Wine Australia for Australian Wine

NSW GOVERNMENT | Department of Primary Industries

MANIPULATING WINEGRAPES WITH ANTITRANSPIRANTS

FINAL REPORT TO WINE AUSTRALIA

Project Number: **DPI 1702**

Principal Investigator: **DARREN FAHEY**

Research Organisation: **NSW DEPARTMENT OF PRIMARY INDUSTRIES**

Date: **1/12/2018**

Manipulating winegrapes with antitranspirants

Darren J. Fahey
Development Officer – Viticulture
Department of Primary Industries | Plant Systems
Orange Agricultural Institute
1447 Forest Road Orange NSW 2800
M: 0457 842 874
E: darren.fahey@dpi.nsw.gov.au
W: www.dpi.nsw.gov.au

Date: 1/12/2018

Publisher
NSW Department of Industry

Authorship declaration
The author contributed significantly and agrees with the manuscript.

Disclosure statement
The author declares that there is no conflict of interest.

ISBN: 978-1-76058-295-1 (Print)
ISBN: 978-1-76058-296-8 (Web)

Table of Contents

Abstract

Increasing temperatures are impacting grape production, winery logistics and affecting resultant wines. To address this we tested the efficacy of a film-forming antitranspirant, di-1-*p*-menthene, to manipulate winegrape ripening. Berry weight, bunch weight and yield were increased in treated vines, but anthocyanin concentration was reduced. Pinot Noir and Shiraz wines made from treated vines were lower in alcohol concentration, providing an alternative to water addition at the winery and in keeping with a growing consumer trend for lower alcohol products. Pivot profiling results highlighted perceived attribute differences, suggesting this treatment might provide vignerons an easily adoptable mitigation tool to address vintage compression and other climate change effects.

Executive summary

To determine if winegrape production could be manipulated without negatively affecting specific grape and wine parameters, this project tested the efficacy of an antitranspirant on two red *Vitis vinifera* L. cultivars, Shiraz and Pinot Noir.

Nine field trial sites were established on commercial vineyards across seven wine growing regions of NSW. The antitranspirant di-1-*p* menthene was applied at a 1% application rate as a single treatment at pre-flowering, pre-veraison, or both, to form a flexible film surface coating. The coating forms a physical barrier which reduces water loss from the leaves, bunches and other vine parts, whilst allowing them to breathe normally. These were compared against an untreated control.

The trial was undertaken in one season during drought-declared conditions of 2017-2018 in NSW, providing an excellent opportunity to trial the effectiveness of the antitranspirant. Berry weight, bunch weight, and yield were all increased across the majority of sites, while pH and titratable acidity (TA) remained mostly unaffected by application of the antitranspirant. Reductions in °Brix and anthocyanins occurred across several sites, with no impact on total phenolics across any site.

Juice samples were taken from the sites in which wines were made. No differences in pH or Baumé occurred. However, TA was increased in juice from all treatments except the dual antitranspirant treatment for Pinot Noir. Shiraz YAN was not affected by the antitranspirant while Pinot Noir YAN was decreased in all treatments.

Alcohol concentration was decreased in both Pinot Noir and Shiraz wines from treated vines. Total red pigments in the Shiraz were significantly reduced in all antitranspirant treatments. Acetic acid concentrations were increased by the treatment, with TA decreased in Pinot Noir wine and pH increased in Shiraz wine with treatment. However, no significant differences resulted between treatments in free, bound or total sulphur and phenolics in both wines.

Pivot profiling was able to separate the Pinot Noir trial wines in a more distinct and logical manner than Shiraz trial wines. Perceived attributes of antitranspirant wines were expressed as less ripe, green, herbaceous and high acidity whereas control wines were characterised as more red (less orange/brown), darker and associated with higher alcohol and complexity.

This project achieved its aim of evaluating use of the film-forming antitranspirant di-1-*p* menthene on two red grape varieties across different viticultural climatic zones of NSW. These preliminary results suggest this treatment might provide vignerons with an easily adoptable mitigation tool to address vintage compression and changes to grape, juice and wine characters caused by climate change. However, further long-term research across several seasons is required to assess the full potential and benefit of its use.

This research was supported by funding from Wine Australia. Wine Australia invests in and manages research, development and extension on behalf of Australia's grape growers and winemakers and the Australian Government.

Background

In recent years a warming trend has resulted in earlier, more compressed vintages (Sadras et al. 2013). This challenges winery logistics and results in wines with lower titratable acidity (TA), higher pH and higher alcohol, due to increased sugar accumulation. Godden et al. (2015) examined changes in wine composition of over 24,000 commercially bottled Australian white, rosé and red wines from 1984 to 2014. The results revealed a decrease in TA and an increase in pH, especially since 2007 for red wines, with mean alcohol content steadily rising in both white and red wines between 1984 and 2008.

Managing grapevines and maintaining fruit quality under challenging climatic conditions might include applications of antitranspirants as part of a mitigation strategy (Keller 2010). Antitranspirants are film-forming polymers that are sprayed onto leaf surfaces to act as a physical barrier to reduce water loss and gas exchange (Palliotti et al. 2010). Intrieri et al. (2013) found antitranspirants reduced net assimilation of treated leaves for 20–40 days after application. Gatti et al. (2016) showed that ripening of cv. Barbera could be manipulated with antitranspirants, where sugar accumulation was slowed, delaying ripening without any effect on colour development. In cv. Sangiovese, Palliotti et al. (2013) reported that berry sugaring could be hindered to obtain lower alcohol wines, although the anthocyanin concentration was also reduced.

All research to date has been carried out overseas and involved antitranspirant application at rates of 2 and 3% (Palliotti et al. 2010, 2013; Intrieri et al. 2013; Brillante et al. 2016; Gatti et al. 2016). However, little published research exists under Australian conditions and at a lower 1% application rate.

Project aim

This study was designed to test the effects of applying an antitranspirant at an application rate of 1% on two red *Vitis vinifera* L. cultivars in field conditions across cool, warm, warm/dry, warm/humid and hot growing regions of NSW. The aim was to determine whether winegrape ripening could be manipulated while maintaining grape and wine quality parameters.

Materials and methods

Field trials

The field trials were run over a two-year period (2018 vintage) on nine separate commercial vineyards across seven wine growing regions of NSW (Table 1). This incorporated a broad range of viticultural climatic zones including cool, warm, warm/dry, warm/humid and hot growing regions.

Table 1: Site details of field trials.

Site	Location	GPS coordinates	Climate	Cultivar	Clone	Vine age (years)	Irrigation
1	Hunter Valley	32.43° S, 151.15° E	Warm/humid	Shiraz	PT23	23	Drip
2	Mudgee	32.37° S, 149.37° E	Warm/humid	Shiraz	PT23	21	Drip
3	Orange	33.22° S, 148.51° E	Cool	Shiraz	1654	18	Drip
4	Hilltops	34.23° S, 148.19° E	Warm/dry	Shiraz	1654	18	Drip
5	Hilltops	34.23° S, 148.19° E	Warm/dry	Pinot Noir	Unknown	43	Dryland
6	Canberra	34.59° S, 149.30° E	Cool	Shiraz	1654	20	Drip
7	Griffith	34.15° S, 146.13° E	Hot	Shiraz	1654	12	Drip
8	Griffith	34.16° S, 146.80° E	Hot	Shiraz	Mass select	38	Drip
9	Tumbarumba	35.42° S, 148.00° E	Cool	Pinot Noir	MV6	26	Drip

All sites were pruned by commercial pruning teams or landholders with bud numbers based on individual vine balance. Sites 1–6 were trained on a vertical shoot position cordon trellis, with spurs pruned. Sites 7 and 8 were box pruned and site 9 was cane pruned. Landholders were asked to assign an area within a block where underperforming vines existed on either Shiraz or Pinot Noir cultivars. Eleven adjacent rows in each vineyard were selected to form a randomised block experimental design with nine tagged vines per treatment and untreated buffer rows, replicated five times for each of the four treatments (Figure 1).

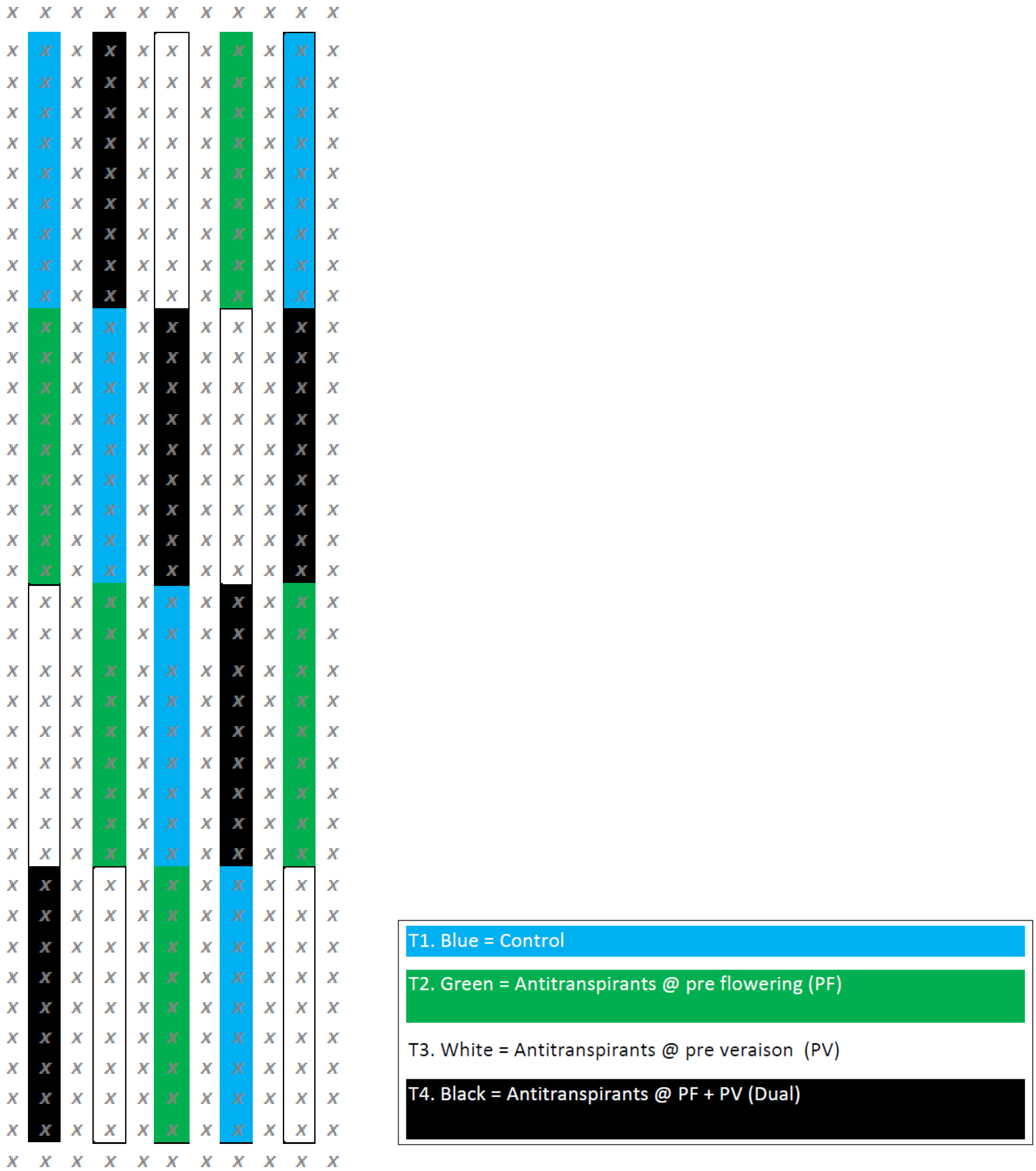

Figure 1. Antitranspirant trial randomised experimental design layout undertaken at each site.

The antitranspirant Vapor Gard® (Agspec, Adelaide South Australia), is a water emulsifiable organic concentrate formulated as a terpenic polymer with the active ingredient di-1-*p* menthene. This antitranspirant is also known as Pinolene® and is derived from conifer resin. The antitranspirant was prepared as a 1% solution in water, agitated and applied as a single treatment at pre flowering (PF, growth stage EL 17) and pre veraison (PV, growth stage EL 34) or at both pre flowering and pre veraison (PFPV) to form a flexible film surface coating. Measurements from treated vines were compared against an untreated control (C). All pest, disease, irrigation, fertiliser and canopy management was undertaken by the landholder with any and all interventions carried out across the entire trial area in each season.

Yield, grape and wine composition

At each site, on the first day of commercial harvest, 20 randomly selected, hand-picked bunches from either side of the treatment vines were harvested to obtain two 100-berry samples for each of the five treatment replicates. These were collected into a plastic container, weighed and stored at -20 °C prior to analysis of berry quality measurements. Yield (as t/ha) was calculated using bunch weight × bunches/vine × vines/ha. Key measures of quality were determined for berries, grape juice and wine, including Titratable acidity (TA) and juice pH, °Brix Total anthocyanins and phenolic content.

Titratable acidity (TA) and juice pH was determined using a Metrohm Fully Automated 59 Place Titrando System (LMWI 40-15 Metrohm Ltd., CH-9101 Herisau Switzerland). °Brix was measured using an Anton Paar DMA 35 N portable density meter. Total anthocyanins and phenolic content were determined according to Iland et al. (2004) using a Shimadzu UV 1700 PharmaSpec analyser on a second separate 100-berry sample per treatment replicate. Absorbance values were measured at 520 nm (anthocyanins) and 280 nm (phenolics) and expressed as mg/g and total phenolics/berry respectively.

Small lot experimental winemaking was undertaken on Pinot Noir (site 9) and Shiraz (site 7) grapes that were collected from combined treatment replicates. Chemical analysis of wine followed the methods of Iland et al. (2004) and sensory analysis (pivot profiling) was carried out at the National Wine and Grape Industry Centre, Wagga Wagga, NSW. Yield, grape and wine quality data was subjected to one way ANOVA. Means were compared using least significant difference (LSD) tests at the 5% probability level.

Results

Climate data

Site 6 was the only site to receive rainfall totals above the long-term mean (Table 2). Mean monthly maximum temperatures across all sites were 0.5 and 2.1 °C above the long-term mean.

Table 2: Meteorological data showing long-term means for rainfall and temperature compared to vintage actuals across the trial period of 2017–2018.

Site	Location	Mean rainfall Sep–Mar (mm)		Mean max temperature Sep–Mar (°C)	
		*Long term	Vintage	*Long term	Vintage
1	Hunter Valley	502	494	27.2	29.1
2	Mudgee	447	327	26.4	28.3
3	Orange	542	410	21.9	23.9
4 and 5	Hilltops	359	338	26.4	27.9
6	Canberra	419	436	25.1	25.8
7 and 8	Griffith	237	201	28.2	30.3
9	Tumbarumba	514	424	23.7	25.5

**Source* BOM sites 061260, 062101, 063254, 073138, 070351, 075041 and 072043.

Grape yield

Applying the antitranspirant increased berry weight at six of the nine sites that were treated at PV and PFPV compared with the control (Table 3). At sites 8 and 9, all treatments increased berry weight above the control. The PF treatment at site 5 was the only one to decrease berry weight. Antitranspirant application improved berry moisture content at sites 1 and 5, and berry numbers at sites 3, 4 and 8.

Table 3: Mean berry weight differences in field grown Pinot Noir and Shiraz vines treated with antitranspirant at pre flowering (PF), pre verasion (PV), at both times of pre flowering and pre veraison (PFPV) or left untreated (C).

Site	**Location**	**Mean berry weight (g)**			
		C	**PF**	**PV**	**PFPV**
1	Hunter Valley	1.37 b	1.42 ab	1.49 a	1.53 a
2	Mudgee	1.7 ns	1.7 ns	1.83 ns	1.78 ns
3	Orange	1.35 b	1.41 b	1.58 a	1.55 a
4	Hilltops	1.77 b	1.78 b	1.91 a	1.91 a
5	Hilltops	1.16 c	1.09 d	1.20 b	1.24 a
6	Canberra	1.82 ns	1.81 ns	1.81 ns	1.87 ns
7	Griffith	1.51 ns	1.54 ns	1.52 ns	1.55 ns
8	Griffith	1.12 b	1.21 a	1.24 a	1.20 a
9	Tumbarumba	1.42 d	1.49 c	1.63 a	1.57 b

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

All antitranspirant treatments increased bunch weight at sites 1, 2, 3 and 9 (Table 4). The PV and PFPV treatments resulted in the greater increases in bunch weight, with significant differences occurring at seven of the nine sites. Bunch weight increases occurred at sites 2, 6 and 7 where berry weight was not significantly different.

Table 4: Mean bunch weight differences in field grown Pinot Noir and Shiraz vines treated with antitranspirant at pre flowering (PF), pre verasion (PV), at both times of pre flowering and pre veraison (PFPV) or left untreated (C).

Site	**Location**	**Mean bunch weight (g)**			
		C	**PF**	**PV**	**PFPV**
1	Hunter Valley	131 d	154 b	153 c	166 a
2	Mudgee	178 c	197 b	222 a	193 b
3	Orange	103 d	119 c	133 b	149 a
4	Hilltops	153 c	155 c	171 b	197 a
5	Hilltops	95 ns	92 ns	108 ns	108 ns
6	Canberra	231 b	225 b	266 a	275 a
7	Griffith	150 b	160 b	178 a	172 a
8	Griffith	122 ns	122 ns	134 ns	143 ns
9	Tumbarumba	156 c	176 b	192 a	182 b

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

Yield increased at seven of the nine sites with antitranspirant application (Table 5). All treatments increased grape yield at sites 1, 2, 3 and 9. The PV and PFPV applications increased yield at sites 4, 6 and 7 (Table 5).

Table 5: Yield differences in field grown Pinot Noir and Shiraz vines treated with antitranspirant at pre flowering (PF), pre verasion (PV), at both times of pre flowering and pre veraison (PFPV) or left untreated (C).

Site	**Location**	**Yield (t/ha)**			
		C	**PF**	**PV**	**PFPV**
1	Hunter Valley	9.67 c	11.42 b	11.34 b	12.28 a
2	Mudgee	13.19 c	14.61 b	16.40 a	14.30 b
3	Orange	7.64 d	8.80 c	9.85 b	11.03 a
4	Hilltops	11.32 c	11.44 c	12.68 b	14.55 a
5	Hilltops	7.00 ns	6.81 ns	7.96 ns	8.01 ns
6	Canberra	17.06 b	16.66 b	19.70 a	20.36 a
7	Griffith	11.09 b	11.82 b	13.15 a	12.72 a
8	Griffith	9.02 ns	9.01 ns	9.93 ns	10.61 ns
9	Tumbarumba	11.53 c	12.99 b	14.22 a	13.48 b

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

Berry quality

The pH at six of the nine sites was unaffected by applying the antitranspirant. The PFPV application decreased berry pH at sites 3 and 9 (Table 6). At site 7, antitranspirant application at PFPV increased the pH while its application at PF decreased the pH. Overall, many sites recorded pH readings above 4.0 (Table 2). Only the cool climate sites (6 and 9) had pH below 4.0.

Table 6: Mean pH differences in field grown Pinot Noir and Shiraz vines treated with antitranspirant at pre flowering (PF), pre verasion (PV), at both times of pre flowering and pre veraison (PFPV) or left untreated (C).

Site	**Location**	**pH units**			
		C	**PF**	**PV**	**PFPV**
1	Hunter Valley	4.05 ns	4.07 ns	4.03 ns	4.03 ns
2	Mudgee	4.03 ns	4.07 ns	4.08 ns	4.07 ns
3	Orange	4.37 a	4.33 a	4.29 a	4.22 b
4	Hilltops	4.17 ns	4.20 ns	4.15 ns	4.17 ns
5	Hilltops	4.30 ns	4.29 ns	4.29 ns	4.25 ns
6	Canberra	3.69 ns	3.76 ns	3.75 ns	3.78 ns
7	Griffith	4.53 b	4.34 c	4.51 b	4.65 a
8	Griffith	4.56 ns	4.60 ns	4.56 ns	4.50 ns
9	Tumbarumba	3.91 a	3.90 a	3.80 b	3.76 b

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

Titratable acidity was mostly unaffected by antitranspirant use, except for increases at site 7 with PF application and at site 8 with PFPV application (Table 7).

Table 7: Mean titratable acidity (g/L) differences in field grown Pinot Noir and Shiraz vines treated with antitranspirant at pre flowering (PF), pre verasion (PV), at both times of pre flowering and pre veraison (PFPV) or left untreated (C).

Site	**Location**	**Titratable acidity (g/L)**			
		C	**PF**	**PV**	**PFPV**
1	Hunter Valley	4.14 ns	4.14 ns	4.32 ns	4.30 ns
2	Mudgee	4.38 ns	4.06 ns	3.94 ns	4.08 ns
3	Orange	4.32 ns	4.54 ns	4.36 ns	4.50 ns
4	Hilltops	3.9 ns	3.9 ns	4.0 ns	4.0 ns
5	Hilltops	2.68 ns	2.86 ns	2.64 ns	2.72 ns
6	Canberra	4.24 ns	4.0 ns	4.0 ns	4.08 ns
7	Griffith	2.84 b	3.62 a	3.12 b	2.60 bc
8	Griffith	2.76 b	2.76 b	2.88 b	3.14 a
9	Tumbarumba	4.02 ns	4.0 ns	4.22 ns	4.26 ns

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

Applying the antitranspirant at PV decreased the °Brix for sites 3, 4, 7 and 9. It was decreased even further by the PFPV application at sites 3 and 9 (Table 8).

Table 8: Mean °Brix differences in field grown Pinot Noir and Shiraz vines treated with antitranspirant at pre flowering (PF), pre verasion (PV), at both times of pre flowering and pre veraison (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	Hilltops	23.51 ns	23.72 ns	22.46 ns	22.43 ns
6	Canberra	21.78 ns	22.14 ns	21.96 ns	21.96 ns
7	Griffith	22.93 a	22.97 a	22.25 b	21.85 c
8	Griffith	25.45 ns	25.31 ns	25.34 ns	25.20 ns
9	Tumbarumba	23.58 a	23.22 a	20.84 b	20.45 b

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

Anthocyanin readings decreased with PV and PFPV antitranspirant application at sites 1, 3 and 4 (Table 9).

Table 9: Mean anthocyanins per gram berry weight (mg/g) differences in field grown Pinot Noir and Shiraz vines treated with antitranspirant at pre flowering (PF), pre verasion (PV), at both times of pre flowering and pre veraison (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	Hilltops	0.99 ns	0.90 ns	1.07 ns	1.09 ns
6	Canberra	1.33 ns	1.42 ns	1.32 ns	1.33 ns
7	Griffith	0.80 ns	0.78 ns	0.76 ns	0.61 ns

8	Griffith	1.07 ns	1.01 ns	0.97 ns	0.98 ns
9	Tumbarumba	0.48 ns	0.55 ns	0.61 ns	0.58 ns

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

Juice quality

There were no differences in pH or Baumé in the juice samples taken after pressing from any sites (Table 11). Titratable acidity in Shiraz juice was increased by all treatments, although decreased in the PFPV treatment for Pinot Noir. Levels of yeast assimilable nitrogen (YAN) in Shiraz juice was not affected by the antitranspirant while YAN decreased in Pinot Noir juice for all treatments (Table 11).

Table 11: Mean juice composition differences recorded in field grown Shiraz (site 7) and Pinot Noir (site 9) vines treated with antitranspirant at pre flowering (PF), pre verasion (PV), at both times of pre flowering and pre veraison (PFPV) or left untreated (C).

Location and variety	Treatment	pH	Titratable acidity (g/L)	Baumé	YAN (mg/L)
Site 7 Shiraz	C	4.19 ns	3.70 d	12.1 ns	232 ns
	PF	4.17 ns	3.83 c	12.1 ns	248 ns
	PV	4.14 ns	4.00 a	12.0 ns	245 ns
	PFPV	4.13 ns	3.93 b	11.9 ns	252 ns
Site 9 Pinot Noir	C	3.29 ns	7.90 a	13.2 ns	194 a
	PF	3.29 ns	7.87 a	13.3 ns	173 c
	PV	3.28 ns	7.83 ab	13.0 ns	161 d
	PFPV	3.32 ns	7.70 c	12.9 ns	178 b

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

Wine quality

Wine pH increased and alcohol concentration decreased with antitranspirant use in the experimental Shiraz wine (Table 12). Total red pigments were significantly reduced in all antitranspirant treatments. The acetic acid concentration of the Shiraz wine was decreased by the PV treatment, increased by the PFPV but not affected by the PF treatment. Antitranspirant application had no effect on Shiraz TA. In the Pinot Noir experimental wine, the TA and alcohol concentration were decreased by the PV and PFPV treatments. The acetic acid concentration was decreased by the PF, increased by the PV treatment and unchanged by the dual treatment (Table 12). There were no significant differences between treatments and the control in free, bound or total sulphur and phenolics in both wines.

Table 12: Mean wine composition differences recorded in 2018 vintage in field grown Shiraz (site 7) and Pinot Noir (site 9) vines treated with antitranspirant at pre flowering (PF), pre verasion (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 7 Shiraz	C	3.54 c	5.53	12.2 a	11.35 a	0.34 b
	PF	3.56 b	5.37	12.0 b	10.50 b	0.34 b
	PV	3.56 b	5.37	11.8 c	8.92 c	0.33 c
	PFPV	3.57 a	5.33	11.8 c	8.92 c	0.38 a

Site 9 Pinot Noir	C	3.50	5.40 a	14.0 a	2.83	0.39 b
	PF	3.49	5.33 a	14.0 a	2.26	0.33 c
	PV	3.49	5.10 b	13.5 b	2.42	0.42 a
	PFPV	3.53	5.06 b	13.2 c	2.39	0.38 b

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

Pivot profiling

The wine sensory technique used in this study, namely pivot profiling, was able to separate the Pinot Noir trial wines in a more distinct and logical manner than the Shiraz trial wines. In the Pinot Noir correspondence analysis (CA), factor 1 separated the control and PF treatments from PV and PFPV on the basis of ripeness. The control and PF treatments were perceived as more red (less orange/brown) and associated with higher alcohol, complexity and red fruit characteristics. Treatments PV and PFPV were associated with higher acidity and green attributes (Figure 2).

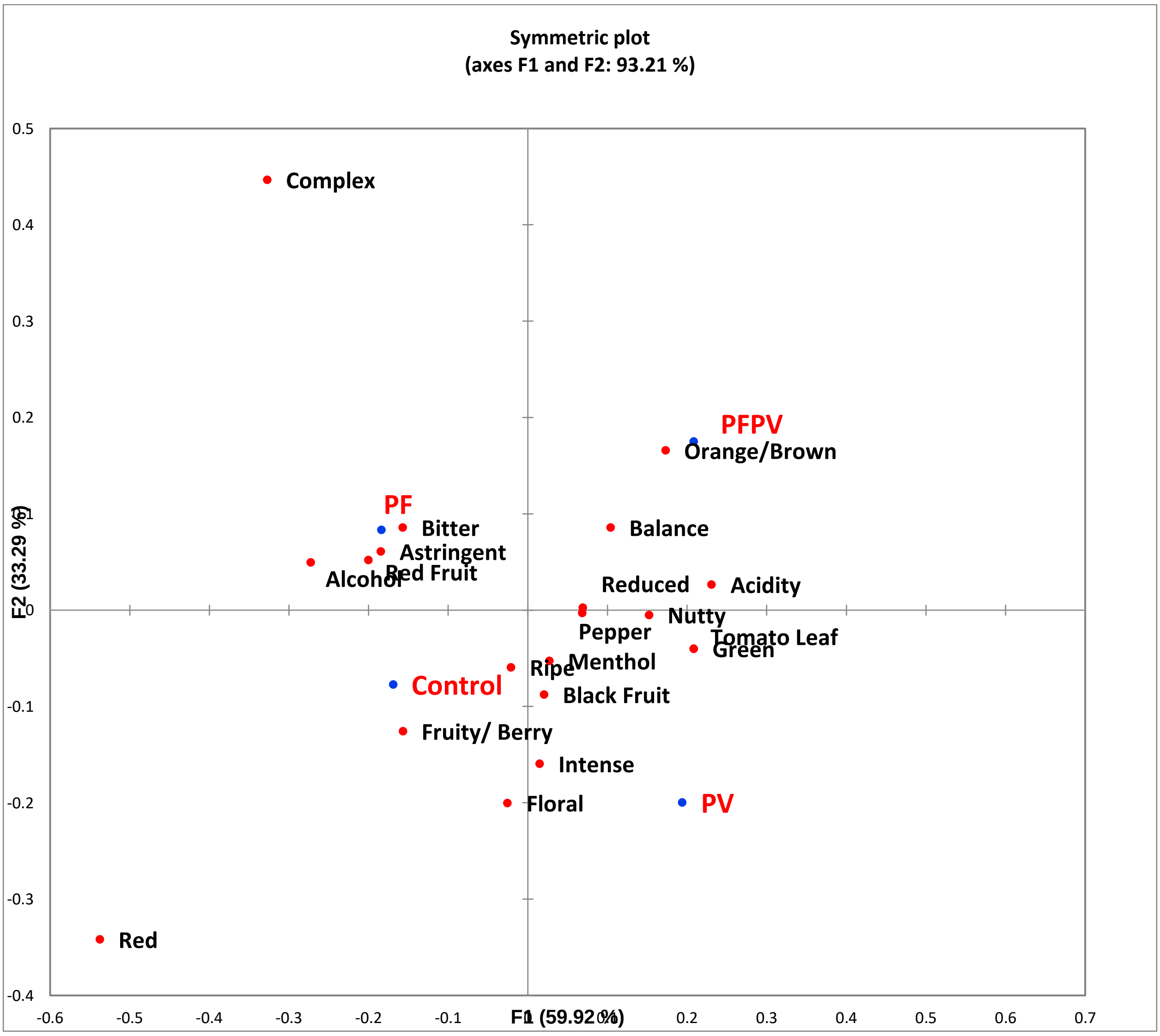

Figure 2. Pinot Noir wine pivot profile assessment, all treatment replicates combined.

Similarly, for the Shiraz correspondence analysis, control and PF treatment wines were perceived as darker with more red and dark fruit and associated with higher alcohol. Wines from the PV and PFPV treatments were characterised by less ripe attributes, with the PV treatment in particular associated with herbaceous attributes and higher acidity (Figure 3).

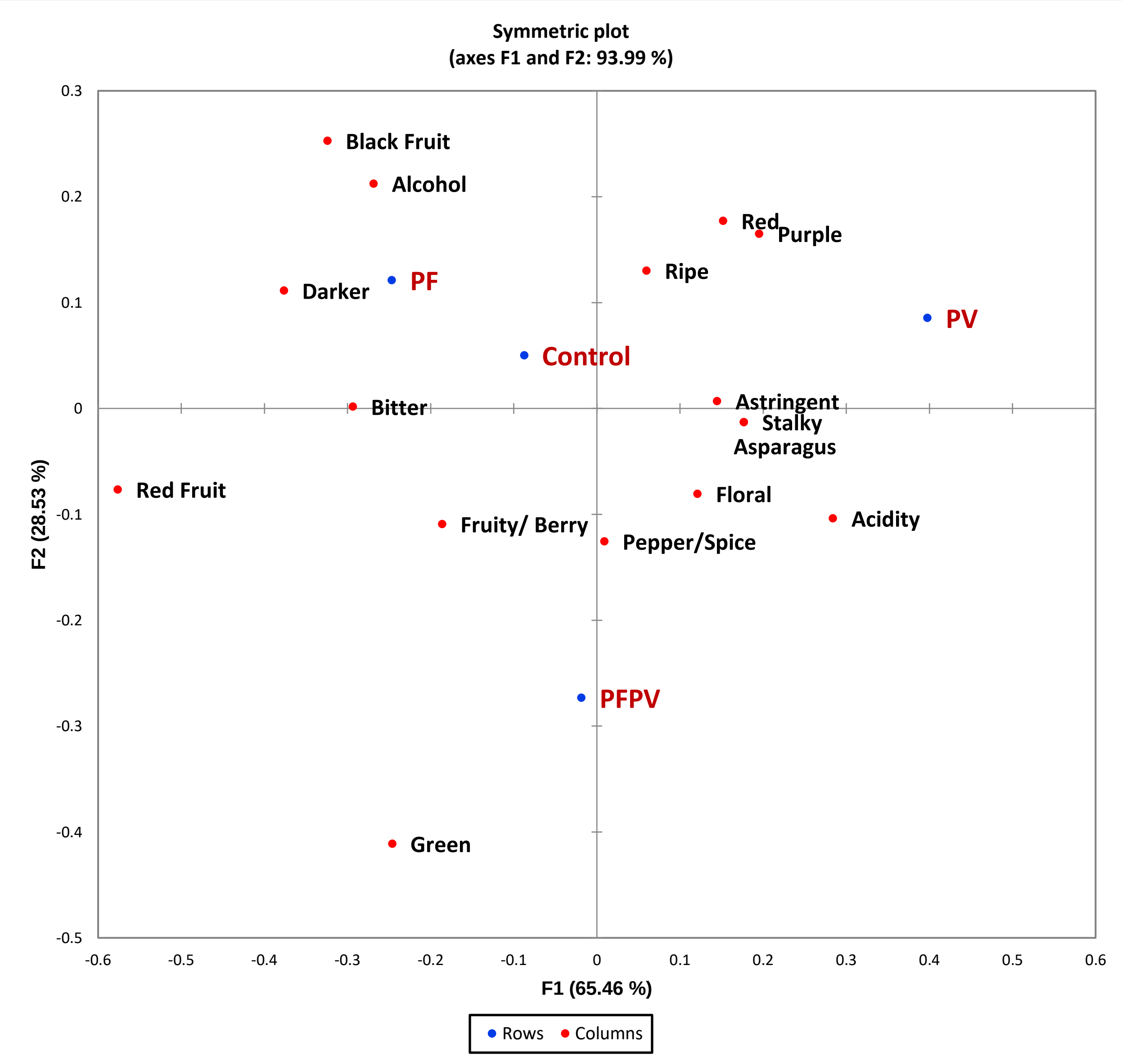

Figure 3. Shiraz wine pivot profile assessment, all treatment replicates combined.

Discussion

Results from this work suggest that application of a film-forming antitranspirant at a 1% solution rate is effective in manipulating ripening whilst maintaining grape and wine quality parameters across distinctly different climatic grape growing regions of NSW.

The most notable effect of antitranspirant application on grape yield was the increase in berry size at six of the nine sites, as compared to the control. The lower rainfall and higher temperatures that occurred during the growing season would have caused stress to the berries during cell division and expansion, subsequently affecting berry growth and final size (Keller 2010). It appears that the antitranspirant negated these effects, effectively restoring yield in the treated vines.

Berry size increase was greater 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 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 as a result of greater turgor pressure (Matthews et al. 2009, Castelarrin et al. 2016).Anecdotally, berries treated with antitranspirants demonstrated less berry shrivel compared to control in this trial. However, measurements were not taken and further research would be required to demonstrate a link between use of antitranspirants and reduced berry shrivel.

The effect of antitranspirant on grape quality was less pronounced than grape yield, with limited impact on pH and TA. Overall, many sites recorded readings of above 4.0 pH units, 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.

°Brix readings were significantly reduced in the PV and PFPV treatments, compared to the control. Similar reductions have been reported on antitranspirant-treated 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 application rate of antitranspirant.

The decrease in anthocyanin content in PV and PFPV treatments (at three sites of varying climate) is similar to results reported by Palliotti et al. (2013). 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). An alternative is that the enhanced berry size and weight observed across all sites resulted in a lower skin-to-pulp ratio and therefore lower anthocyanin content.

Wines 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. This result suggests that antitranspirants can mitigate the known effects of higher temperatures on winegrape characters, and fits well with a growing consumer trend for low-alcohol products (Saliba et al. 2013). The lower alcohol percentage was also perceived in the pivot profile assessment of both wines. Both 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 the wines were made with underripe fruit, rather than the low °Brix , deriving from the treatment itself. All fruit for winemaking was picked based on commercial harvest dates and not against a determined sugar level. While this trial wine outcome might be undesirable for consumers, it demonstrates the potential of antitranspirants to delay ripening in the vineyard and mitigate vintage compression (Jarvis et al. 2018). Allowing treated fruit further hang time would allow further flavour and aroma development. Moreover, it provides an alternative to adding water to high-sugar fruit in the winery (Schelezki and Jeffery 2018).

Despite the equal 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, demonstrating the spread and lack of clustering in the correspondence analysis of the Shiraz wines regardless of treatment.

All antitranspirant treatments significantly increased Shiraz wine pH and the PV and PFPV antitranspirant treatments reduced TA in Pinot Noir, suggesting that antitranspirants were not able to alleviate reduced acidity in a warmer climate. However, all results are well within winery specifications for both parameters (Krstic et al. 2003).

The antitranspirant applied pre flowering (PF treatment) on grape ripening was less effective than the single application at pre veraison (PV treatment). On reflection, it might be more effective if the antitranspirant is applied when the grapes are at peppercorn or pea size to limit stress and maintain berry turgidity and perhaps still elicit reduced sugar levels.

Conclusions

Faster ripening, higher °Brix grapes and higher alcohol content in wine, together with vintage compression, are known consequences of a warming climate. This project achieved its aim of evaluating a film-forming antitranspirant for its ability to manipulate winegrape production in two red wine cultivars across different viticultural climatic zones of NSW, Australia.

As compared with untreated control vines, applying the antitranspirant at various times in the 2017-18 growing season resulted in:

- increased grape yield at seven of the nine sites
- reduced °Brix (delayed ripening) at four of the nine sites
- limited impact on TA and pH of grapes and wine
- reduced anthocyanins at only three of the nine sites, with significant differences between varieties
- lower alcohol wines from both varieties across different climatic locations

Taken together, these results agree with previous studies which suggest that antitranspirants can mitigate the effects of higher temperatures on winegrape production and offer a viable, simple tool for growers to mitigate vintage compression in the vineyard.

Recommendations

Although results from this project have demonstrated that antitranspirants can manipulate winegrape production, only one season of data was collected and further research is required to assess the full potential of its use. The following are recommended as priority areas for future work:

- field studies to determine the efficacy of antitranspirants on white grape varieties
- field studies to investigate the use of antitranspirants to reduce applied irrigation in winegrape production
- evaluation of other natural and synthetic biopolymers to compare their effectiveness to di-1-p-menthene
- evaluation of application timings such as EL 29 and young berries at peppercorn size, instead of pre flowering
- conduct field trial winemaking using grapes harvested at a determined sugar level
- evaluation of targeted leaf and canopy applications only versus bunch-only applications.

Acknowledgements

- Funding was provided by Wine Australia and NSW DPI Skills Development Program.
- Ted Cox, Brian Freeman, Ken Bray, Kristy Bartrop, Jeremy Cass, Cathy Gairn, John Collingwood and Justin Jarrett for providing trial sites.
- Casella Family Brands and Courabyra Wines for providing winegrapes for experimental wines.
- Dr Suzy Rogiers, Adrian Englefield, Dr Aude Gourieroux, Campbell Meeks, Dr John Blackman, and Oscar Malek (NWGIC) for assistance throughout the trial.

Appendix 1: Communications

The results of this project have been presented to industry and scientific communities through discussions and seminars with industry personnel, presentations to industry meetings, workshops and scientific conferences, articles in industry journals and refereed publications in scientific journals. Specifically as follows:

1. Presentations at meetings, workshops, seminars and media
   - Crush 2017 The grape and wine symposium, Adelaide South Australia
   - Crush 2018 The grape and wine symposium, Adelaide South Australia
   - NSW DPI Spring Vine Health Field Day workshops August–September 2018 Canberra, Griffith, Hunter Valley, Mudgee, Orange and Tumbarumba.

- Washington State University, Richland on 4 September 2018. Efficacy of the antitranspirant Vapor Gard under controlled and field conditions.
- The Second World Beverage Conference in Xi'an, China on 25 October 2018. Addressing climate change in the vineyard.
- Could the use of antiranspirants be a hot tip in mitigating the effects of heatwaves? Daily Wine News, 4 December 2018, https://winetitles.com.au/could-the-use-of-antitranspirants-be-a-hot-tip-in-mitigating-the-effects-of-heatwaves/

2. Publications
    - Fahey, D. and Rogiers, S. (2018) Di-1-p-menthene reduces grape leaf and bunch transpiration. Australian Journal of Grape and Wine Research doi: 10.1111/ajgw.12371.
    - Bowman. S (2018). Could the use of antiranspirants be a hot tip in mitigating the effects of heatwaves? Australian & New Zealand Grapegrower & Winemaker, November 2018, Winetitles **658**, 18–20.

Appendix 2: Intellectual property

The IP arising as technical knowledge from the research has been disclosed in the form of communications and publications.

Appendix 3: References

Brillante, L., Belifore, N., Gaiotti, F., Lovat, L., Sansone, L., Poni, S. and Tomasi, D. (2016) Comparing Kaolin and Pinolene to improve sustainable grapevine production during drought. *PLOS One* **11** (6), 1–19.

Bucchetti, B., Matthews, M.A., Falginella, L., Peterlunger, E. and Casterllarin, S.D. (2011) Effect of water deficit on Merlot grape tannins and anthocyanins across four seasons. *Scientia Horticulturae* **128**, 297–305.

Castellarin, S.D., Gambetta, G.A., Wada, H., Krasnow, M.N., Cramer, G.R., Peterlunger, E., Shackel, K.A. and Matthews, M.A. (2016) Characterization of major ripening events during softening in grape: turgor, sugar accumulation, abscisic acid metabolism, colour development, and their relationship with growth. *Journal of Experimental Botany* **67**, 709–722.

Escudier, J.L., Bes, M., Salmon, J.M., Caillé, S. and Samson, A. (2014) Adaptation of enological practices towards long term hydric stress of vineyards. *Innovations Agronomiques* **38**, 67–86.

Fahey, D. and Rogiers, S. (2018) Di-1-*p*-menthene reduces grape leaf and bunch transpiration. *Australian Journal of Grape and Wine Research* doi: 10.1111/ajgw.12371.

Gatti, M., Galbignani, M., Garavani, A., Bernizzoni, F., Tombesi, S., Palliotti, A. and Poni, S. (2016) Manipulation of ripening via antitranspirants in cv. Barbera (*Vitis Vinifera* L.). *Australian Journal of Grape and Wine Research* **22**, 245–255.

Godden, P., Wilkes, E. and Johnson, D. (2015) Trends in the composition of Australian wine 1984–2014. *Australian Journal of Grape and Wine Research* **21**,741–753.

Iland, P., Bruer, N., Edwards, G., Weeks, S. and Wilkes, E. (2004) Chemical analysis of grapes and wine: techniques and concepts. *Partick Iland Wine Promotions*. Campbelltown

Intrieri, C., Allegro, G., Valentini, G., Pastore, C., Colucci, E. and Filippetti, I. (2013) Effect of pre-bloom antitranspirant treatments and leaf removal on 'Sangiovese' (*Vitis vinifera* L.) winegrapes. *Vitis* **52** (3), 117–124.

Isbell, R. (2002) The Australian soil classification. CSIRO, Collingwood, Victoria, Australia.

Jarvis, C., Darbyshire, R., Goodwin, I., Barlow E.W.R., and Eckard, R. (2018) Advancement of winegrape maturity continuing for winegrowing regions in Australia with variable evidence of compression of the harvest period. *Australian Journal of Grape and Wine Research* doi: 10.1111/ajgw.12373.

Keller, M. (2010) Managing grapevines to optimize fruit development in a challenging environment: a climate change primer for viticulturists. *Australian Journal of Grape and Wine Research* **16**, 56–69.

Krstic, M., Moulds, G., Panagiotopoulos, B. and West, S. (2003) Growing quality grapes to winery specifications – quality measurement and management options for growers. *Winetitles*, Adelaide.

Matthews, M.A., Thomas, T.R. and Shackel, K.A. (2009) Fruit ripening in *Vitis vinifera* L.: possible relation of veraison to turgor and berry softening. *Australian Journal of Grape and Wine Research* **15**, 278–283.

McCarthy, M.G. (1997) The effect of transient water deficit on berry development of cv. Shiraz (*Vitis vinifera* L.). *Australian Journal of Grape and Wine Research* **3**, 2–8.

McCarthy, M.G. (1999) Weight loss from ripening berries of Shiraz grapevines (*Vitis vinifera* L. cv. Shiraz). *Australian Journal of Grape and Wine Research* **5**, 1–16.

Palliotti, A., Poni, S., Berrios, J.G. and Bernizzoni, F. (2010) Vine performance and grape composition as affected by early-season source limitation induced with antitranspirants in two red *Vitis vinifera* L. cultivars. *Australian Journal of Grape and Wine Research* **16**, 426–433.

Palliotti, A., Panara, F., Famiani, F., Sabatinini, P., Howell, G.S., Silvestroni, O. and Poni, S. (2013) Post-veraison application of antitranspirant Di-1-*p*-menthene to control sugar accumulation in Sangiovese grapevines. *American Journal of Enology and Viticulture* **64**, 378–385.

Poni, S., Intrieri, C., Rebucci, B., Magnanini, E. and Filippetti, I. (2001) A custom-built simple system for conditioning and measurement of *in situ* whole-cluster transpiration. *Vitis* **40**, 55–58.

Sadras, V.O., M Moran, M.A. and Petrie P.R. (2013) Effects of elevated temperature in grapevine. II juice pH, titratable acidity and wine sensory attributes. *Australian Journal of Grape and Wine Research* **19**, 107–115.

Saliba, A.J., Ovington, L.A. and Moran, C.C. (2013) Consumer demand for low-alcohol wine in an Australian sample. *International Journal of Wine Research* **5**, 1–8.

Schelezki, O. and Jeffery, D. (2018) Water into wine: Pre-fermentation strategies for producing lower alcohol wines. *Technical note no. 7* – ARC Training Centre for Innovative Wine Production School of Agriculture, Food & Wine.

Spayd, S.E., Tarara, J.M., Mee, D.L. and Ferguson, J.C. (2002) Separation of sunlight and temperature effects on the composition of *Vitis vinifera* cv. Merlot berries. *American Journal of Enology and Viticulture* **53**, 171–182.

Appendix 4: Budget

Expenses	**Provider**	**Cost**
Grape Sample analysis	NWGIC	10,000.00
Experimental winemaking	NWGIC	19,200.00
Travel	NSW DPI	15,000.00
Labour	NSW DPI	15,000.00
Trial inputs	NSW DPI	5,000.00
Total		64,200.00

Wine Australia funding totalled $20,000.00 – DPI 1702.

NSW DPI contributed $44,200.00 toward undertaking this project.