBOROUGH, SUPPLIED BY NZW

High performance from lower alcohol wines

Domestic sales from lower alcohol wines have already eclipsed the original target set for 2024 by New Zealand Winegrowers' Lifestyle Wines Programme

New Zealand lower alcohol wines have not only struck a chord with a growing number of Kiwi consumers, they are also responsible for a significant portion of value growth in total wine sales in the domestic market.

Lower alcohol wines (containing less than 10% alcohol by volume) are the focus of New Zealand Winegrowers' 'Lifestyle Wines' research and development programme, established in March 2014. Funded jointly by the Ministry for Primary Industries' Primary Growth Partnership (PGP), wine industry levies, and commercial contributions from participating wine companies, the seven-year programme aims to develop production approaches for the creation of high-quality, lower alcohol and lower calorie wines.

Lifestyle Wines PGP Programme	
Programme Start:	March 2014
Length:	7 years
Total funding:	$16.97 million
PGP funding:	$8.13 million
Industry funding:	$8.84 million
Commercial partners:	NZ Winegrowers and contibuting wineries*

*Accolade Wines, Allan Scott Wines, Constellation Brands, Forrest Estate, Giesen Wine Estate, Indevin, Kono, Lawson's Dry Hills, Marisco Vineyards, Mount Riley Wines, Mt Difficulty Wines, Pernod Ricard, Runner Duck Estate, Spy Valley Estate, Villa Maria, Whitehaven Wine Company, Wither Hills and Yealands.

The programme seeks to deliver economic benefits of $285 million a year by 2024 via increased production and sales of lower alcohol wines, with $22 million of this targeted to come from domestic sales.

Given that domestic sales for lower alcohol wines reached $30 million for the 12 months to 21 February 2016, the category is likely to see accelerated growth via the PGP programme. According to Richard Lee, Lifestyle Wines Marketing Manager, the domestic market has doubled in two years with volume sales now in excess of two million litres. "To put this in perspective, if lower alcohol wine was considered a winery in its own right, it would be classified as a Category 2 company, with annual sales between 200,000 and four million litres," he notes.

Choice Plus Quality

"New Zealand consumers and retailers have shown strong support for lower alcohol wines," adds Lee, "and that includes new sparkling wines from some of the biggest brands. It's about providing more choices for consumers across a range of social occasions."

Typically, lower alcohol wines produced within the PGP programme are being marketed as line extensions of trusted premium wine brands, he says. "The approach is providing consumers with a level of assurance about the quality and flavour of these wines versus their preferred wine styles."

Quality is not only key in terms of holding buyers' interest and retaining their support, it's also key to understanding the nature of the programme itself, according to Dr David Jordan, Lifestyle Wines' Programme Manager.

"PGP programme participants have indicated that the informational exchange between companies and researchers – combined with solid marketing intelligence on sales potential – has aided and reinforced their decisions on lower alcohol wine production," says Jordan.

"The programme has served as an incubator, resulting in continued improvements in the vineyard and the winery, along with the rapid growth we've seen in domestic sales."

Growing Total Wine Sales

Supermarket scan data measures the majority of wine sold in New Zealand and provides a key means for assessing what Lee calls 'wallet behaviour' – that is, consumer purchasing decisions in product categories.

While lower alcohol wines currently command a relatively small proportion of the total domestic market with a 2.4% share of wine sales, this represents the highest proportion of lower alcohol wine sold in the world – much higher than in Australia or the United Kingdom, for example.

Importantly, lower alcohol wine sales have been incremental to the total wine category, accounting for around 40% of value growth in the 12 months ending 21 February 2016 (a timeframe that enables easy analysis of quarterly sales over the key summer and holiday trading period).

According to Lee, the dollar sales growth of lower alcohol wine is exceeded only by Pinot Noir (ranked first for growth) and Champagne (ranked second). In the 12 months to 21 February 2016, the lower alcohol wine category was up more than 31% in value, whereas total wine was up 1.4%. And for sales over the summer and holiday season, the category was equivalent to twice the value of Riesling and 30% of the value of Chardonnay.

Hot Hot Hot – Pinot Gris & Rosé

Lower alcohol wines have performed particularly well in the already hot Pinot Gris and Rosé segments (both ranked in the top five for dollar growth in the 12 months to 21 February 2016).

Lower alcohol Pinot Gris accounted for 29% of the dollar growth in the Pinot Gris segment, and lower alcohol Rosé accounted for 14% of the growth in the Rosé segment.

Three wine styles accounted for around 85% of lower alcohol wines sold in New Zealand in the same period:

- Lower alcohol Pinot Gris (5.9% of total Pinot Gris sales).
- Lower alcohol Rosé (7.7% of total Rosé sales).
- Lower alcohol Sauvignon Blanc (6.0% of total Sauvignon Blanc sales).

Boom For Bubbles

Not surprisingly, sales of lower alcohol sparkling wines also excelled over the summer trading period, with growth of more than 115% versus growth of 8.9% for full-strength sparkling wines. "There is no doubt that consumers opted for lower alcohol sparkling wine for certain occasions last summer," says Lee. "Sales in this instance also proved to be incremental to dollar growth in the total sparkling wine category."

Category Laboratory

Lee says New Zealand consumers are ahead of the pack in terms of their thirst for lower alcohol wines.

"The domestic market is effectively providing us with a consumer-led category laboratory," he adds. "New Zealand is leading the world in terms of both development and consumption of lower alcohol wines."

Bunch of Grapes.
PHOTO PETER BURGE, SUPPLIED BY NZW.