A centre of excellence in cool temperate agricultural research

TIAR

Australian Government

Grape and Wine Research and Development Corporation

TIAR is joint venture between the University of Tasmania,
Department of Primary Industries, Water and Environment, Tasmania, and industry

Temperature-based management of powdery mildew in Tasmania



FINAL REPORT to

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Project Number: **RITA 04/04-1**

Project Leader: **Katherine J. Evans PhD**

Research Organisation:
Tasmanian Institute of Agricultural Research, University of Tasmania, in collaboration with the Vineyards Association of Tasmania

Date: **September, 2005**

Temperature-based management of powdery mildew in Tasmania

AUTHORS

Katherine J. Evans and Steffi Dix,
Tasmanian Institute of Agricultural Research
University of Tasmania
13 St Johns Avenue
New Town
Tasmania 7008
Australia

Tony Scherer
Frogmore Creek Vineyard
PO Box 187
Richmond TAS 7025

Acknowledgements

This project was supported by Australia's grape growers and wine makers through their investment body the Grape and Wine Research and Development Corporation, with matching funds from the Australian Government. We thank Adrian Hallam (Meadowbank Wines), Matthew Pooley (Pooley Wines), Danny Belbin (Roslyn vineyard) and staff of Frogmore Creek Vineyard for their cooperation, and members of the technical committee of the Vineyards Association of Tasmania for reviewing this report, including Simon Stanley, Fred Peacock and Mark Brewer. Thanks also to Duncan Farquhar, Department of Primary Industries, Water and Environment, Tasmania, for facilitating communication and Bob Emmett (DPI, Victoria), Trevor Wicks and Peter Magarey (PIRSA) for advice during the planning phase of the project. Special thanks to W.D. Gubler (UC Davis) and C.S. Thomas (FieldWise Inc., California) for inspiring us to undertake this project.

Disclaimer: This publication may be of assistance to you but the authors, their employees and the Grape and Wine Research and Development Corporation do not guarantee that the publication is without flaw of any kind or is wholly appropriate for your particular purposes and therefore disclaim all liability for any error, loss or other consequence which may arise from you relying on any information in this publication.

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Temperature-based management of powdery mildew in Tasmania

Table of Contents

	Page
Executive Summary	4
Background	5
Aims	6
General methods of technical component	7
Results/Discussion	12
Frogmore Creek	15
Meadowbank	27
Cooinda Vale	33
Roslyn	40
Conclusions	46
Communication	47
Appendix A MEA versus Avatel datalogger	48
Appendix B Active constituents of fungicides	49
Appendix C Budget reconciliation	49

GRAPE AND WINE RESEARCH & DEVELOPMENT CORPORATION

Temperature-based management of powdery mildew in Tasmania

Executive summary

As in all viticultural regions in Australia, grape growers in Tasmania apply fungicides repeatedly to protect vines from powdery mildew caused by *Erysiphe necator* (syn. *Uncinula necator*). Tasmania has never had a mildew management strategy developed specifically for local conditions. Growers have tried to modify recommendations applied elsewhere but poor spray timing and coverage still lead to control failures in some vineyards each growing season. The aim of this project was to monitor weather and disease development in four vineyards located in the Coal River Valley of southern Tasmania. The UC Davis powdery mildew risk index, also known as the Gubler-Thomas (GT) index, is a temperature-based indicator of when conditions are favourable for rapid development of powdery mildew. This risk index was used as a guide for timing sprays at each vineyard before and after the flowering-fruit set period, based on materials currently applied by each grower cooperator. Berries are highly susceptible to infection by *E. necator* during flowering and fruit set and spray intervals were generally kept to the minimum recommended on the label at this time.

In 2004/05, conditions in the Coal River Valley were highly favourable for development of powdery mildew. Flag shoots were detected at one site in late October (E-L crop stage 13-15) and powdery mildew was first detected on the underside of leaves from mid December, following an increase in the frequency of days from mid November when the maximum temperature exceeded 21^{o}C. Mean disease incidence and severity on Chardonnay bunches prior to veraison in untreated plots at Frogmore Creek vineyard was 100% and 60%, respectively. Results of this project indicate that, in the absence of flag shoots, it may not be necessary to apply the first application of a powdery mildew fungicide before E-L crop stage 13, possibly later, in the Coal River Valley.

Using Avatel dataloggers, the cumulative GT index reached the threshold value of 60 between December 6 and 11, 2004, at three vineyards that had similar values for heat summation. Powdery mildew was first detected in untreated panels 18 days after the critical threshold at Meadowbank and Cooinda Vale, and 37 days later at Roslyn vineyard. The threshold index for the fourth vineyard (Frogmore Creek) was not recorded until January 27, 2005, well after disease was first detected on December 15, 2005. Unlike the other vineyards, Frogmore Creek was a cooler site with a lower heat summation, based on temperature data obtained from an on-site MEA weather station. The cumulative GT index does not appear to predict disease onset in all cases and more work is required to determine weather conditions and crop factors correlated to disease increase in Tasmania. However, a cumulative GT index above 60 indicates that the pathogen is capable of reproducing rapidly, assuming that a high risk index coincides with the availability of disease susceptible plant tissue (eg. green floral parts, rapid shoot growth).

The benefit of a temperature-based fungicide program for Tasmania appears to be elimination of fungicide applications during early-season cool weather and/or for extension of spray intervals during cool periods before and after flowering. The contribution of cleistothecia to disease epidemics and the conditions and timing of ascospore release in most Tasmanian vineyards is unknown. If this knowledge gap is filled, then options for preventing formation of cleistothecia and/or timing fungicide sprays to protect young, green tissue from ascospore infection can be developed. Further observations of weather, crop development and powdery mildew in subsequent growing seasons will allow development of a region-specific disease management strategy.

Background

Like all viticultural regions in Australia, grape growers in Tasmania apply fungicides repeatedly to protect vines from powdery mildew caused by *Erysiphe necator* (syn. *Uncinula necator*). Tasmania has never had a mildew management strategy developed specifically for local conditions. Growers have tried to modify recommendations applied elsewhere, for example, the 2, 4, 6 rule applied in the Riverland is sometimes extended to 3, 6, 9 (weeks after budburst) in Tasmania to account for slow rates of shoot development. In addition, high rates of sulfur, commonly 800 to 1,200 g/100 L, are applied to compensate for cool temperatures that can occur at any time. Despite these modifications, poor spray timing and coverage still lead to control failures.

In 2003/2004, Dr Kathy Evans of the University of Tasmania monitored disease progress in untreated control plots at two sites in southern Tasmania. The first appearance of noticeable mildew correlated well with the time of year when the UC Davis powdery mildew index, described below, reached the 'high' category for the first time. A potentially more informative finding was that the powdery mildew index did not register above zero until mid November, which was at least a month later than the time at which many growers began protecting vines from powdery mildew. Using this preliminary data, there appears to be scope to eliminate early season sprays, especially until daily maximum temperatures exceed 20^{o}C. Once the mildew epidemic commences, there may be scope to extend spray intervals during times when the powdery mildew index indicates 'low' disease pressure.

The benefit of a temperature-based fungicide program would be the elimination of sprays during early-season cool weather and/or to extend spray intervals during cool periods mid season. A flow-on benefit might be that the rate of sulfur is lowered if used only during warmer weather. As sulfur also has a negative impact on beneficial predators, reducing the amount used in the vineyard is an additional benefit. Overall, reduced fungicide input and effective disease management will reduce losses in yield and quality while improving the sustainability of Tasmanian viticulture. Socially, this will contribute to the viability of the many small vineyards that contribute to wine-tourism.

The UC Davis powdery mildew index

The UC Davis powdery mildew index was developed by W.D. Gubler and colleagues at the University of California, Davis, and C.S. Thomas of Western Farm Service, California. Gubler *et al.* (1999) described the index and its application.

Reference

Gubler WD, Rademacher MR, Vasquez SJ, Thomas CS. 1999. Control of powdery mildew using the UC Davis powdery mildew risk index [online]. APSnet Feature, The American Phytopathological Society. Available from http://www.apsnet.org/online/feature/pmildew/Top.html

Aims

A. Technical component

The objective was to evaluate a method for timing sprays for powdery mildew that coincided with the development of the disease epidemic in Tasmanian vineyards. Within this broad aim, the specific objectives were to

- determine if the first spray of the season can be delayed until EL crop stage 13[a], when daily temperatures rarely exceed 20^{o}C for more than 6 hours
- apply the UC Davis mildew index for determining the length of the spray interval before and after the critical flowering-fruit set period, when developing berries are highly susceptible to infection, and
- evaluate the level of disease control achieved using a spray program guided by the UC Davis index in comparison with a standard 'grower' spray program.

[a]Coombe BG. 1995. Adoption of a system for identifying grapevine growth stages. *Australian Journal of Grape and Wine Research* **1**, 100-110.

B. Communication

Our aim was to communicate project outcomes at a field day organised by the Vineyards Association of Tasmania (VAT) and through the local rural press and State Department (DPIWE) web site. The technical committee of the Vineyards Association of Tasmania was the local technical reference group, and individual growers involved in the project were involved in communicating outcomes informally at meetings of Coal River Valley growers.

General methods of technical component

Site selection, trial design and collection of weather data

Four vineyards were selected in the Coal River Valley of southern Tasmania (Figure 1). Figure 2 illustrates heat summation above a base temperature of 10^{o}C for each vineyard. Details of each vineyard block, trial layout and results are presented separately in the next section. Frogmore Creek vineyard is managed organically. In short, each cooperator applied powdery mildew fungicides in trials involving comparison of their current spray schedule ('grower' schedule) with a spray schedule based on application of the UC Davis temperature-based decision rule ('model' schedule). Up to two end-of-row panels in each of two rows were left untreated in order to detect when *Erysiphe necator* was active and reproducing.

At all vineyards except Frogmore Creek, weather data were collected by an FS-TH 'field station' datalogger (Avatel Inc., Fort Bragg, California). Each datalogger was placed at fruit-zone height and mounted on a wooden or steel pole that formed part of the grapevine trellis. At Frogmore Creek, weather data were collected from an MEA weather station located at the south-eastern corner of the vineyard block. On one occasion we compared data output from the MEA weather station with one of the Avatel dataloggers used at Cooinda Vale. In general, the temperatures recorded by the Avatel logger appeared to be less than the temperatures logged by the MEA station (refer to Appendix A). Weather data were collected and compiled by the project officer, S. Dix, and decisions on spray timing made by consultation between S. Dix, K. Evans and the relevant vineyard employee. Crop stages were recorded according to the modified E-L system (Coombe 1995). Fungicides and active ingredients are listed in Appendix B.

Pages 10 and 11 outline the decision rules that were used as a guide for making decisions about spray timing. The decision rule was written by K. Evans to address the need for adapting the UC Davis mildew index to local conditions. The decision rule had not been tested empirically prior to this project and sometimes decisions were made outside the framework of the decision rule. In practice, the grower cooperator was given the final decision as to when the spray was actually applied, given prevailing weather conditions and/or the need to combine the spray with other management tasks. The spray date was conveyed to the project officer as soon as possible. According to current recommendations for best practice management (Dr Trevor Wicks, SARDI, personal communication), the 'grower' and 'model' schedules were identical during the flowering-fruit set period, when spray intervals were reduced and the most effective powdery mildew fungicides applied to ensure adequate bunch protection.

Disease assessment

The entire trial area was inspected for symptoms and signs of disease caused by *Erysiphe necator* at fortnightly intervals until early December and then at weekly intervals thereafter until veraison. A final disease assessment was made pre-harvest in the sprayed area of each trial site. Disease was assessed in untreated panels at weekly intervals from the date disease was first detected. Disease was assessed on leaves and bunches in rows marked for disease assessment among the 'grower' and 'model' sprayed rows as dictated by the development of the disease. Only active powdery mildew colonies (white-grey surface growth) were scored, as opposed to scarring that results from infection by *E. necator*.

Unless indicated otherwise, disease incidence and severity was assessed on 40 leaves per panel or 'replicate' of vines (20 leaves on either side of the panel) and on 20 bunches per panel or 'replicate' of vines (10 bunches on either side of the panel). Ten panels were assessed per 'grower' or 'model' spray schedule and four panels were assessed in the untreated area.

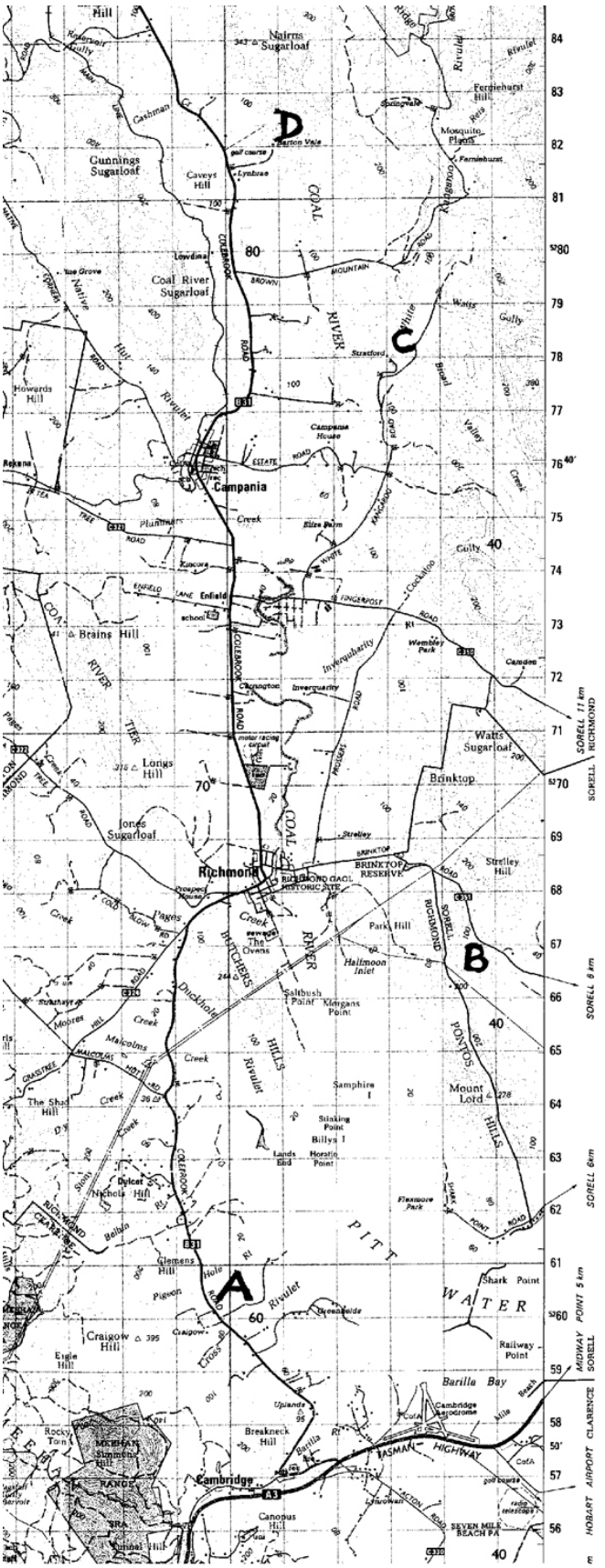


Figure 1 Locations of vineyards in the Coal River Valley, southern Tasmania, extending from Cambridge to north of Campania: (A) Meadowbank, (B) Frogmore Creek, (C) Roslyn and (D) Coodinda Vale. Map reproduced from a section of Derwent 8312, Tasmania, 1:100,000 Land Tenure Index Series, Edition 1, 1985, Tasmap, Lands Department, Hobart.

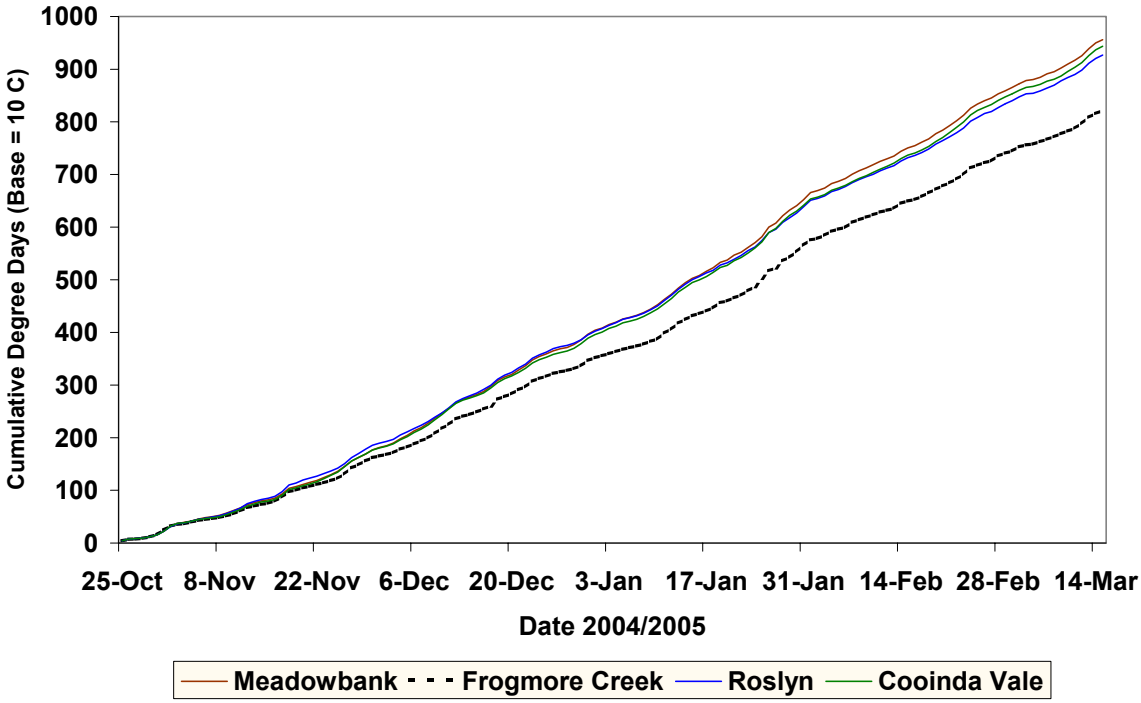


Figure 2 Cumulative degree days above a base temperature of 10°C for each vineyard between October 25, 2004 and March 14, 2005. Frogmore Creek vineyard appears to be a cooler site when compared with the other three vineyards.

Decision Rule

The following decision rule was used as a guide for timing spray intervals. The decision rule had not been tested previously and it applies strictly to this project. Therefore, the decision rule should not be extended beyond the context of this work. The grower cooperator was given the final decision as to when the spray was actually applied

1. Timing the first spray of the growing season.

Sulfur is applied at bud burst if needed for mite control. Begin monitoring for flagshoots or powdery mildew colonies every 2 weeks, until 4 weeks post bud burst, then monitor every week until the first spray is applied.

Did you observe flag shoots or mildew colonies BEFORE E-L stage 13 OR
Has the daily cumulative mildew index risen above zero BEFORE E-L stage 13?

If YES to either of these questions	**NO**
Spray within 7 days of detection or positive record.	Apply first spray as close to E-L stage 13 as possible.

2. Timing of subsequent sprays between the first spray and immediately pre-flowering

A.

At 7 days since last spray or decision, has the cumulative mildew index exceeded zero on any day?

YES		**NO**	
Has the cumulative mildew index exceeded[1] 50 on any day?		At 14 days[2] since last spray, has the cumulative mildew index exceeded zero on any day?	
YES	**NO**	**YES**	**NO**
Apply the next spray as soon as possible for sulfur, or 10 days since the last spray for other materials	Go to **B** below	Apply the next spray as soon as possible	Apply the next spray on or before 21 days since the last spray

[1] That is, the index is between 60 and 100.

[2] If very warm days are predicted between 7 and 11 days since the last spray, then the cumulative mildew index could be checked again at 10 or 11 days since the last spray.

B. **..continued from A.**

Has the cumulative mildew index been observed in the range 40-50?

YES	**NO**	
Apply the next spray 10-14 days since the last spray	Index in the range 10-30?	
	YES	**NO,** index is zero
	Apply the next spray 14-21 days since the last spray. Check index again at 14 days since last spray for decision on whether or not to extend interval out to 21 days.	Go back to A.

Decision Rule continued…

FROM BEGINNING of CAPFALL

3. Protection of developing berries immediately pre-flowering to early fruit set when berries average 3-4 mm (range might be 2-7 mm or 1-6 mm)

As soon as the beginning of capfall is observed, apply the next spray within 7 days of the last time a decision was made or 7-10 days since the last spray. Begin applying sprays at minimum intervals, regardless of weather, until berries average 3-4 mm. If the weather is warm, the aim is to apply one spray before flowering, two sprays during flowering (your best materials), and one spray during early fruit set.

The weather-based decision rule is not applied during this period because it is known that clusters during flowering and fruit set are highly susceptible to infection by *E. necator*. Recent studies indicate that individual berries become increasingly resistant to infection by *E. necator* from 10 days after fruit set (Ficke *et al.* 2003). This means that under Tasmanian conditions, berries are likely to be highly resistant to new infection by the time they are pea size.

Reference

Ficke A, Gadoury DM, Seem RC, Dry IB (2003) Effects of ontogenic resistance upon establishment and growth of *Uncinula necator* on grape berries. *Phytopathology* **93**, 556-563.

POST FRUIT SET

4. Post fruit-set to veraison including leaf protection for young vines and/or during long ripening periods

Resume the weather-based decision rule as per instructions in item 2.

SPRAY INTERVALS

Spray intervals selected for application of the UC-Davis mildew index:

Mildew Index	**Guideline on spray interval**
0	apply longest spray interval, which is 21 days
10-30	spray interval will be in the range of 14-21 days
40-50	spray interval will be in the range 10-14 days
60-100	shortest spray interval of 10 days will apply for all materials, except sulfur, which can be reduced to a 7-day interval during the critical flowering-fruit set period.

RESULTS/DISCUSSION

Development of powdery mildew in 2004/05

In addition to disease assessments made for each vineyard (see reports in next section), Figures 3 and 4 illustrate the development of powdery mildew in six panels of Chardonnay at Frogmore Creek vineyard. These data are included in this report to illustrate a likely 'worst case' scenario for development of powdery mildew in the Coal River Valley in 2004/05. The six panels of Chardonnay were selected at random across 12 vineyard rows, and comprised untreated control plots for a 'randomised block' trial to evaluate alternatives to sulfur for control of powdery mildew organically (GWRDC project UA03/03). No flag shoots were detected in the trial area, although they were detected in other blocks of the vineyard between October 22-25, 2004, and again on November 10, 2004. Powdery mildew was not detected anywhere in the UA03/03 trial area until the first incidence of disease was recorded on the underside of leaves (abaxial surface) on December 2, 2004, at the beginning of cap fall. Powdery mildew on bunches was first detected on December 30, 2004, albeit on one bunch only in one untreated control plot. Incidence of disease on bunches then increased rapidly to almost 100% by January 10, 2005. Figure 4 illustrates disease progress and the increase of disease severity on bunches to a maximum of 58% by February 10, 2005. At this time, powdery mildew was evident on the upper surface (adaxial surface) of leaves. It is worth noting that disease severity on bunches continued to increase after sulphur (@ 8g/L) was applied to control plots on January 17, 2005, when berries were (on average) pea size. Therefore, it was unlikely that there were a significant number of new berry infections after January 17. Disease expression was more likely the result of expansion of mildew colonies from pre-existing infections.

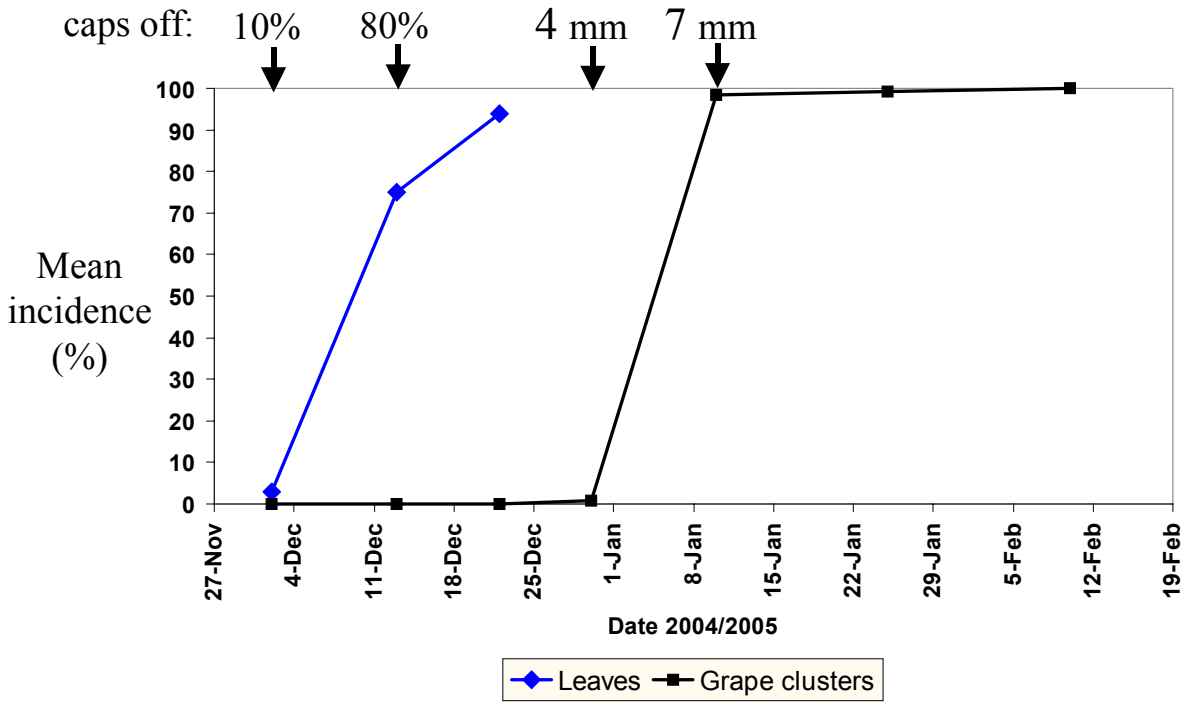


Figure 3 Mean incidence of powdery mildew (%) on Chardonnay leaves and bunches between December 2, 2004 (EL 19-20, cap fall commences) and February 10, 2005 (EL 33-34, pre-veraison) at Frogmore Creek vineyard. Disease incidence is the percentage of leaves or clusters that exhibit symptoms of powdery mildew.

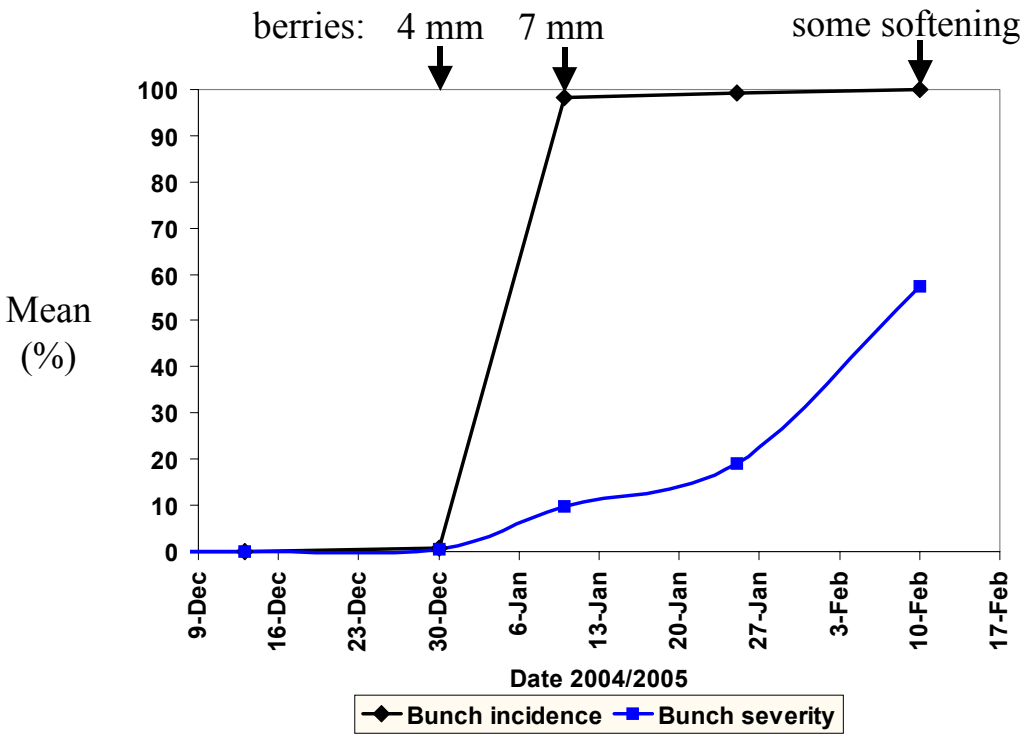


Figure 4 Mean incidence and severity of powdery mildew (%) on Chardonnay bunches between December 2, 2004 (EL 19-20, cap fall commences) and February 10, 2005 (EL 33-34, pre-veraison) at Frogmore Creek vineyard. Disease incidence is the percentage of leaves or clusters that exhibit symptoms of powdery mildew. Disease severity is the area of leaves or clusters covered in colonies of powdery mildew.

Figure 5 illustrates the average daily temperature and relative humidity at Frogmore Creek vineyard in relation to the epidemic of powdery mildew presented in Figures 3 and 4.

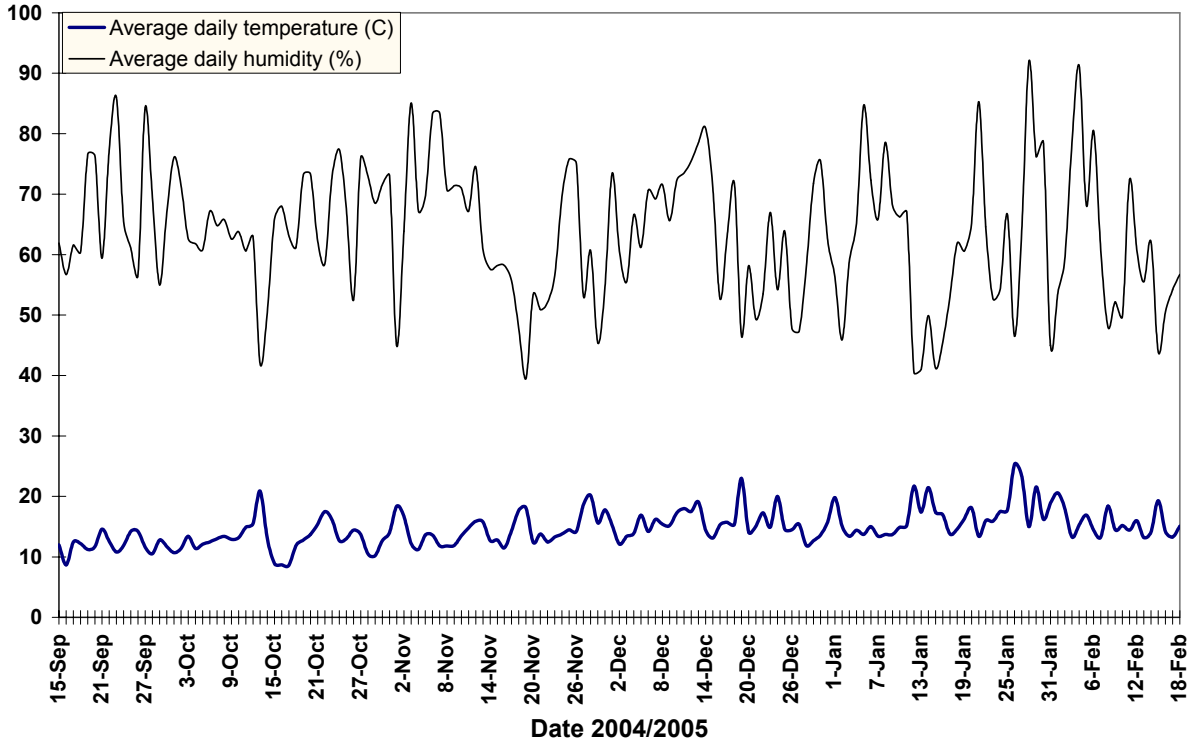


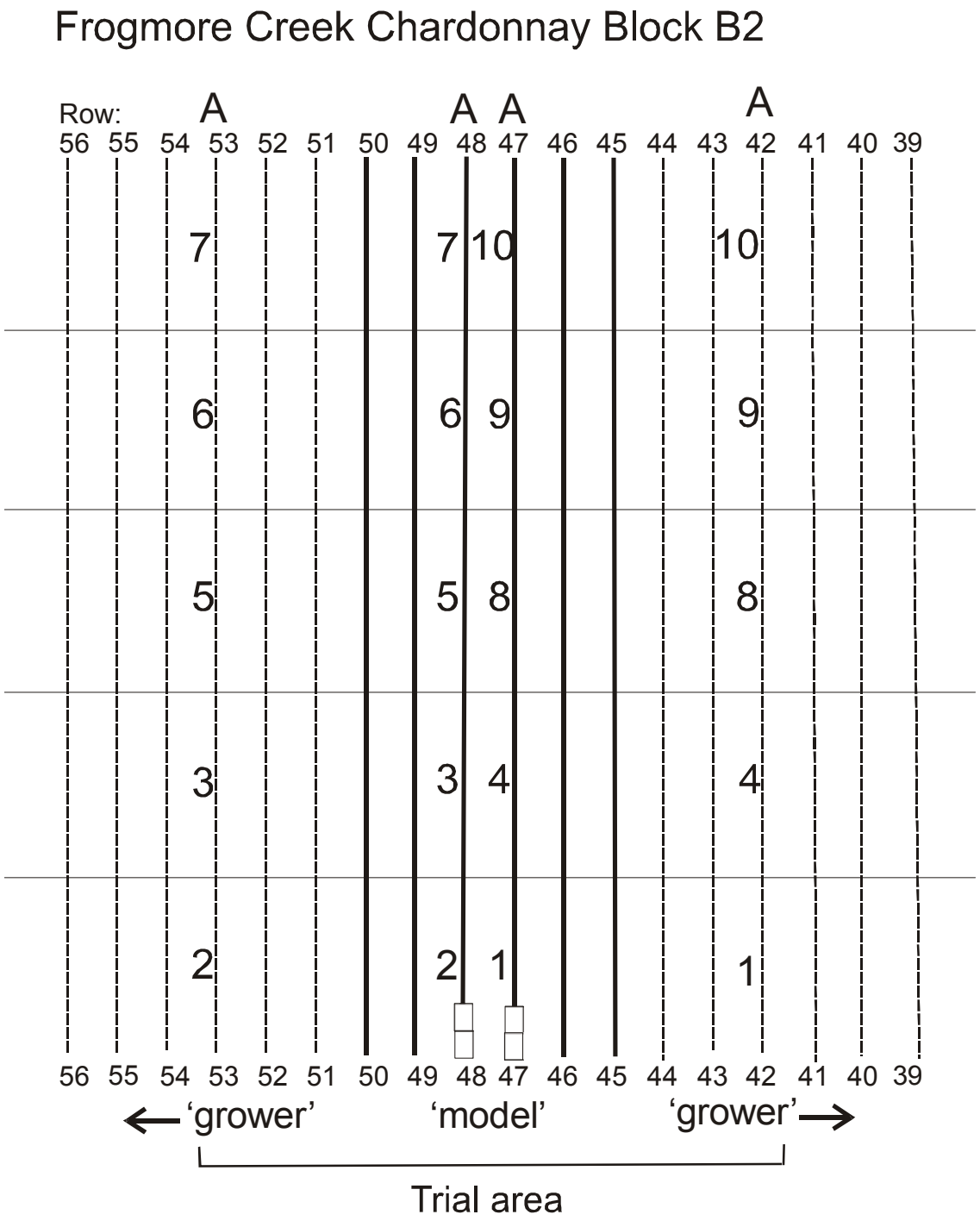
Figure 5 Average daily temperature (^{o}C, solid line) and humidity (%) at Frogmore Creek vineyard, 2004/2005.

TRIAL LAYOUT, RESULTS AND DISCUSSION FOR EACH VINEYARD

1. FROGMORE CREEK VINEYARD

Cooperator:	Mr Tony Scherer and staff
Location:	Brinktop Road between Richmond and Midway Point Coal River Valley, South East Tasmania
Contact details:	mobile: 0407 192 699 fax: 6248 5855 (winery) email: morefrogs@bigpond.com postal address: Hathaway Trading Pty Ltd PO Box 187 Richmond 7025
Variety:	Chardonnay
Trellising:	Vertical Shoot Positioning with arched canes
Spacing:	1.25 m intra row, 2.5 m between rows, 3,200 vines/ha
Row orientation:	N to S
Bud burst:	EL-04 (green tip) on or before September 16, 2004. EL 05-06-07, September 21, 2004.
Canopy density:	On January 13, 2005, the leaf layer number was 1.5-2.0, the percentage interior leaves were 22-27% and the percentage interior clusters were 26-40%.
Harvest date:	May, 2005
Trial layout	See next page.

Description of trial layout:
Dashed lines represent 'grower' spray schedule, solid lines represent 'temperature-based' or 'model' schedule. Sprays timed according to the temperature-based model were applied to rows 45 to 50 inclusive. All other rows in the block were sprayed according to the 'grower' spray program. The entire trial area comprised rows 42 to 53 with A = row in which mildew was assessed because spray drift from adjacent spray schedule was minimised. Open boxes = two panels at end of each of rows 47 and 48 that were left unsprayed until January 14, 2005. Numbers represent 'replicates' for assessment purposes in a randomized block design.



Southern end of trial area

Spray schedule

Table 1 and Figure 6 outline the spray schedule in relation to crop stage and disease appearance.

Table 1. Record of 'grower' and 'model' spray schedule, crop stage and disease appearance in Chardonnay at Frogmore Creek vineyard, 2004/2005. 'Grower' and 'model' spray schedules were identical. Dates in bold text indicate days on which a powdery mildew fungicide was applied.

Date	Crop stage	Interval since last spray	Spray Vol. L/ha	Materials applied per 100 L and comments
Oct. 11	EL 10-12			
Oct 18		1st spray	250	Every second row: Ecocarb @ 400 g Synertrol Hortioil @ 250 ml Acadian @ 200 g
Oct. 25	EL 13-14			
Nov. 2	EL 15-16			
Nov. 8	EL 15-16	21 days	400	Synertrol Hortioil @ 250 ml *Bacillus thuringiensis* (BT) @ 250 g cool weather during previous week
Nov. 10		23 days	400	Every second row: Ecocarb @ 400 g Synertrol Hortioil @ 250 ml Acadian @ 200 g
Nov. 15	EL 17			
Nov. 23/24		14 days	600	Every row (from here on) Ecocarb @ 400 g Synertrol Hortioil @ 250 ml Acadian @ 200 g Close to full canopy development
Nov. 29	EL 19-20			No evidence of powdery mildew in trial area.
Dec. 4	EL 20			10% caps off
Dec. 6/7		13 days	600	Cosavet sulfur @ 800 g Synertrol Hortioil @ 250 ml Acadian @ 200g
Dec. 13	EL 25			Powdery mildew observed on underside of leaves in untreated panels, 80% caps off to cap fall complete
Dec. 16	EL 25	9 days	600	Cosavet sulfur @ 1000 g Synertrol Hortioil @ 250 ml BT @ 100g
Dec. 21	EL 27			
Dec. 29	EL 29			

Date	Crop stage	Interval since last spray	Spray Vol. L/ha	Materials applied per 100 L and comments
Dec. 30/31		15 days		Synertrol Hortioil @ 250 ml BT @ 100g
Jan. 14	EL 30		1,200	Control panels sprayed out with Cosavet sulfur @ 1,000 g Synertrol Hortioil @ 250 ml BT @ 50 g
Jan. 17/18	EL 30	33 days since last sulfur	600	Control panels and remainder of block: Cosavet sulfur @ 1000 g Synertrol Hortioil @ 250 ml BT @ 100 g
Feb. 13		27 days	600	Cosavet sulfur @ 1000 g Synertrol Hortioil @ 250 ml

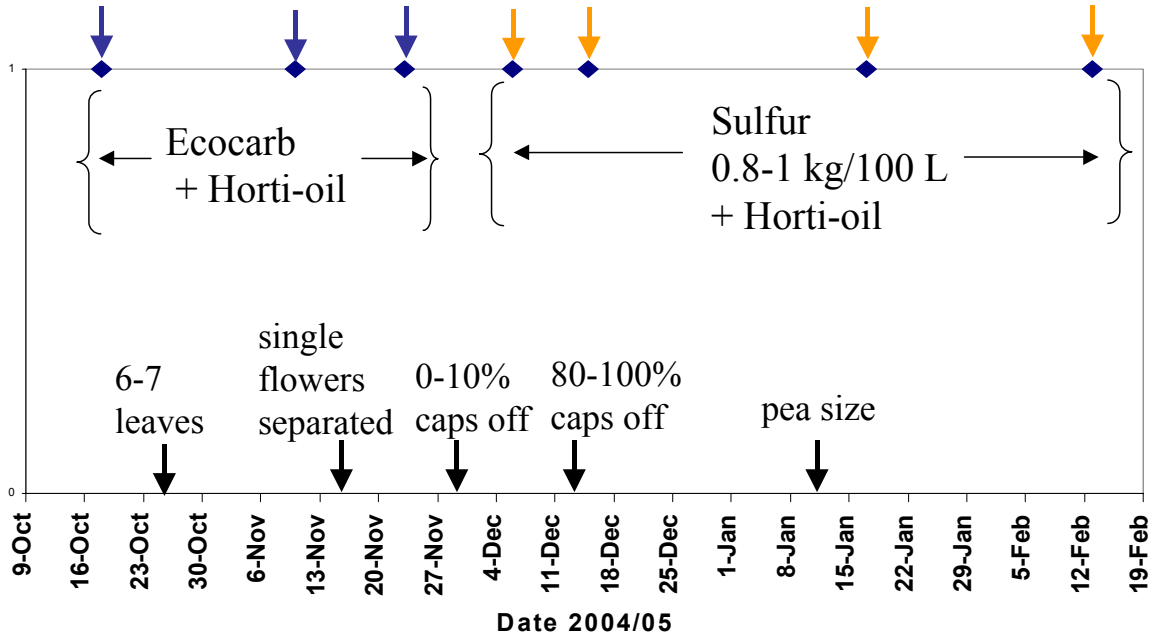


Figure 6 Summary of spray schedule for powdery mildew in relation to crop stage. Powdery mildew was first recorded on the underside of leaves on December 13, 2004.

Temperature and risk index for powdery mildew

Figures 7 and 8 illustrate the number of days where the temperature exceeded 20.5°C and translation of the number of hours greater than 20.5°C per day into the cumulative Gubler-Thomas risk index for powdery mildew.

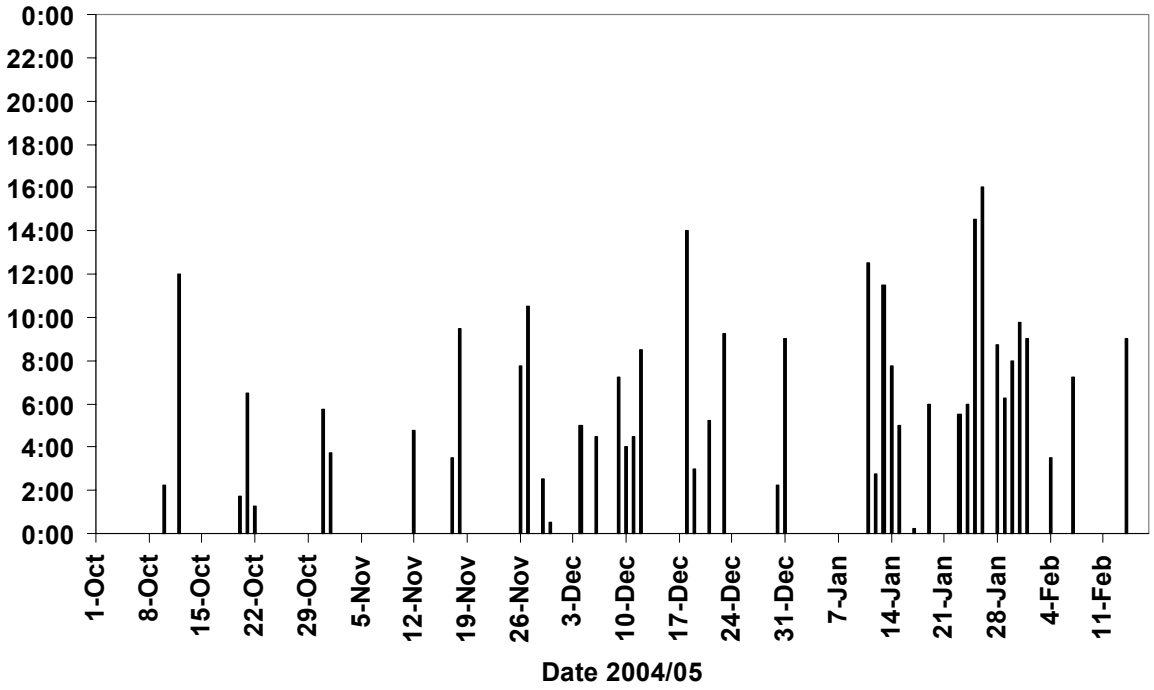


Figure 7 The number of hours greater than 20.5°C per day between October 1, 2004 and February 18, 2005 at Frogmore Creek vineyard. The temperature did not exceed 20.5°C for more than 45 minutes on any day in September, 2004.

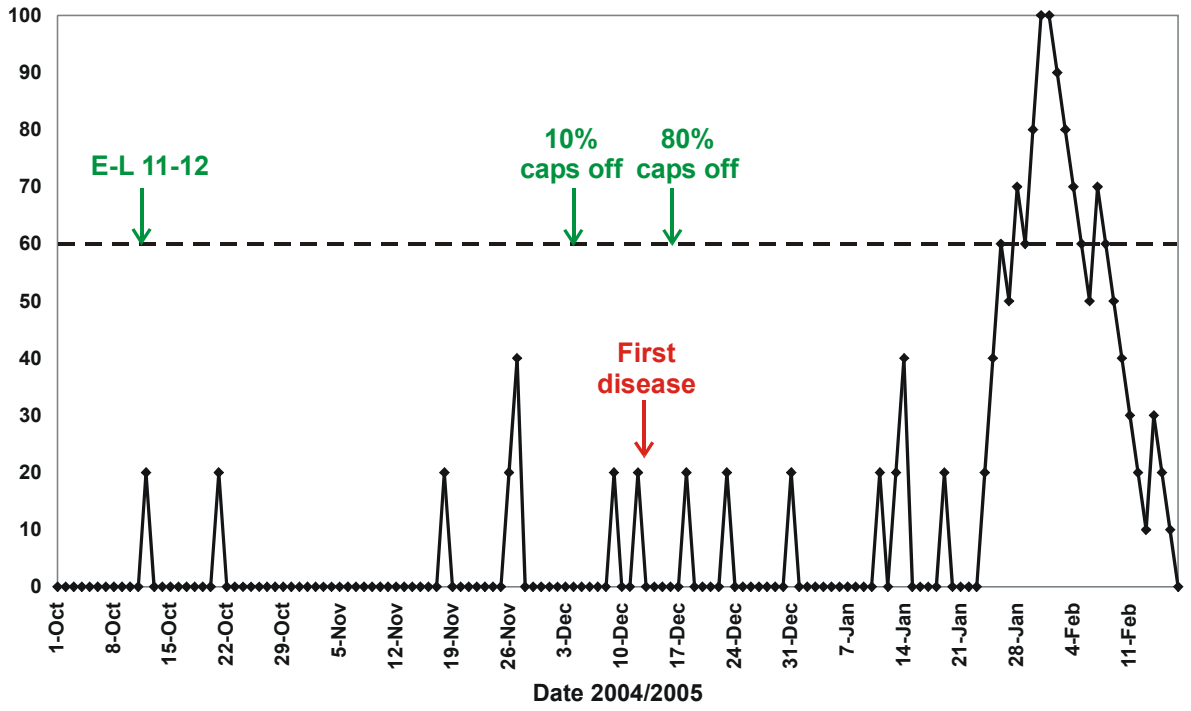


Figure 8 Gubler-Thomas risk index (cumulative) for powdery mildew at Frogmore Creek vineyard between October 1, 2004 and February 18, 2005, in relation to the appearance of powdery mildew in the trial site. The dashed line represents a cumulative risk index of 60, which Gubler and Thomas use as the threshold indicating the commencement of the powdery mildew epidemic. Disease was first detected on the underside of leaves in untreated panels on December 13, 2004. The cumulative risk index reached 60 for the first time on January 27, 2005.

Disease progression in untreated panels

The trial site was downwind and separated by three rows from a small-plot field trial that had panels of vines that developed severe powdery mildew (refer to Figures 3 and 4). Therefore, inoculum load from this adjacent trial site was high. No flag shoots were found in the trial area and disease was first recorded on the underside of leaves in the untreated panels at the end of rows 47 and 48 on December 13, 2004, during flowering. Table 2 summarises disease progression in the untreated panels and in the area of the trial that was sprayed.

Table 2 Mean incidence and severity (%) on leaves (n = 80 per panel) and clusters (n = 40 per panel) of Chardonnay in (**A**) untreated panels in rows 47 and 48, and (**B**) sprayed trial area (mean of 20 assessed panels).

A. Unsprayed[a]

Date	Crop stage	Tissue	Mean incidence (%)	Mean severity (%)
15 Dec., 2004	90-100% caps off	leaves - underside	60	0.35
21 Dec., 2004	berries setting	leaves - underside	50	0.14
30 Dec., 2004	berries 4 mm	leaves - underside	41	0.20
12 Jan., 2005	berries up to pea size	clusters	85	2.4
18 Feb., 2005	berries softening	clusters	90	3.3

[a]Untreated panels were sprayed with sulphur on Jan. 16-18, 2005.

B. Sprayed

Date	Crop stage	Tissue	Mean incidence (%)	Mean severity (%)
15 Dec., 2004	90-100% caps off	leaves - underside	19	0.04
7 Feb., 2005	berries still hard and green	clusters	32	0.25
6 April, 2005	pre-harvest	clusters	34	0.36

Disease progression in trial area

Table 3 is a series of schematic diagrams illustrating disease progression in time and space in the trial area.

Table 3 Mean incidence or severity (%) of powdery mildew on leaves (n = 40) or clusters (n = 20) in each plot of the trial area over time. Refer to page 16 for more detail on trial layout. Within a single row, plots assessed for disease were separated by a number of panels that were not assessed.

A. 15 December, 2004 – Mean incidence (%) on underside of leaves.

Row 53	Row 48	Row 47	Row 42
10 Plot 7	**10** Plot 7	**15** Plot 10	**55** Plot 10
7.5 Plot 6	**5** Plot 6	**20** Plot 9	**35** Plot 9
15 Plot 5	**40** Plot 5	**18** Plot 8	**10** Plot 8
7.5 Plot 3	**20** Plot 3	**15** Plot 4	**22.5** Plot 4
13 Plot 2	**15** Plot 2	**15** Plot 1	**28** Plot 1
	57 Untreated	**63** Untreated	

B. 15 December, 2004 – Mean severity (%) on underside of leaves.

Row 53	Row 48	Row 47	Row 42
0.02 Plot 7	**0.01** Plot 7	**0.02** Plot 10	**0.11** Plot 10
0.06 Plot 6	**0.01** Plot 6	**0.02** Plot 9	**0.08** Plot 9
0.02 Plot 5	**0.05** Plot 5	**0.02** Plot 8	**0.01** Plot 8
0.01 Plot 3	**0.05** Plot 3	**0.02** Plot 4	**0.03** Plot 4
0.03 Plot 2	**0.52** Plot 2	**0.02** Plot 1	**0.03** Plot 1
	0.25 Untreated	**0.45** Untreated	

C. 30 December, 2004 – Mean (%) incidence and severity (1st and 2nd figure listed, respectively) on underside of leaves. NA = not assessed.

Row 53	Row 48	Row 47	Row 42
NA Plot 7	**NA** Plot 7	**NA** Plot 10	**23, 0.06** Plot 10
NA Plot 6	**NA** Plot 6	**NA** Plot 9	**5, 0.01** Plot 9
NA Plot 5	**NA** Plot 5	**NA** Plot 8	**7.5, 0.01** Plot 8
NA Plot 3	**NA** Plot 3	**NA** Plot 4	**7.5, 0.01** Plot 4
NA Plot 2	**NA** Plot 2	**NA** Plot 1	**10, 0.01** Plot 1
	55, 0.11 Untreated	**28, 0.29** Untreated	

D. 7th February 2005 - Mean incidence (%) on clusters

Row 53	Row 48	Row 47	Row 42
25 Plot 7	**10** Plot 7	**5** Plot 10	**50** Plot 10
15 Plot 6	**0** Plot 6	**5** Plot 9	**75** Plot 9
25 Plot 5	**8** Plot 5	**10** Plot 8	**80** Plot 8
30 Plot 3	**0** Plot 3	**25** Plot 4	**70** Plot 4
35 Plot 2	**21** Plot 2	**15** Plot 1	**75** Plot 1

E. 7th February 2005 – Mean severity (%) on clusters

Row 53	Row 48	Row 47	Row 42
0.20 Plot 7	**0.04** Plot 7	**0.03** Plot 10	**0.35** Plot 10
0.06 Plot 6	**0** Plot 6	**0.03** Plot 9	**0.75** Plot 9
0.20 Plot 5	**0.04** Plot 5	**0.05** Plot 8	**0.60** Plot 8
0.15 Plot 3	**0** Plot 3	**0.15** Plot 4	**0.90** Plot 4
0.30 Plot 2	**0.13** Plot 2	**0.08** Plot 1	**0.53** Plot 1

F. 6th April, 2005 – Mean incidence (%) on clusters.

Row 53	Row 48	Row 47	Row 42
15 Plot 7	**6** Plot 7	**10** Plot 10	**20** Plot 10
15 Plot 6	**0** Plot 6	**10** Plot 9	**50** Plot 9
25 Plot 5	**30** Plot 5	**20** Plot 8	**95** Plot 8
25 Plot 3	**29** Plot 3	**45** Plot 4	**70** Plot 4
45 Plot 2	**33** Plot 2	**15** Plot 1	**80** Plot 1

G. 6th April, 2005 – Mean severity (%) on clusters

Row 53	Row 48	Row 47	Row 42
0.08 Plot 7	**0.03** Plot 7	**0.04** Plot 10	**0.13** Plot 10
0.08 Plot 6	**0** Plot 6	**0.05** Plot 9	**0.53** Plot 9
0.13 Plot 5	**0.18** Plot 5	**0.13** Plot 8	**1.83** Plot 8
0.11 Plot 3	**0.14** Plot 3	**0.33** Plot 4	**1.00** Plot 4
0.33 Plot 2	**0.13** Plot 2	**0.08** Plot 1	**1.25** Plot 1

Discussion about observations made at Frogmore Creek

Development of disease in untreated panels
As illustrated in Figures 3 and 4, environmental conditions and crop vigour were highly conducive for the development of powdery mildew, especially on clusters. Disease in the adjacent small-plot trial site first appeared on December 2, 2004, whereas it was detected some 11 days later in the untreated panels of this trial site. This time interval appears to correspond to one generation of *Erysiphe necator*, given the temperatures during early December. The final mean disease severity in the untreated panels of 32-24% was lower than the value of 58% observed in the untreated panels in the adjacent trial site. This finding might be explained by the apparent delay in the beginning of the epidemic in this trial site when compared with the neighbouring trial. Given the small area left untreated, the final level of disease observed is not necessarily the level that would have been observed if the whole block had not been sprayed. Instead, the detection of powdery mildew indicated that the pathogen was active at the time of assessment.

Development of disease in relation to the Gubler-Thomas risk index for powdery mildew
The first observation of powdery mildew in the trial area occurred at least 45 days before the mildew risk index reached a cumulative threshold value of 60 on January 27, 2005. By this time, the mean incidence and severity of powdery mildew on clusters in the untreated panels was at least 85% and 2%, respectively. For comparison, the mean incidence and severity of powdery mildew on clusters in untreated panels in the adjacent trial site on January 10, 2005, was 98% and 10%, respectively. Clearly, the cumulative mildew risk index should not be used to time the first application of protective fungicide in Chardonnay at Frogmore Creek.

Effectiveness of spray program and timing
The spray schedule applied in the trial site effectively reduced mean powdery mildew severity on clusters to less than 0.4%. Therefore, disease severity was below the 1-5% category, which has been shown to have some impact on sensory characters of wine made from Chardonnay grapes[a].

[a]Stummer, B.E., Francis I.L, Zanker, T., Lattey, K.A., Scott, E.S. (2005) Effects of powdery mildew on the sensory properties and composition of Chardonnay juice and wine when grape sugar ripeness is standardised. *Australian Journal of Grape and Wine Research* 11, 66-76.

On April 6, 2005, mean disease severity in individual plots ranged from 0 to 1.8%, with plots in row 42, the row closest to the adjacent small-plot trial, exhibiting disease severities at the higher end of this range. Inoculum from the adjacent trial may have increased disease pressure in row 42, although vines in this row had a dense canopy when compared with row 48, which had a number of gaps plus young or replacement vines.

According to current best-practice management, a critical period for protecting grape clusters from infection by *E. necator* is immediately before flowering, during flowering and as berries are setting. Disease was first observed on December 13, 2004, so the first infection probably occurred anywhere between 7 and 14 days previously, which would have coincided with the beginning of flowering. The first application of sulfur was applied on December 6 at about 30-50% cap fall. Had sulfur also been applied for the previous spray, then it seems plausible that disease severity on clusters would have been even closer to zero. However, Mr Scherer's goal in 2004/05 was to reduce the amount of sulfur used in this vineyard, hence the decision to delay the first application of sulfur as long as possible. Furthermore, the first sulfur application was followed by another sulfur application only 8 days later. Hence, spray intervals were kept tight at this critical time.

The length of the spray intervals at Frogmore Creek, as guided by the mildew risk index and the decision rule, appears to have corresponded well to temperatures observed during the growing season and the relative susceptibility of each crop stage to powdery mildew. The longest spray intervals were between the first and second spray of the season (23 days) and between applications made on Dec. 15 and Jan. 17 (33 days). Indeed, there was a period of very cool weather during 9 days in early January, so the longer spray interval appears to have been justified. The final spray interval of 27 days was also justified in terms of the grape clusters becoming increasingly resistant to new infections as they developed beyond pea size, despite the weather being warmer in late January and early February.

2. MEADOWBANK

Cooperator:	Mr Adrian Hallam for Mr Gerald Ellis	
Location:	699 Richmond Rd Cambridge Coal River Valley, South East Tasmania	
Contact details:	mobile:	0409 583 661
	office:	6248 4484
	fax:	6248 4485
	email:	office@meadowbankwines.com.au
	postal address:	PO Box 180 Richmond 7025

Variety:	Pinot gris (mixture of two clones)
Age:	Planted 1999, first commercial crop in 2003.
Trellising:	Vertical Shoot Positioning
Spacing:	1.5 m intra row, 2.1 m between rows, 3,175 vines/ha
Vines per panel:	4
Row orientation:	NNW to SSE
Fruit zone:	0.9 to 1.0 m
First crop stage recorded:	EL 01-03 woolly bud, September 16, 2004.
Harvest date:	April 9, 2005.

Trial layout See next page.

Description of trial layout:
Dashed lines represent 'grower' spray schedule, solid lines represent 'temperature-based' or 'model' schedule. Sprays timed according to the temperature-based model were applied to rows 27 to 32 inclusive. All other rows in the block were sprayed according to the 'grower' spray program. The entire trial area comprised rows 24 to 35 with A = row in which mildew was assessed because spray drift from adjacent spray schedule was minimised. Open boxes = two panels at end of each of rows 29 and 30 that were left unsprayed until February 16, 2005. Numbers represent 'replicates' for assessment purposes in a randomized block design.

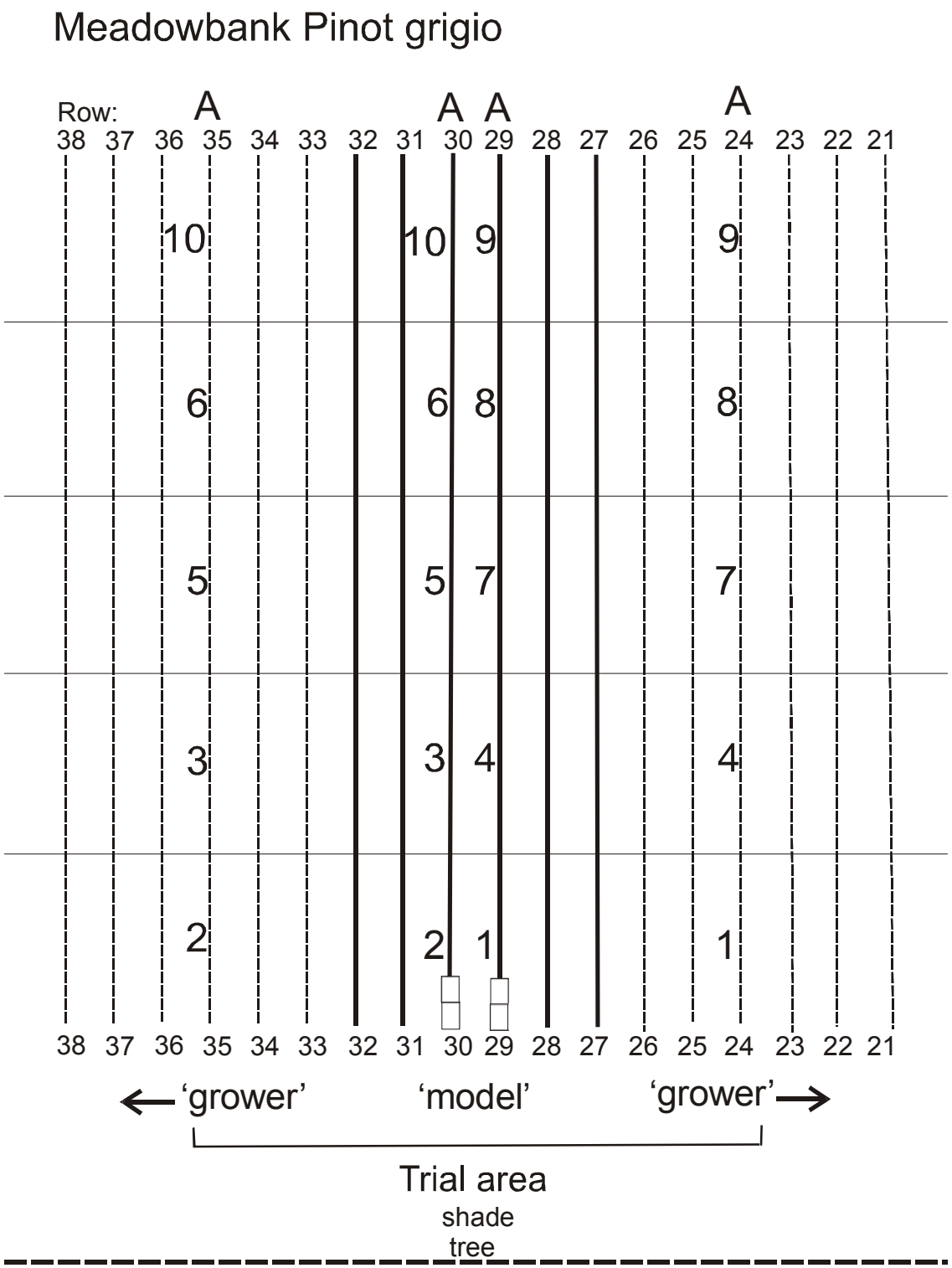
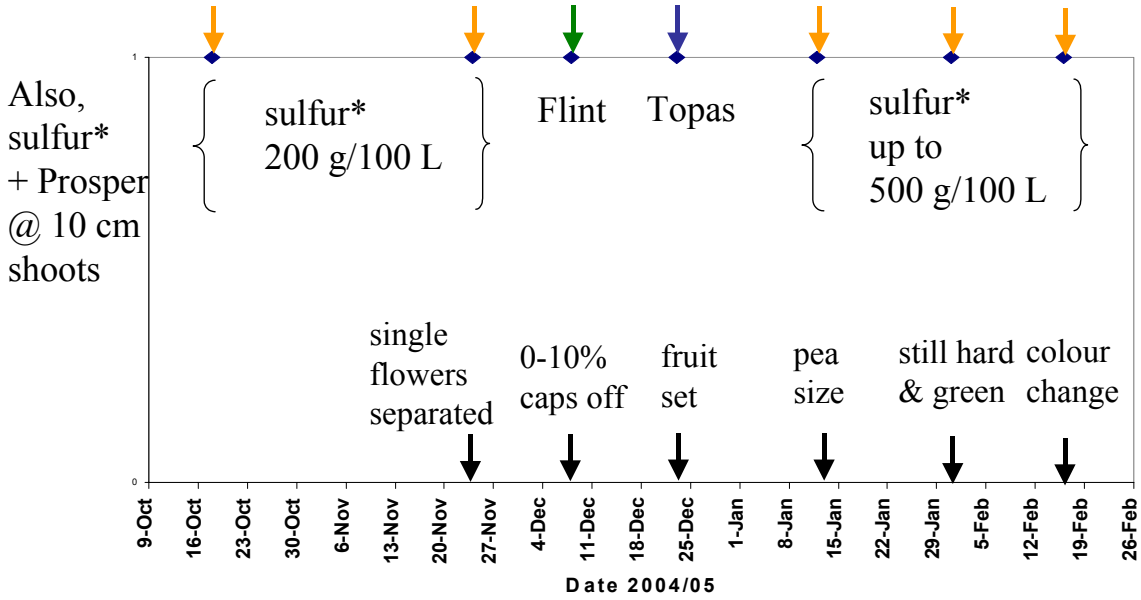


Table 4 Record of 'grower' and 'model' spray schedule, crop stage and disease appearance in Pinot gris at Meadowbank vineyard, 2004/2005. 'Grower' and 'model' spray schedules were identical. Dates in bold text indicate days on which a powdery mildew fungicide was applied.

Date	Crop stage	Interval since last spray	Spray Vol. L/ha	Materials applied per 100 L and comments
Sept. 15	EL 01-03	1st spray	250	**Thiovit Jet** @ 200 g **Prosper** @ 60 ml Dipel DF
Oct. 11	EL 10-12			
Oct. 18	EL 13	33 days	300	**Thiovit Jet** @ 200 g Agrol
Nov. 2	EL 15			
Nov. 15	EL 16			
Nov. 24	EL 17	37 days	300	**Thiovit Jet** @ 200g Foliar fertilizer
Nov. 29	EL 20			10% caps off
Dec. 8	(EL 19)	14 days	300	**Flint** @15 g Scala @ 200 ml
Dec. 13	EL 25-27			
Dec. 21	EL 27-29			No evidence of powdery mildew in trial area.
Dec. 23	(EL 25)	15 days	400	**Topas** @125 ml Switch @ ? Success @ 40 ml
Dec. 29	EL 28-31			Powdery mildew evident on undersides of leaves in untreated control
Jan. 5	EL 30			
Jan. 12	EL 31	20 days	600	**Thiovit Jet** @ 200g Captan @125 g Dipel DF@100 g No evidence of powdery mildew on bunches
Jan. 15				Datalogger damaged
Jan. 19	EL 30-32			Powdery mildew evident on bunches at 2.5% incidence (very low) in untreated control
Jan. 31	EL 33	19 days	600	**Thiovit Jet** @ 200g Captan @125 g
Feb. 16	EL 35	17 days	600	**Thiovit Jet** @ 200g Rovral Aquaflo @ 100ml Dipel DF@100 g
Mar. 4	EL 36		500	Rovral Aquaflo @ 100ml



*Thiovit Jet

Figure 9 Summary of spray schedule for powdery mildew in relation to crop stage in Pinot gris at Meadowbank. Powdery mildew was first recorded on the underside of leaves in untreated panels on December 29, 2004.

Temperature and risk index for powdery mildew

Figures 10 and 11 illustrate the number of days where the temperature exceeded 20.5°C and translation of the number of hours greater than 20.5°C per day into the cumulative Gubler-Thomas risk index for powdery mildew.

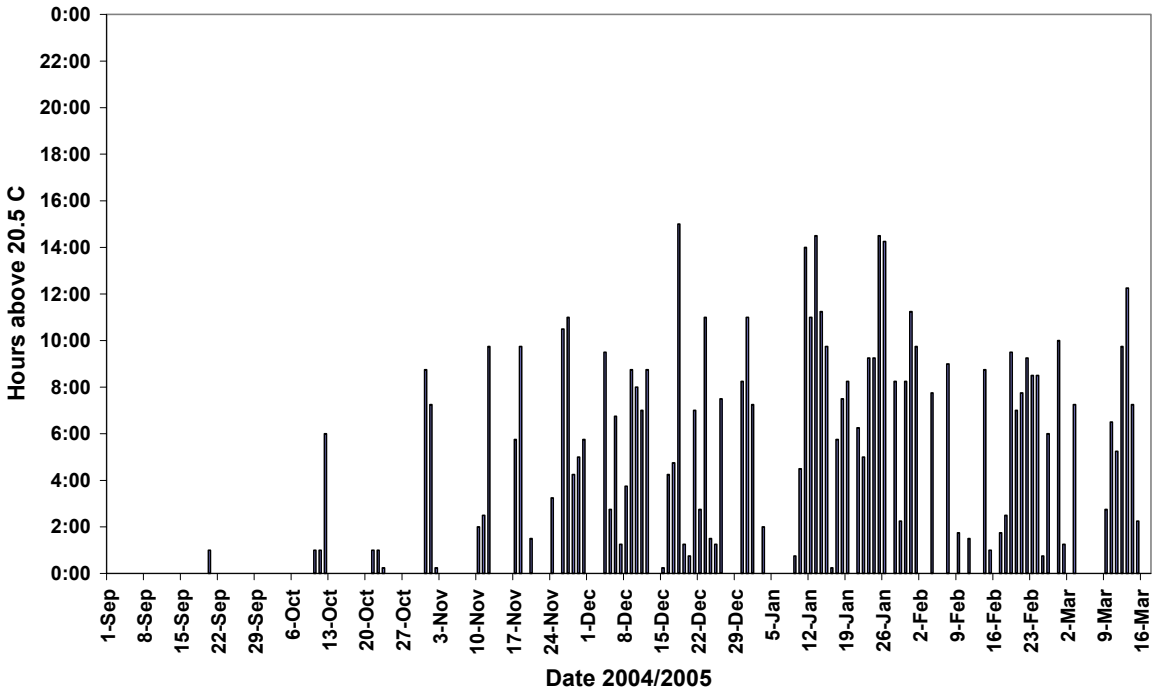


Figure 10 The number of hours greater than 20.5°C per day between September 1, 2004 and March 16, 2005 at Meadowbank.

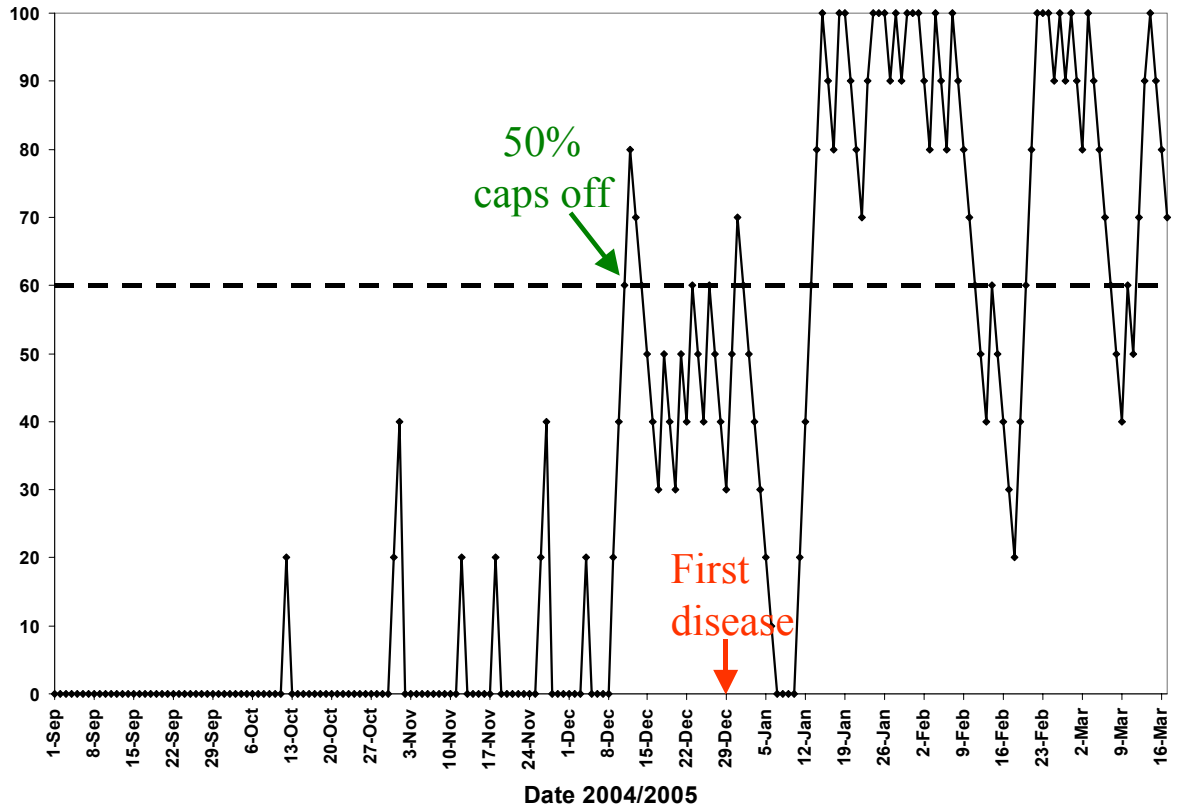


Figure 11 Gubler-Thomas risk index (cumulative) for powdery mildew at Meadowbank between September 1, 2004 and March 16, 2005, in relation to the appearance of powdery mildew in the trial site. The dashed line represents a cumulative risk index of 60, which Gubler and Thomas use as the threshold indicating the commencement of the powdery mildew epidemic. Disease was first detected on the underside of leaves in untreated panels on December 29, 2004. The cumulative risk index reached 60 for the first time on December 11, 2004.

Disease progression in untreated panels and trial area

Table 5 summarises disease progression in the untreated panels. Disease was not detected in the sprayed area, even at the final two assessment dates of February, 9 and April 5, 2005.

Table 5 Mean incidence and severity (%) on leaves (n = 80 per panel) and clusters (n = 40 per panel) in untreated panels of Pinot gris at Meadowbank. Untreated panels were sprayed with sulfur on Feb. 16, 2005.

Date	Crop stage	Tissue	Mean incidence (%)	Mean severity (%)
Jan. 5, 2005	berries 4-7 mm	leaves - underside	25	0.51
Jan. 12., 2005	berries pea size	leaves - underside	15	0.03
Jan. 19, 2005	pea size to bunch closure	clusters	2.5	0.13
Jan. 25, 2005	berries hard, green	clusters	0	0
Feb. 18, 2005	colour change	clusters	0	0
April 5, 2005	pre-harvest	clusters	0	0

Discussion about observations made at Meadowbank

Development of disease in untreated panels
Powdery mildew first appeared in the untreated panels on the underside of leaves and at a time when the developing berries were likely to be acquiring increasing resistance to infection by *E. necator* (Table 5). This delay in the beginning of the mildew epidemic meant that the berries would never develop severe disease. Indeed, an almost undetectable level of mildew was evident when the berries were pea size and these symptoms were not detected at later assessment dates. Given the small area of the block left unsprayed, these observations do not reflect the level of powdery mildew that might have developed if the whole block was left unsprayed. Instead, the detection of powdery mildew indicated that the pathogen was active at the time of assessment.

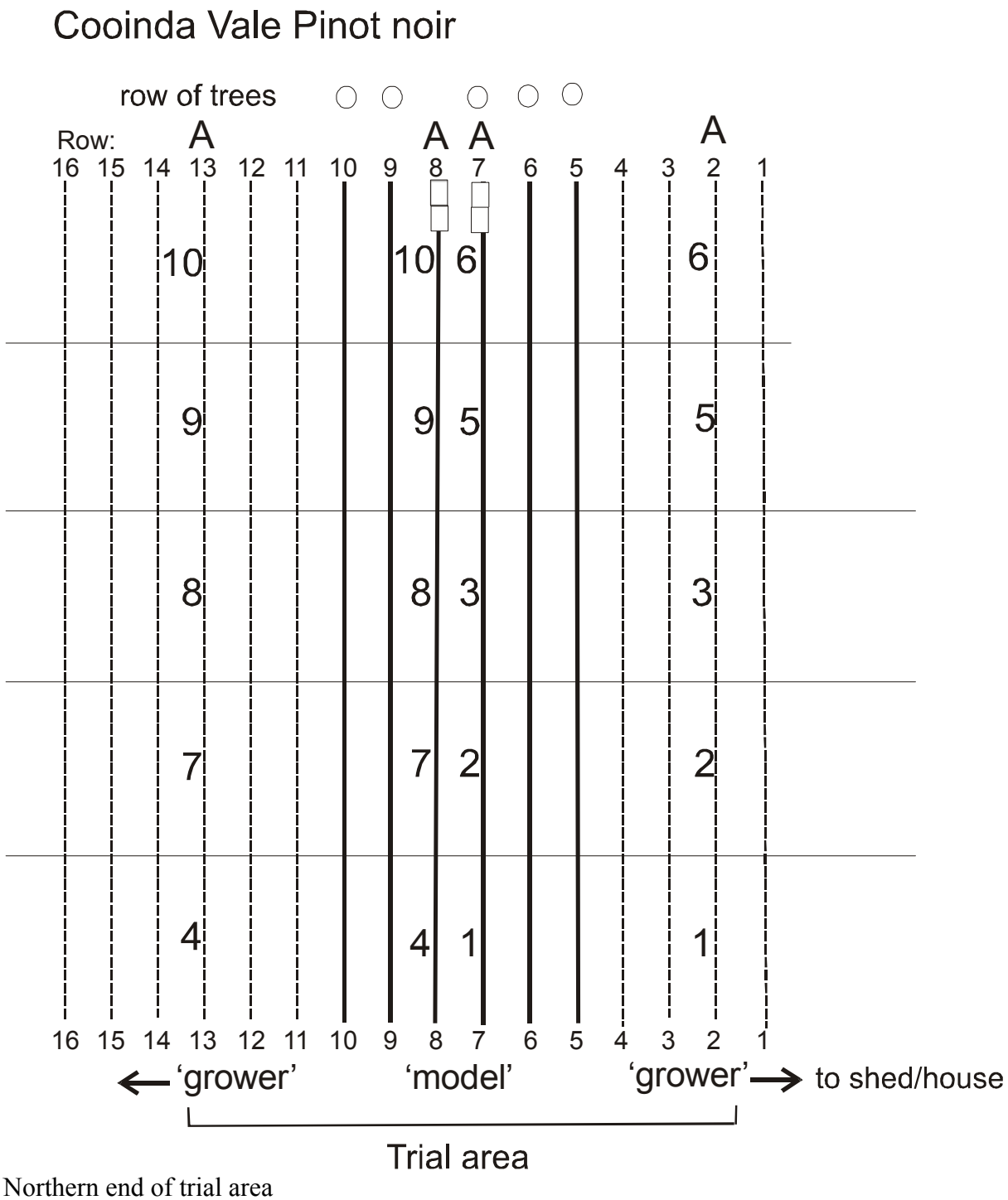
Development of disease in relation to the Gubler-Thomas risk index for powdery mildew
The cumulative GT index reached 60 for the first time on Dec. 11, 2004 (50% caps off) and disease was first detected in the untreated panels some 18 days later. Given that there is a lag phase between infection by the pathogen and disease expression, the GT risk index appeared to predict disease onset at this site in 2004/05.

Effectiveness of spray program and timing
The spray program at Meadowbank was 100% effective in preventing the development of powdery mildew in Pinot gris. Although disease in the untreated panels did not appear until Dec. 29, it is likely that disease would have begun to increase (slowly) several weeks beforehand. The sprays that probably provided the majority of powdery mildew protection for clusters were the sulfur application before flowering and Flint at early flowering followed by Topas 15 days later. The early applications of sulfur and Prosper at 10 cm shoots and at E-L 13 were applied by the grower cooperator to protect the vines from primary or early secondary infection. Flagshoots were not detected in this block, so primary inoculum either came from ascospores released from cleistothecia or from conidia arriving on the wind from elsewhere. As the level of overwintering cleistothecia was unknown, these early applications of relatively low rates of sulfur were applied as a form of crop insurance. Applications of sulfur from pea size berries onwards, at the higher rate of 500 g/100 L, protected leaves until harvest in early April. The spray interval of 20 days between the application of Topas on Dec. 23 and sulfur on Jan. 12, appeared to be appropriate given the cool weather in early January.

3. COOINDA VALE

Vineyard:	Cooinda Vale
Cooperator:	Matthew Pooley
Location:	76 Barton Vale Road, north of Campania Coal River Valley, South East Tasmania
Contact details:	mobile: 0408 652 296 fax: 03 6248 4304 email: mpooley@bigpond.com postal address: PO Box 204 Richmond 7025
Variety:	Pinot noir
Age:	Planted 1999, first commercial crop in 2002.
Trellising:	Vertical Shoot Positioning
Spacing:	1.2 m intra row, 2.2 m between rows, 3,500 vines/ha
Vines per panel:	4-5
Row orientation:	NNE to SSW
Fruit zone:	1 m
Bud burst:	EL-03-05 (green tip) on September 21, 2004.
Harvest Date:	April, 2005
Trial layout	See next page.

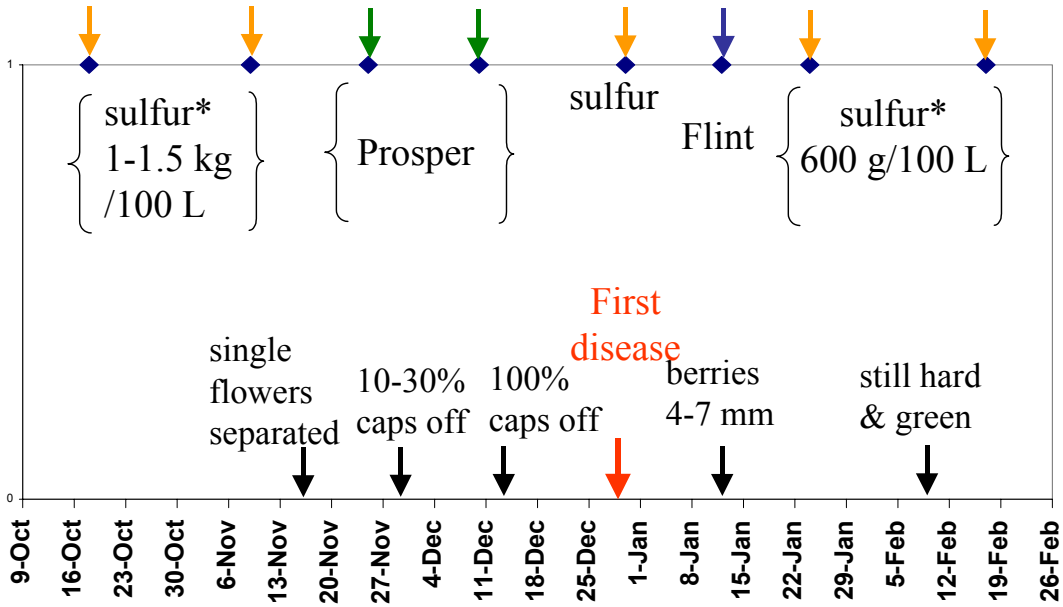
Description of trial layout:
Dashed lines represent 'grower' spray schedule, solid lines represent 'temperature-based' or 'model' schedule. Sprays timed according to the temperature-based model were applied to rows 5 to 10 inclusive. All other rows in the block were sprayed according to the 'grower' spray program. The entire trial area comprised rows 2 to 13 with A = row in which mildew was assessed because spray drift from adjacent spray schedule was minimised. Open boxes = two panels at end of each of rows 7 and 8 that were left unsprayed. Numbers represent 'replicates' for assessment purposes in a randomized block design.



Northern end of trial area

Table 6. Record of 'grower' and 'model' spray schedule, crop stage and disease appearance in Pinot noir at Cooinda Vale vineyard, 2004/2005. 'Grower' and 'model' spray schedules were identical, except for the first spray, as indicated. Dates in bold text indicate days on which a powdery mildew fungicide was applied.

Date	Crop stage	Interval since last spray	Spray Vol. L/ha	Materials applied per 100 L and comments
Oct. 6	E-L 7	1st spray	300	'grower' schedule (rows 1-4 and 11-16) Thiovit @ 2 kg
Oct. 11	EL 11			
Oct. 18		1st spray	400	'model' schedule (rows 5-10) Thiovit @ 1.5 kg
Oct. 25	EL 13-14	19 or 7 days	400	'grower' and 'model' (error in communication about timing of 'model' spray) Thiovit @ 1 kg
Nov. 2	EL 16			
Nov. 9	EL 16	15 days	400	Thiovit @ 1 kg
Nov. 15	EL 17			
Nov. 25	EL	16 days	500	Prosper @ 180 ml
Nov. 29	EL 20-21			
Dec. 9	EL 25-27			
Dec. 10		15 days	500	Prosper @ 180 ml
Dec. 11				mildew index reaches '60' for the first time
Dec. 13	EL 26-27			
Dec. 21	EL 29			no evidence of powdery mildew in trial area
Dec. 29	EL 30			powdery mildew observed on young leaves of lateral shoots in untreated area
Dec. 30		20 days	500	Thiovit @ 600 g
Jan. 12		13 days	500	Flint @ 75 g Powdery mildew evident on Riesling and Pinot noir berries
Jan. 24		12 days	500	Thiovit @ 600 g
Feb. 17		24 days	500	Thiovit @ 600 g



*Thiovit Jet

Figure 12 Summary of 'model' spray schedule for powdery mildew in relation to crop stage in Pinot noir at Cooinda Vale. Powdery mildew was first recorded on young leaves of lateral shoots in untreated panels on December 29, 2004.

Temperature and risk index for powdery mildew

Figures 13 and 14 illustrate the number of days where the temperature exceeded 20.5°C and translation of the number of hours greater than 20.5°C per day into the cumulative Gubler-Thomas risk index for powdery mildew.

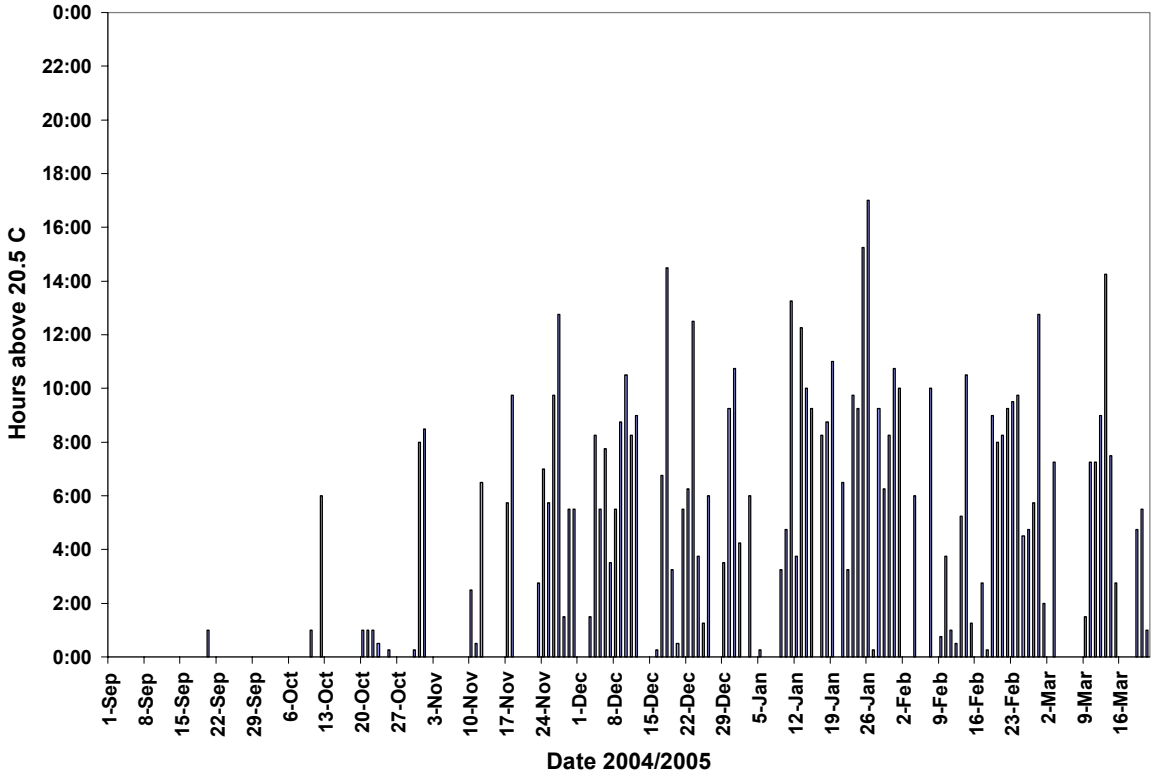


Figure 13 The number of hours greater than 20.5°C per day between September 1, 2004 and March 24, 2005 at Cooinda Vale.

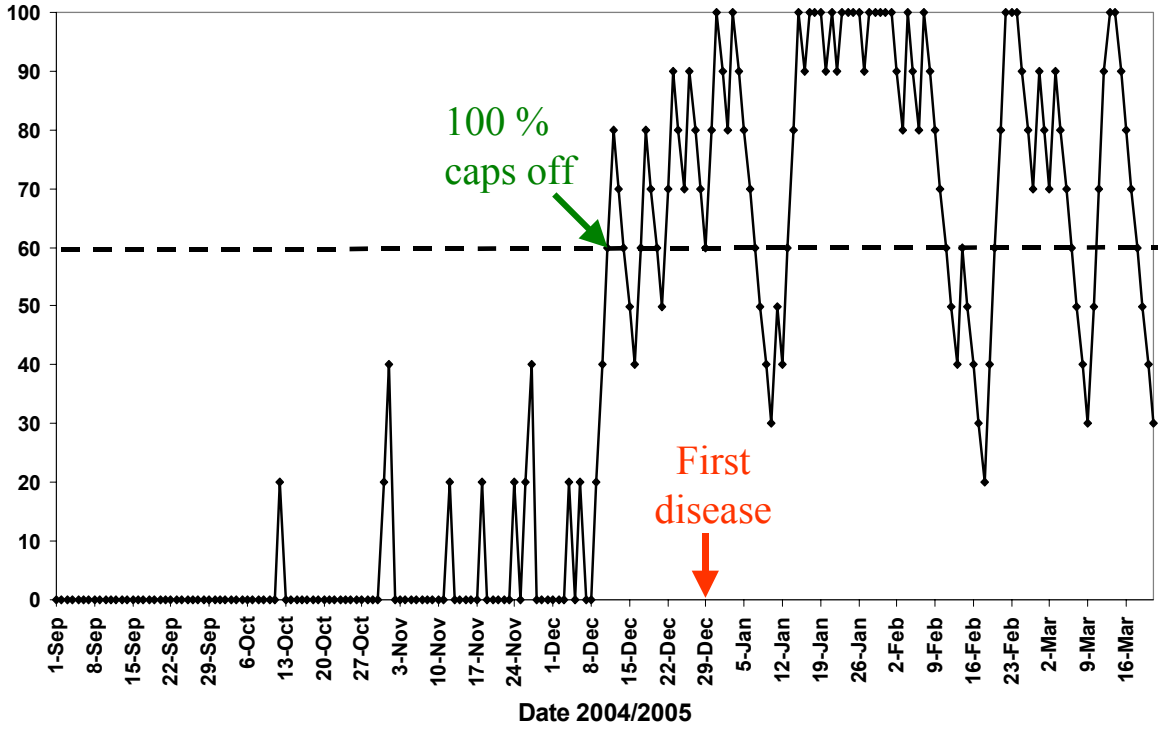


Figure 14 Gubler-Thomas risk index (cumulative) for powdery mildew at Cooinda Vale between September 1, 2004 and March 24, 2005, in relation to the appearance of powdery mildew in the trial site. The dashed line represents a cumulative risk index of 60, which Gubler and Thomas use as the threshold indicating the commencement of the powdery mildew epidemic. Disease was first detected on young leaves of lateral shoots in untreated panels on December 29, 2004. The cumulative risk index reached 60 for the first time on December 11, 2004.

Disease progression in untreated panels and trial area

Table 7 summarises disease progression in the untreated panels. Disease was not detected in the sprayed area, even at the later assessment dates of February 8 and April 4, 2005.

Table 7 Mean incidence and severity (%) on leaves (n = 80 per panel) and clusters (n = 40 per panel) in untreated panels of Pinot noir at Cooinda Vale. Untreated panels were sprayed with sulphur on February 17, 2005.

Date	Crop stage	Tissue	Mean incidence (%)	Mean severity (%)
Jan. 5, 2005	berries 4 mm	leaves - underside	34	0.71
Jan. 12., 2005	berries 4-7 mm	leaves - underside	30	0.49
Jan. 25, 2005		leaves – underside	28	0.33
Feb. 18, 2005	berries beginning to soften	leaves – underside	18	0.02
Jan. 12., 2005	berries 4-7 mm	clusters	23	0.39
Jan. 19, 2005		clusters	23	0.20
Jan. 25, 2005		clusters	10	0.21
Feb. 18, 2005	berries beginning to soften	clusters	6	0.08

Discussion about observations made at Cooinda Vale

Development of disease in untreated panels

Powdery mildew first appeared in the untreated panels on young leaves of lateral shoots and at a time when developing berries were still moderately susceptible to infection by *E. necator*, but also acquiring increasing resistance to infection (Table 7). This delay in the beginning of the powdery mildew epidemic and the small area left untreated meant that the final disease severity observed on clusters was very low. Given the small area of the block left unsprayed, these observations do not reflect the level of powdery mildew that might have developed if the whole block was left unsprayed. Instead, the detection of powdery mildew indicated that the pathogen was active at the time of assessment.

Development of disease in relation to the Gubler-Thomas risk index for powdery mildew

The cumulative GT index reached 60 for the first time on Dec. 11, 2004 (100% caps off) and disease was first detected in the untreated panels some18 days later. Given that there is a lag phase between infection by the pathogen and disease expression, the GT risk index appeared to predict disease onset at this site in 2004/05.

Effectiveness of spray program and timing

The spray program at Cooinda Vale was 100% effective in preventing the development of powdery mildew in Pinot noir. Although disease in the untreated panels did not appear until Dec. 29, it is likely that disease would have begun to increase (slowly) several weeks beforehand. The sprays that probably provided the majority of powdery mildew protection for clusters were the sulfur application before flowering and applications of Prosper during flowering followed by sulfur 20 days later. The application of Flint on Jan. 12 was possibly unnecessary, given that most berries were, in theory, becoming highly resistant to new infection by *E. necator*. The weather was cool in early January, so the sulfur application on

Dec. 30 may have provided enough protection until the next sulfur application on Jan 24. Applications of sulfur from Jan. 24 onwards protected leaves until harvest in April.

The very high rates of sulfur selected by Mr Pooley for application in October and November were based on anecdotal evidence of growers in the region that these rates are necessary to compensate for the lack of vapour activity of sulfur at low temperatures. The extra potential benefit provided by higher rates of sulfur need to be balanced with the likelihood that the fungus is relatively inactive at this time of the season. The late appearance of mildew in untreated panels and the cumulative GT index suggests that development of powdery mildew in October and November either did not occur or was occurring at an extremely low and undetectable level. Flagshoots were not detected in this block, so primary inoculum either came from ascospores released from cleistothecia or from conidia arriving on the wind from elsewhere. As the level of overwintering cleistothecia was unknown, the first application of sulfur, at least, was applied as a form of crop insurance. Whether the first sulfur spray was applied at E-L 7 ('grower' schedule) or E-L 13-14 ('model' schedule) made no difference to the final level of disease observed (zero disease) in the sprayed area (Tables 6 and 7).

There is one argument for applying sulfur at budburst for powdery mildew control.
W.D. Gubler (University of California, Davis, personal communication) has stated that wettable sulfur applied in a high water volume to the cordon (bark) at bud burst, when temperatures are greater than 10^{o}C, can cause 90% of cleistothecia to release their ascospores prematurely. As there are no leaves available for infection, then this practice, in theory, reduces overwintering inoculum and delays the epidemic by about 10 days under Californian conditions. The effectiveness of this practice for powdery mildew management has not yet been evaluated under Tasmanian conditions. Other grape pathologists recommend that the level of in-season disease control should be high enough so that cleistothecia never form in the first place.

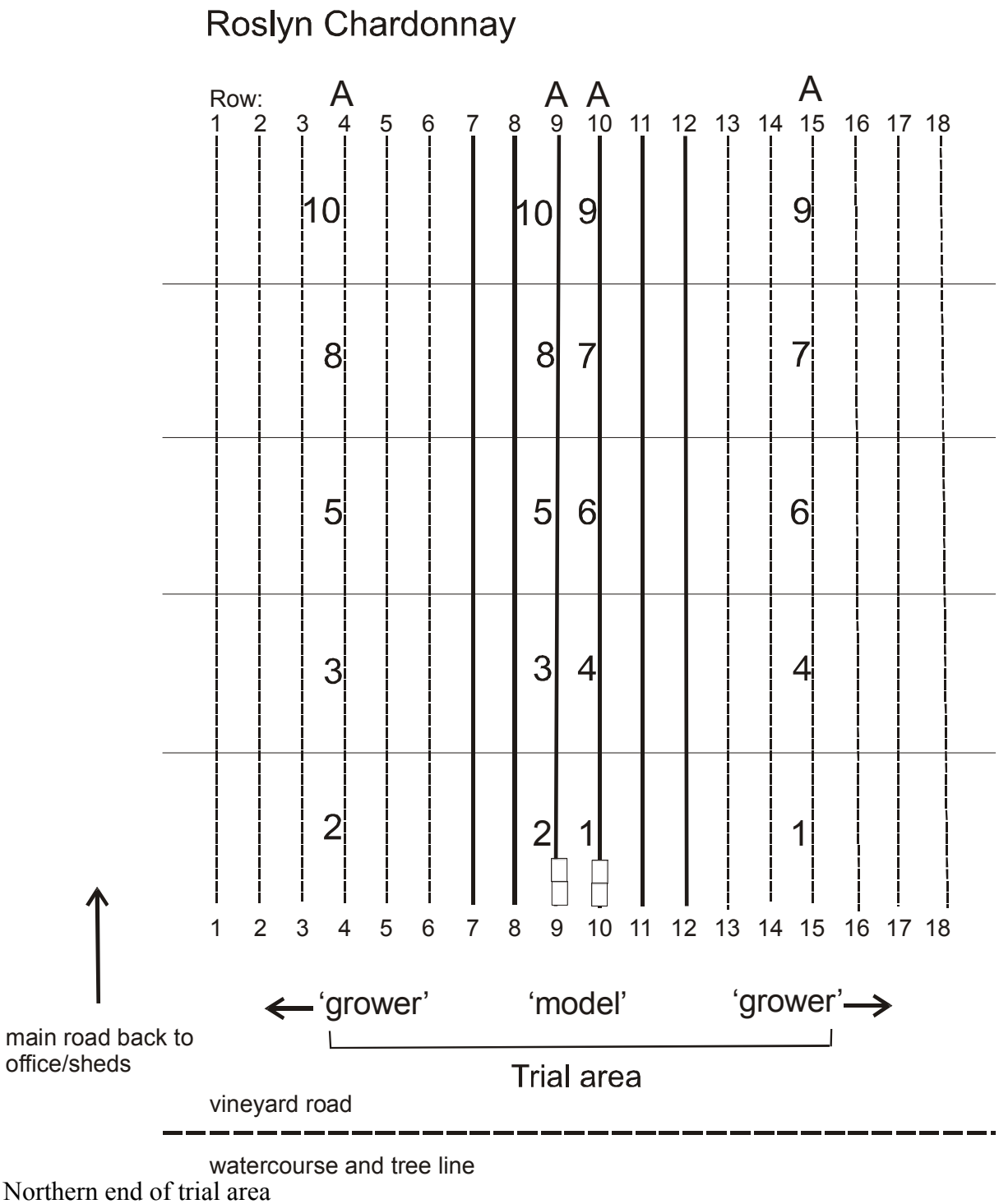
4. ROSLYN

Cooperator: Mr Danny Belbin
Location: Coal River Valley via Campania, Southern Tasmania
Contact details: mobile: 0418 552 812
office: 6260 4077
fax: 6260 4072
postal address:
PO Box 70
Campania 7026

Variety: Chardonnay
Age: mostly 3 years
Trellising: Vertical Shoot Positioning
Spacing: 1 m intra row, 2 m between rows, 5,000 vines/ha
Vines per panel: 6
Row orientation: N to S
Fruit zone: 0.8 to 1.0 m
Harvest date: April 28, 2005

Trial layout: See next page.

Description of trial layout:
Dashed lines represent 'grower' spray schedule, solid lines represent 'temperature-based' or 'model' schedule. Sprays were applied to rows 7 to 12 inclusive and were timed according to the temperature-based model. All other rows in the Chardonnay block were sprayed according to the 'grower' spray program. The entire trial area comprised rows 3 to 15 with A = row in which mildew was assessed because spray drift from adjacent spray schedule was minimised. Open boxes = two panels at end of each of rows 9 and 10 that were left unsprayed. Numbers represent 'replicates' for assessment purposes in a randomized block design.



Northern end of trial area

Table 8. Record of 'grower' and 'model' spray schedule, crop stage and disease appearance in Chardonnay at Roslyn vineyard, 2004/2005. 'Grower' and 'model' spray schedules were identical, except for the first spray, as indicated below. Dates in bold text indicate days on which a powdery mildew fungicide was applied.

Date	Crop stage	Interval since last spray	Spray Vol. L/ha	Materials applied per 100 L and comments
Oct. 19		1st spray		'grower' spray, Thiovit Jet @ 500 g
Oct. 22	EL 13-15			
Oct. 25		1st spray		'model' spray, Thiovit Jet @ 500 g
Nov. 2	EL 16			
Nov. 11		17 days		Thiovit Jet @ 500 g
Nov. 15	EL 17			
Nov. 29	EL 20-21			About 25% capfall
Dec. 3		22 days		Thiovit Jet @ 500 g
Dec. 13	EL 26-27			
Dec. 21	EL 29			No evidence of powdery mildew in trial area.
Dec. 29	EL 30			Powdery mildew was not detected in the untreated panels, although there were some indefinite spots on leaves.
Jan. 5	EL 30			Powdery mildew observed on underside of leaves in untreated panels.
Jan. 11		39 days	1,000	Thiovit Jet @ 500 g
Mar. 12	EL 35	57 days	1,000	Thiovit Jet @ 500 g

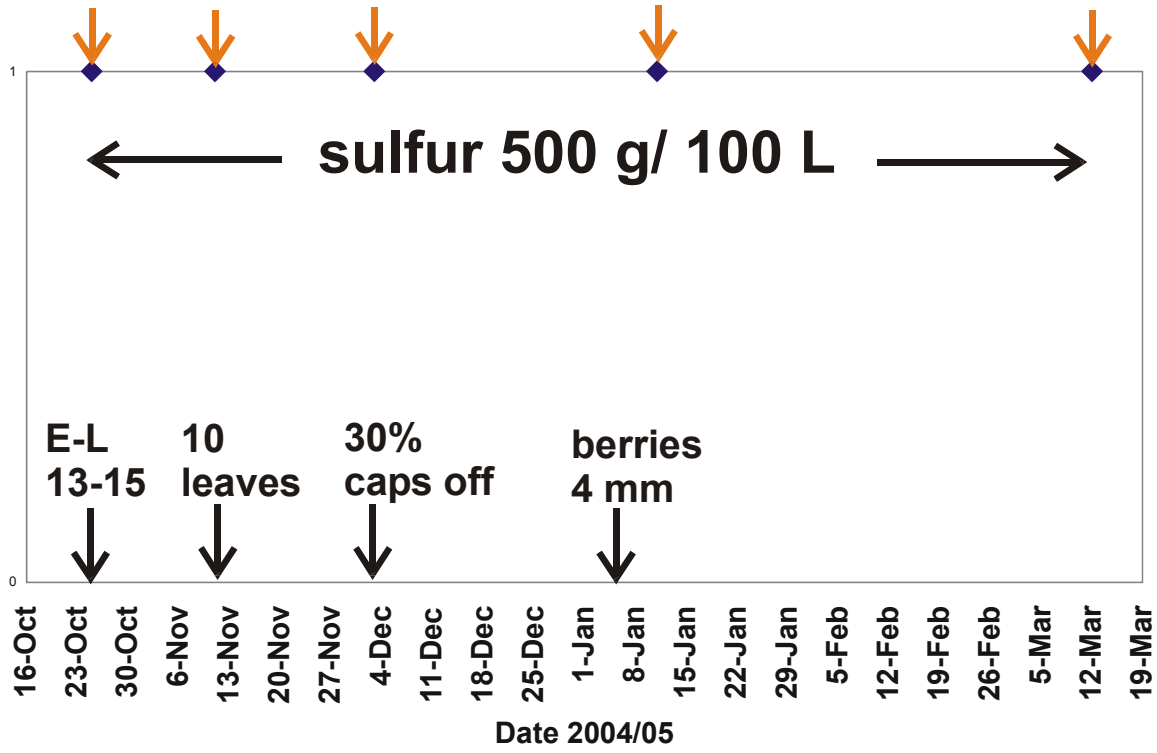


Figure 15 Summary of 'model' spray schedule for powdery mildew in relation to crop stage in Chardonnay at Roslyn. Powdery mildew was first recorded on the underside of leaves in untreated panels on January 5, 2005.

Temperature and risk index for powdery mildew

Figures 16 and 17 illustrate the number of days where the temperature exceeded 20.5°C and translation of the number of hours greater than 20.5°C per day into the cumulative Gubler-Thomas risk index for powdery mildew.

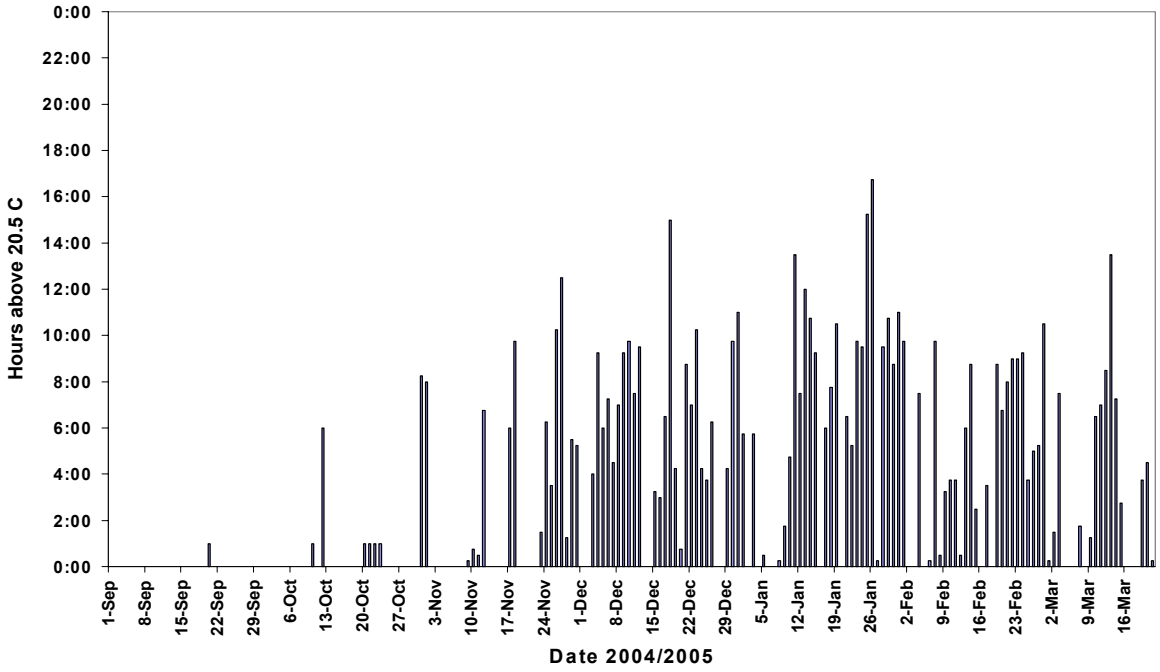


Figure 16 The number of hours greater than 20.5°C per day between September 1, 2004 and March 21, 2005 at Roslyn.

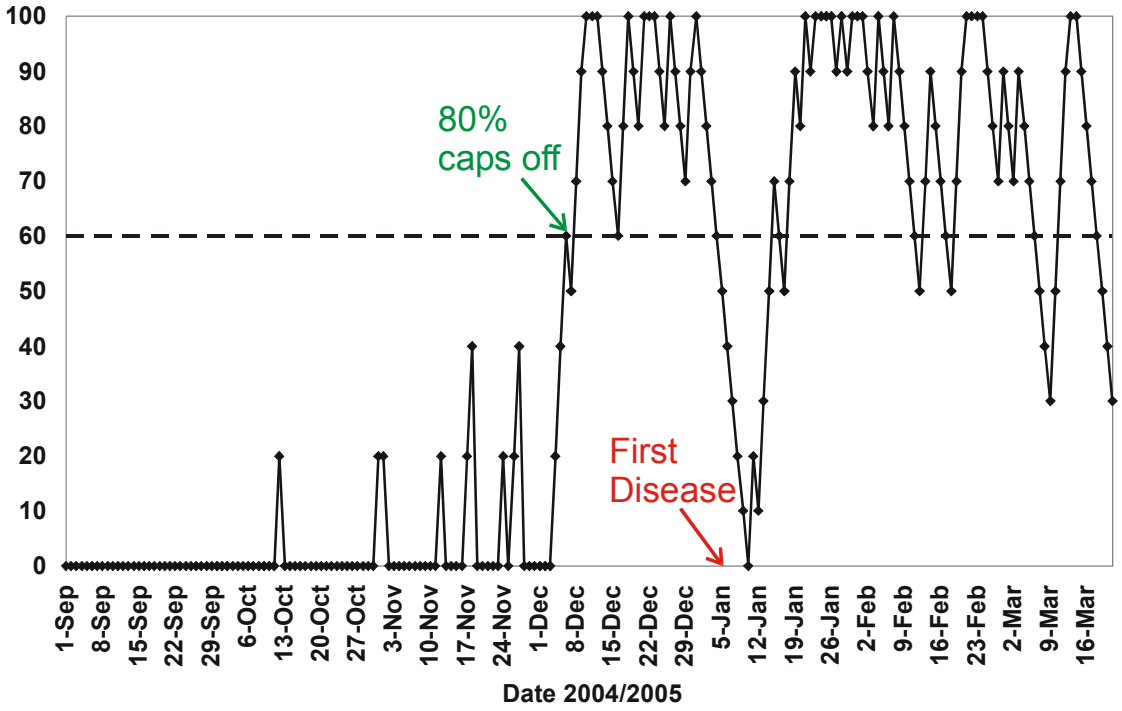


Figure 17 Gubler-Thomas risk index (cumulative) for powdery mildew at Roslyn between September 1, 2004 and March 21, 2005, in relation to the appearance of powdery mildew in the trial site. The dashed line represents a cumulative risk index of 60, which Gubler and Thomas use as the threshold indicating the commencement of the powdery mildew epidemic.

Disease was first detected on the underside of leaves in untreated panels on January 5, 2005. The cumulative risk index reached 60 for the first time on December 6, 2004.

Disease progression in untreated panels and trial area

Table 9 summarises disease progression in the untreated panels. Disease was not detected in the sprayed area, except for a trace amount of powdery mildew detected on clusters in plot 2 of row 9 on February 8, 2005 (0.03% incidence, 0.01% severity). The powdery mildew evident in plot 2, row 9 on Feb. 8 was not detected when the plot was reassessed on April 4, 2005 (E-L stage 38).

Table 9 Mean incidence and severity (%) on leaves (n = 80 per panel) and clusters (n = 40 per panel) in untreated panels of Chardonnay at Roslyn.

Date	Crop stage	Tissue	Mean incidence (%)	Mean severity (%)
Jan. 5, 2005	berries 4-7 mm	leaves - underside	11	0.02
Jan. 19, 2005	berries pea size	clusters	8	0.03
Feb. 1, 2005	bunch closure	clusters	18	0.17

Discussion about observations made at Roslyn

Development of disease in untreated panels

Powdery mildew first appeared in the untreated panels on the underside of leaves and at a time when developing berries were acquiring increasing resistance to infection by *E. necator* (Table 9). This delay in the beginning of the powdery mildew epidemic meant that the final disease severity observed on clusters was very low. Given the small area of the block left unsprayed, these observations do not reflect the level of powdery mildew that might have developed if the whole block was left unsprayed. Instead, the detection of powdery mildew indicated that the pathogen was active at the time of assessment.

Development of disease in relation to the Gubler-Thomas risk index for powdery mildew

The cumulative GT index reached 60 for the first time on Dec. 6, 2004 (80% caps off) and disease was first detected in the untreated panels some 30 days later. While a lag phase between infection by the pathogen and disease expression is expected, a lag phase of 30 days seems too long for the prediction of disease onset at this site in 2004/05.

Effectiveness of spray program and timing

The sulfur only spray program at Roslyn was close to 100% effective in preventing the development of powdery mildew in Chardonnay. Only a trace of powdery mildew was observed in one of the assessment plots on Feb. 8, possibly as a result of poor spray coverage. However, powdery mildew was observed to spread from the untreated panel downwind and down or across the row to plot 2. The spray programs used in trial areas at Cooinda Vale and Meadowbank vineyards achieved greater control of powdery mildew because there was no spread of powdery mildew from untreated panels.

Unlike the other three vineyards, only one protective spray was applied during the flowering-fruit set period. Indeed, some 39 days elapsed between the sulfur application at 30% caps off and the next application when berries were 4 mm. During this time, there were six days where daily rainfall ranged from 2-4 mm at Campania. All other rain events were less than 2 mm, except January 5, when 11 mm of rainfall was recorded at Campania. Hence, there may have been insufficient rainfall to reduce sulfur residues significantly. Effective residues of sulfur

applied at 600 g/100 L are known to persist on grapevine leaves cv. Sultana at least 50 days under dry conditions (R. Emmett *et al.* 2002). Furthermore, a single rain event of 10 mm did not appear to reduce sulfur residues significantly in the studies of Emmett *et al.* (R. Emmett pers. comm.). Therefore, it is possible that residues of sulfur persisted sufficiently long to protect developing berries through this period. Alternatively, this vineyard block may have escaped disease at the critical flowering/fruit set period. The fact that disease was not observed in the untreated panels until January 12 supports this explanation. Berry development seemed to slow significantly in the first weeks of January as a result of cool weather. If primary infection had occurred several weeks prior to January 12, then the crop stage would have been at E-L 29 or 30, meaning that the beginning of the mildew epidemic was delayed beyond the highly susceptible flowering-fruit set period.

Like the other vineyards, flagshoots were not detected in this block of Chardonnay. Roslyn is a young vineyard and geographically isolated from other vineyards in the valley. It is plausible that the powdery mildew epidemic was delayed because conidia of *E. necator* were transported in air currents from other parts of the valley.

Given the low and late disease pressure at this site, the long spray intervals before and after flowering were effective. While the long spray intervals before flowering matched the lower temperatures of late October and November, the high cumulative GT index after flowering, suggested that spray intervals should have been kept tight through December and the latter half of January. The fact that there was some spread of powdery mildew from the untreated plots suggests that the spray interval before the January 11 application was too long. Overall, the results illustrate that some vineyards have the potential to escape severe disease if primary infection is delayed. However, primary inoculum levels can build up as vineyards age leading to an earlier onset of disease. Weather then becomes the dominant driver in disease development.

Reference

Emmett RW, Magarey PA, Reynolds J, Magarey CC, Clarke K (2002) Degradation of sulfur on leaves of grapevine (*Vitis vinifera* cv. Sultana) and its effect on the development of powdery mildew. *Proceedings of the 4th International Workshop on Powdery and Downy Mildew in Grapevine*, Napa, California, USA, Sept. 30–Oct. 4, 2002. (Eds DM Gadoury, Gessler C, Grove G, WD Gubler, GK Hill, H-H Kassemeyer, WK Kast, J Rumbolz, ES Scott) Department of Plant Pathology, University of California, Davis.

Conclusions

It should be noted that the information presented here was generated from observations made in one growing season only. Therefore, observations over subsequent growing seasons and in other viticultural regions of Tasmania will be needed before general recommendations for best-practice disease management can be made. However, there appear to be some general conclusions relevant to the Coal River Valley that can be made and tested in future years.

Conclusions to be verified or refined further are as follows:

1. Applications of protective fungicide for management of powdery mildew before crop stage E-L 13 appear to be unnecessary, unless disease is detected before this time.

   This approach depends on growers monitoring vines for disease at regular intervals. A high disease pressure the previous growing season is likely to lead to an earlier onset of disease in the following growing season. Knowledge of disease pressure the previous growing season and in the vineyard in general should also be used when deciding whether or not to delay or bring forward the date of the first fungicide application.

2. The cumulative UC Davis powdery mildew risk index (GT index) can be used as a guide for setting the interval of fungicide applications before and after the critical flowering/fruit set period.

   Application of the index should also be combined with knowledge of disease susceptibility of each stage of crop growth and development.

3. Levels of disease control observed in 2004/05 confirm that the most effective synthetic fungicides are likely to be cost-effective when applied during the critical flowering-fruit set period.

   Saving your best materials for when they are really needed prolongs the life of fungicides that require resistance management. For organic growers, spray programs based on sulfur can provide effective control of powdery mildew.

4. There appears to be scope to apply sulfur at label rates, as opposed to higher rates, when sulfur is applied during warm weather when the mildew pathogen is active.

   Label rates of sulfur should be adequate for leaf protection from February onwards. Applications of high rates of sulfur very early in the growing season when the mildew pathogen is reproducing very slowly, if at all, should be reviewed.

The focus of this project was on protecting vines from repeated infection by conidia (asexual spores) of the powdery mildew fungus. The contribution of cleistothecia to disease epidemics and the conditions and timing of ascospore (sexual spore) release from these fruiting structures in Tasmanian vineyards is unknown. If this knowledge gap is filled, then options for preventing formation of cleistothecia (eg. eradicating late season disease) and/or timing fungicide sprays to protect new leaves from ascospore infection can be developed.

Communication

1. The main outcomes of this project were communicated as a powerpoint presentation (attached as a separate file) to members of the Vineyards Association of Tasmania (VAT) and Royal Agricultural Society of Tasmania (RAST).

   Details of Event:
   Event: Vineyard of the Year and Field Day
   Organisers: RAST in association with VAT and DPIWE
   Location: Clover Hill Vineyard, Lebrina.
   Date: May 25, 2005.
   Speaker: Dr Kathy Evans
   Length of presentation: 30 min.

2. This final report will be lodged as a pdf on the DPIWE website at www.dpiwe.tas.gov.au/wine

3. Outcomes of the project have been raised during discussions among Coal River Valley growers at informal meetings.

4. An article for the Tasmanian rural press and a short article to be published in a national viticultural magazine are planned.

Appendix A

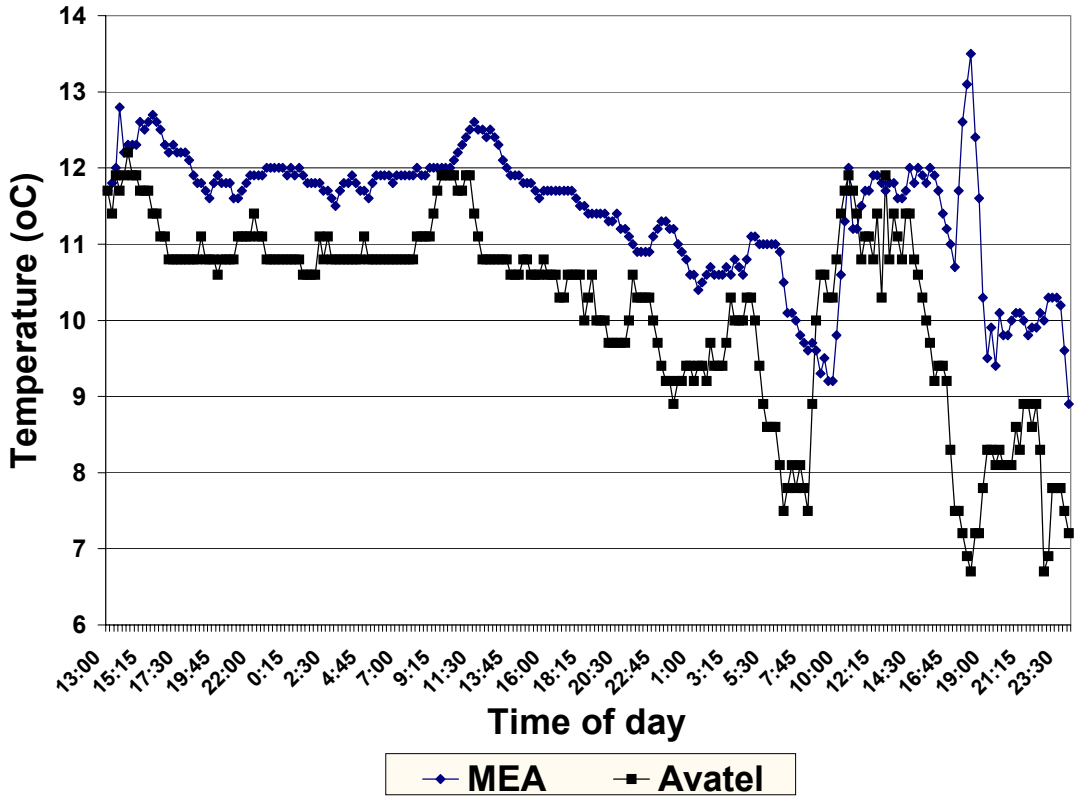


Figure A Comparison of temperatures recorded by the MEA weather station and an Avatel datalogger when placed adjacent to each other at Frogmore Creek vineyard between June 21, 2005 and June 23, 2005. Each logger recorded at 15 min intervals but the Avatel logger recorded 3 minutes after the MEA logger.

Appendix B

Table B Active constituents in materials used for protection from powdery mildew.

Registered product	**Active constituent**
Cosavet DF	sulfur, present as elemental or crystalline sulfur
Ecocarb	potassium bicarbonate
Flint	trioxystrobin
Prosper	spiroxamine
Synertrol Hortioil	canola-based oil
Thiovit Jet	sulfur, present as elemental or crystalline sulfur
Topas	penconazole

Appendix C

Budget reconciliation to be provided under a separate cover letter.