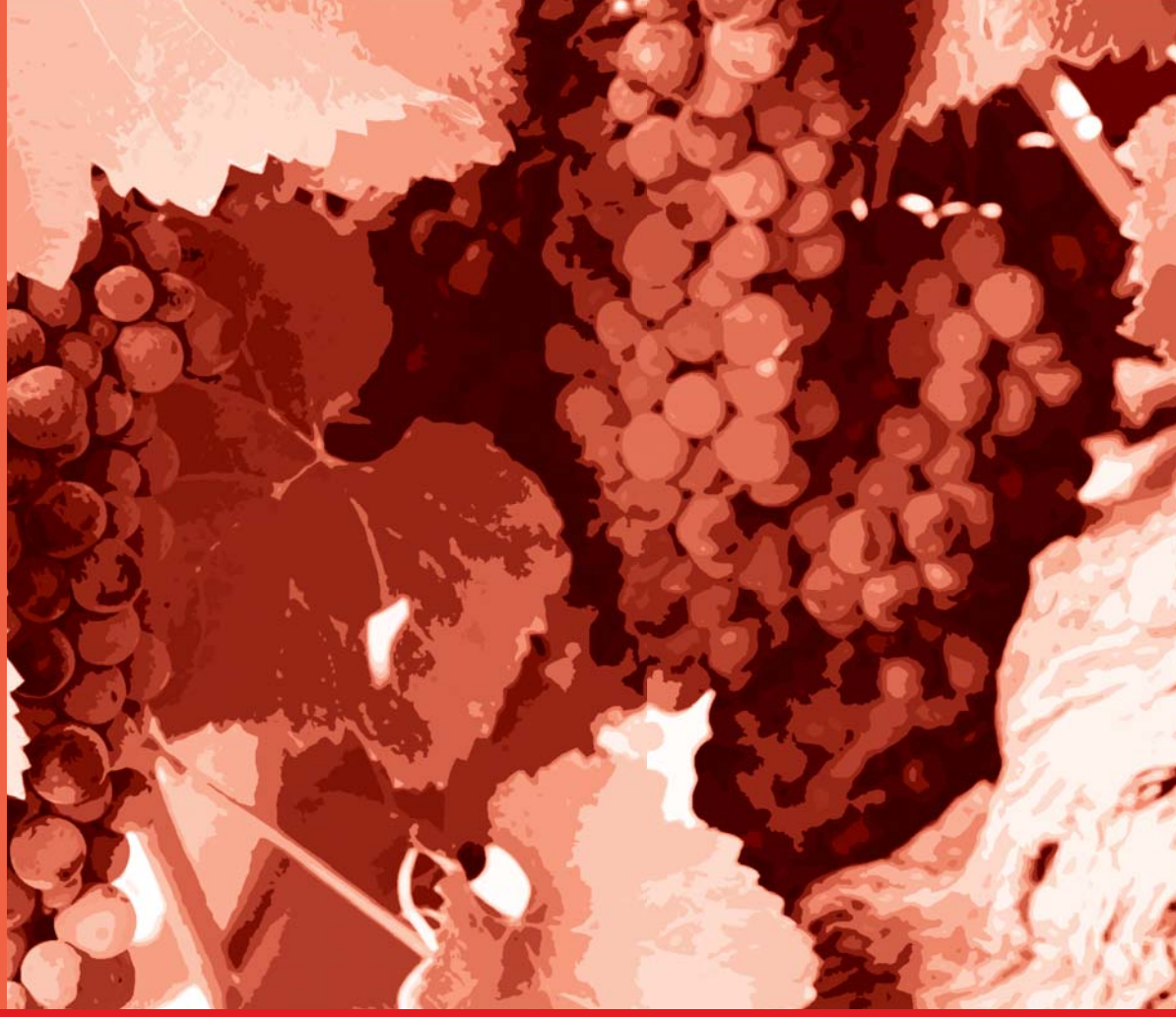
2



VITICARE ON FARM TRIALS

Manual 2.4 - Pests and Diseases

Management of botrytis and other bunch rots

Rust mite management

Pathogenic nematode management

Cooperative
Research Centre
for
Viticulture

Core Participants

About the CRCV

The Cooperative Research Centre for Viticulture is a joint venture between Australia's viticulture industry and leading research and education organisations. It promotes cooperative scientific research to accelerate quality viticultural management from vine to palate. Australian grapegrowers and winemakers are key stakeholders in the CRCV, contributing levies matched by the Commonwealth Government and invested by the Grape and Wine Research and Development Corporation in the Centre.

For more information about the CRCV, please visit www.crcv.com.au.

Disclaimer

Acknowledgments

The following growers have been directly involved in participatory on-farm trials and without them this manual would not exist.

Mal Barclay
Stuart Barclay, Tumbarumba Wines
Lachlan Campbell, Coolongatta Estate
Juliet Cullen, Excellsior Peak Vineyard
Dan Dujic
Cathy Gairns, Courabyra Vineyard
Ryan Johnstone, Warramate Vineyard
Jeff King, Warangesda Vineyard
Vincent Lackey, Ray Monde Vineyard
Simon Locke, Kyeamba Creek Vineyard
John Manfield, Panton Hill Vineyard
Gary Robinson, Minninya VIneyard
Peter Royal, Barters Vineyard
Graham Smith, Bradfield Park

The following people have made the development of this manual possible:

Ms Lee Bartlett, South Australian Research and Development Institute, Adelaide, South Australia (Manual 2.5)
Mr David Braybrook, VitiSolutions, Victoria
Ms Jo-Anne Deretic, Australian Quarantine Inspection Services, Melbourne, Victoria
Mr Marcus Everett, Southcorp, Mildura, Victoria (Manual 2.1)
Dr DeAnn Glenn, Grape and Wine Research and Development Corporation, Adelaide, South Australia
Mr Ian Goodwin, Department of Primary Industries, Tatura, Victoria (Manual 2.3, Manuals 3.1-3.3, editing)
Mr Shayne Hackett, NSW Agriculture, Wagga Wagga, New South Wales (Manual 2.2, 2.3, 2.6)
Mr Chris Haywood, NSW Agriculture, Gosford, New South Wales (Manual 2.4, 2.6)
Mr Graham Hepworth, Statistical Consulting Centre, University of Melbourne, Victoria (Manual 1)
Ms Vanessa Hood, Department to Primary Industries, Box Hill, Victoria
Dr Daryl Joyce, Department of Primary Industries, Knoxfield, Victoria (Manual 1, Manuals 2.1-2.6, editing)
Ms Natalie Laukart, Department of Primary Industries, Knoxfield, Victoria (Manual 1, 2.4, 2.6, Manuals 2.1-2.6, 3.1-3.3, editing)
Mr David Madge, Department of Primary Industries, Irymple, Victoria
Dr Peter Magarey, South Australian Research and Development Institute, Loxton, South Australia
Mr Darren Morrow, NSW Agriculture, Griffith, New South Wales
Mr Phil Nicholas, South Australian Research and Development Institute, Loxton, South Australia
Ms Carol Plummer, NSW (Manual 2.6)
Mr Loothfar Rahman, National Wine and Grape Industry Centre, Wagga Wagga (Manual 2.4)
Ms. Sheri Robinson, formerly CRC for Viticulture, Adelaide, South Australia
Ms Cassandra Schefe, Department of Primary Industries, Rutherglen, Victoria (Manual 2.1, 2.5)
Mr David Shearer, Department of Primary Industries, Box Hill, Victoria
Ms Sylvie Sicard, National Wine and Grape Industry Centre, Wagga Wagga, New South Wales
Dr William Slattery, CSIRO, Canberra, Australian Capital Territory
Mr Anthony Somers, NSW Agriculture, Tocal, New South Wales
Dr Robert Sward, Department of Primary Industries, Melbourne, Victoria
Ms Natalia Tostovrsnik, Department of Primary Industries, Knoxfield, Victoria
Dr Michael Treeby, CSIRO (Manual 2.2)
Mr Ashley Wheaton, Melbourne University, Dookie College, Victoria (Manual 2.1, 2.3, 2.5, Manuals 3.1 - 3.3, editing)
Dr Kevin Wilkinson, Department of Primary Industries, Knoxfield, Victoria (Manual 2.2)
Dr Chris Williams, South Australian Research and Development Institute, Adelaide, South Australia (Manual 2.5)
Dr Erika Winter, Department of Primary Industries, Knoxfield, Victoria

Contents

Introduction

Introduction

The Cooperative Research Centre for Viticulture has conducted On Farm Trials since 1999. The initial trials were conducted in eight regions (Port Phillip, North East Victoria, Central Victoria, Adelaide Hills, Riverland, South West Slopes, Riverina and Hunter Valley) and provided Australian growers with the ability to formally assess and validate new science and technology. The trials were conducted over four growing seasons and helped growers to solve problems in their vineyards and improve their management practices.

In 2004 the On Farm Trials project expanded to cover more than 20 viticultural trials primarily in the Riverina, Riverland and Sunraysia regions. Rather than focusing on individual grower issues, the CRCV team has worked with regional grower groups to determine regional issues. The trials are still conducted on a participant growers' property but a team of people are involved to learn from the trial and to share the workload.

This booklet is part of a series that draws on knowledge gained from this experience in developing and delivering On Farm Trials.

Conducting a trial in your vineyard is not easy and is not a decision that should be made lightly. Although trials can be an excellent method for refining management practices, improving quality or looking for solutions to problems, there are many practical considerations involved in conducting a trial.

On Farm Trials can lead to management improvements in a number of areas. The information in this booklet will guide you through the various protocols involved with setting up On Farm Trials that aim to manage Botrytis, other bunch rots, rust mites and pathogenic Nematodes.

Management of Botrytis and other Bunch Rots

Aims

This trial aims to manage Botrytis and other bunch rots by:

- Evaluating the control of Botrytis bunch rot using spray application
- At different growth stages
- Using a different spray program
- A combination of both.

- Reducing pesticide usage and apply other practices (Integrated Pest Management)
- Leaf plucking
- Bunch thinning
- Light Brown Apple Moth (LBAM) control
- Removing fruit stalks and trash

- Improving vine health
- Evaluate applications of Calcium and Nitrogen to overall vine health

Important Points to Know

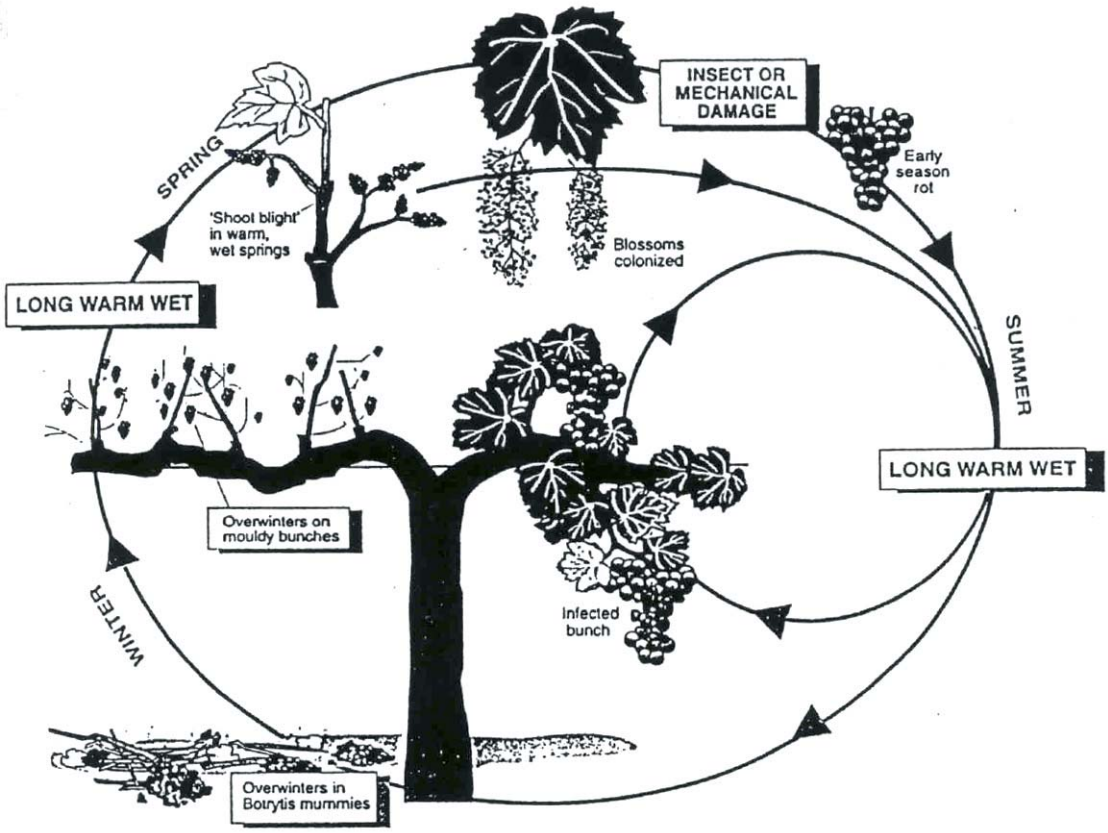
Botrytis cinerea is a fungus that is widespread throughout Australian vineyards. Botrytis can cause grey mould or bunch rot of grape bunches when wet weather occurs between veraison and harvest.

- Chemical sprays are the most widely used methods to control Botrytis bunch rot. However, often they do not provide sufficient control in seasons when disease pressure is high and resistance develops.
- Strategic spraying practices based on seasonal monitoring are required to increase the efficiency of fungicide treatments.
- This trial is only beneficial in regions or locations where Botrytis bunch rot is a significant issue

Botrytis cinerea over-winters on decaying plant debris as black resting bodies (sclerotia) or on dead canes and mummified berries, in the canopy or on the vineyard floor. Spores spread by the wind, infecting flower parts and occasionally individual berries during flowering. Spores also infect insect or mechanical damaged areas on the vine. Fungal growth occurs slowly within the green berries and more quickly as the sugar content of the berries increases (veraison). After the berries soften, the infection spreads to adjoining berries (nesting) or new infections occur from wind-carries spores. Under controlled conditions, wind speed and relative humidity are important in the development of aerial mycelia and conidia of B. cinerea.

B. cinerea generally occurs on mature grape berries during harvest especially after a late season rain. Some infections occur in the senescent floral tissue as early as four months before any noticeable symptoms of infection are obvious. This flower infection can instigate the development of high levels of Botrytis inoculum, which exposes the mature berries to greater infection pressure. The factors influencing the occurrence and severity of the diverse symptoms of bunch rot are difficult to predict. Figure 1 below illustrates the Botrytis lifecycle.

Figure 1: Botrytis lifecycle (Emmett et al. 1994)Positive and Negative Aspects



Positive and Negative Aspects

It is important to determine the risks associated with spray application and timing treatments at the proposed site. These risks must be weighed up against the potential benefits that a particular treatment may impart. Some risks may preclude trialing treatments on a particular site. At other sites, it may be sufficient to monitor a potential risk and have a contingency plan in place to deal with it if it occurs. The advantages and disadvantages of spray application and timing are listed below. These may be used as a guide to risks that may develop.

- Botryticides can harm natural predators depending on the chemical used and timing of the spray
- Good control can be achieved if good coverage/application is accomplished

In light of these issues, some questions worth considering are:

- Which risks are important at your site?
- Which risks would not prevent the trial proceeding but should be monitored?
- What plans need to be put in place to reduce the impact of any risks occurring?

Cost Benefit Analysis

In order to determine the financial viability of a Botrytis management program, a cost/benefit analysis should be completed to relate the monetary requirement of a spray program to a production basis. The risks associated with spray applications in vineyards must be weighed up against the benefits.

Before You Get Started

The following points will help you prepare for this trial:

- Spray unit to deliver application
- Knowledge and skills to use spray unit appropriately
- Appropriate chemicals and appropriate information on their mode of action
- Resistance status of local Botrytis strains

Site Suitability

One or more of the following site characteristics could make it highly suitable for conducting a pest or disease trial.

- The site should have had a significant amount of bunch rot, caused by Botrytis cinerea, in the previous season.
- High moisture in summer or hail in spring
- High rainfall just before harvest
- Declining health of vines
- Sunburn or bird damage of fruit common
- High incidence of other pests and disease eg: LBAM

Potential Treatments

1) Various fungicide treatment
a) Conventional treatment (control)
b) New fungicide

2) Application at various growth stages
a) Conventional application (control)
b) Pre-bunch closure application
c) Flowering and pre-bunch closure application

Measurements and Monitoring

Numerous measurements are applicable to a spray application trial. Unfortunately, no single sets of measurements are applicable to all trials. The correct measurements can only be selected once the trial's objectives have been clearly defined. Following is a list of potential measurements.

The following table indicates potential measurements for a Botrytis management trial, their time involvement, and difficulty.

Measurements	Time*	Difficulty*
Bunch sampling (after spray)	1	C
Vine vigour/shoot length	3	A
Pest and disease and/or bird damage	1	A
Disease visual assessment	1	A
Baumé	1	A
pH	1	B
Titratable acidity	1	C
Colour (anthocyanin)	2	C
Yield	2	A
Vine growth stages (phenology)	1	A

**Time is where 1 = few minutes per replicate, 2 = 15 minutes per replicate, 3 = >30 minutes per replicate; Difficulty is where A = easy, no laboratory skills and/or measurement equipment required, B = some laboratory skills and/or measurement equipment required, and C = laboratory skills and/or sophisticated measurement equipment required. Refer to complete Table 2.2 in Section #2: Trial Design and Variability.*

Trial Timelines

The trial involves the application of a pesticide at flowering and bunch closure and the assessment of Botrytis damage at harvest. The time required to carry out the treatments will be for application of chemical (3 hrs per application) and assessment at each treatment stage (flowering and bunch closure) (0.5 day for bunch sampling) and at harvest (0.5 day for bunch sampling).

Trials involving management of spray application should be run for a minimum of three years. Since seasonal conditions can affect the results it is difficult to measure any significant impact that a change in spray schedule or timing may have in the short term. It requires a number of years during which the pest/disease pressure may differ significantly.

Shaded areas in the following table indicate when measurements or samples suggested above are to be taken. See the measurement manual in this series for more information about measurement protocols.

	Dormancy	Bud burst	Shoots 10 cm	Flowering	50% capfall	Berry set	Berries pea-size	Bunch closure	Veraison	Harvest	Post-harvesty
Shoot length											
Botrytis assessment											
Spray application											
Bunch sampling											
LBAM assessment											

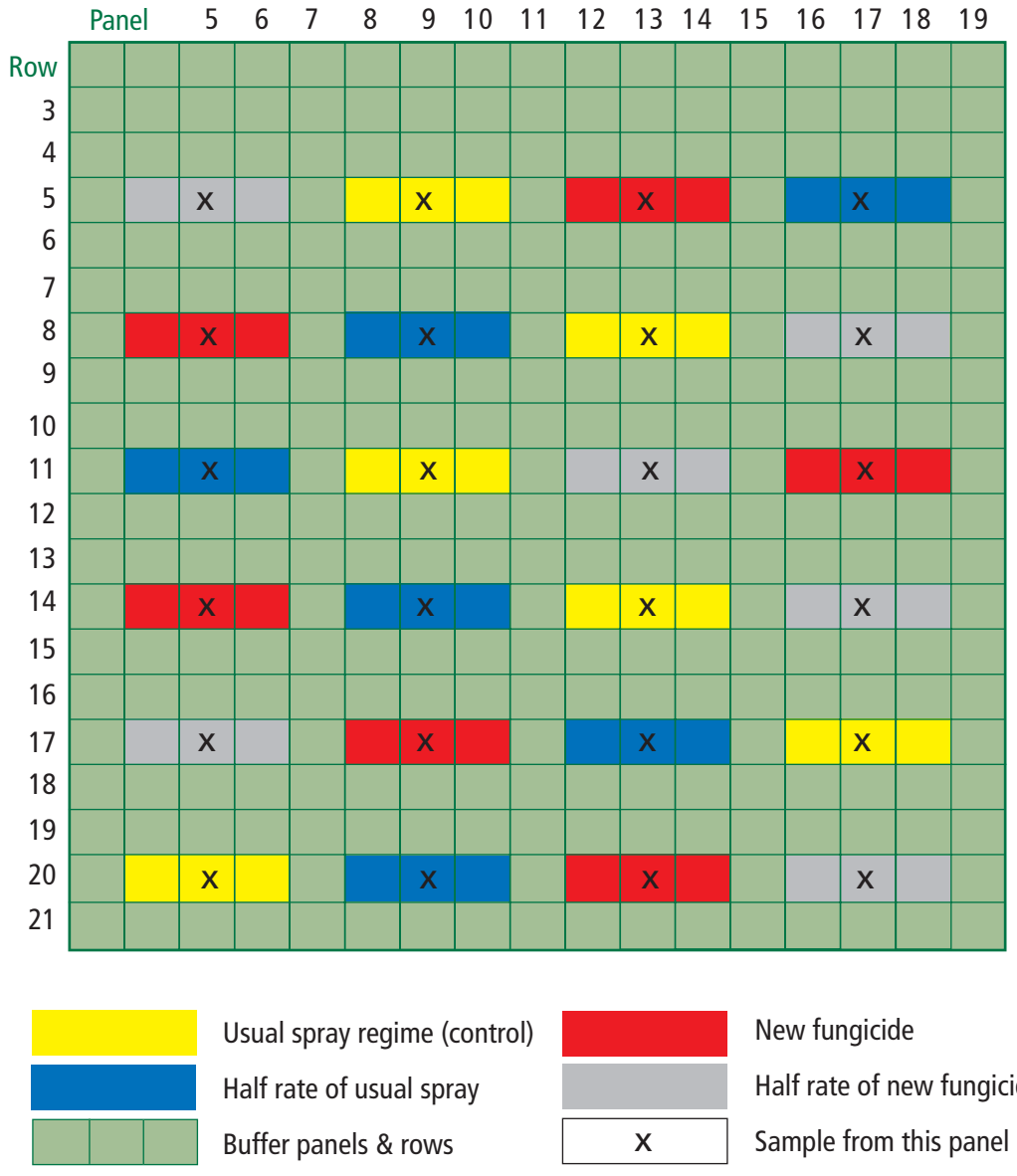
Botrytis and Bunch Rot Trial Designs

Treatments will need to be replicated within the trial area at least six to eight times, more if the area is not very uniform. One of the treatments should be a control, which will often be current practice. It is advised not to have more than three or four treatments to allow enough time for management of the trial.

Plots (or experimental units) can be different shapes and sizes, but a common plot in a liming trial consists of three rows by three panels of vines. The middle panel is used for taking measurements (for example, Row 5 Panel 5).

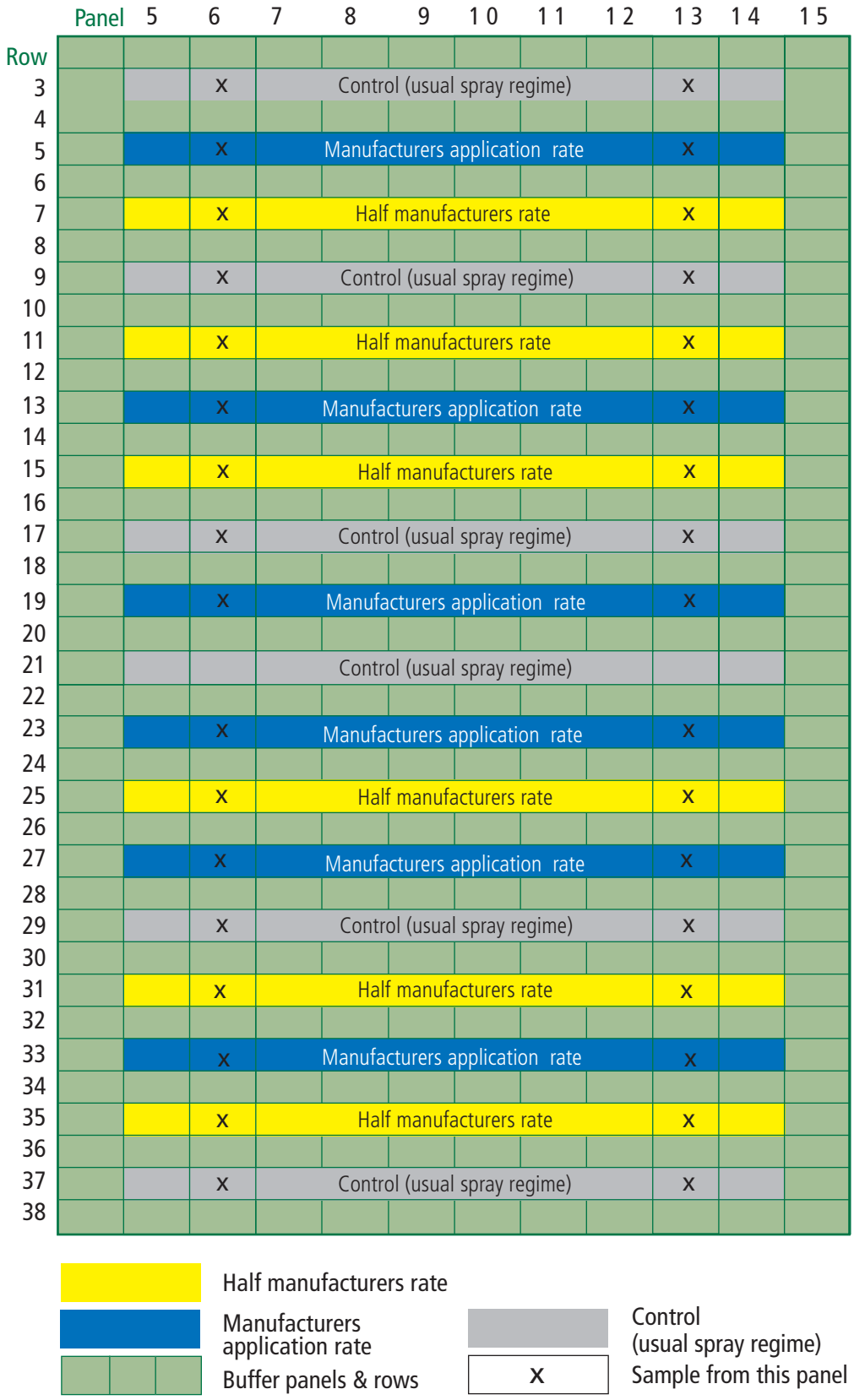
Buffering is important to identify clear treatment areas and to avoid contamination between treatment areas. Buffer zones are marked as panels with grid-lines in the following designs.

Design 1: An example of a randomised block design that could be used to assess the management of bunch rots using fungicides (for example, new fungicide, usual spray regime)



Design 1 gives an example of a trial layout in which a new fungicide is compared with the usual spray regime, at full and half rates. The trial has four treatments and six replications, arranged in a randomised block design, with the blocks being rows (or, more strictly, groups of three adjacent rows).

Design.2: An example of a trial design to test different rates of fungicides (manufacturers application rate, half the rate) using rows as experimental units.



Design 2 gives an example of a trial layout in which the treatments are two fungicide rates plus a control. It uses rows as experimental units as opposed to panels. This can make management of the trial (i.e. spray application) a little easier.

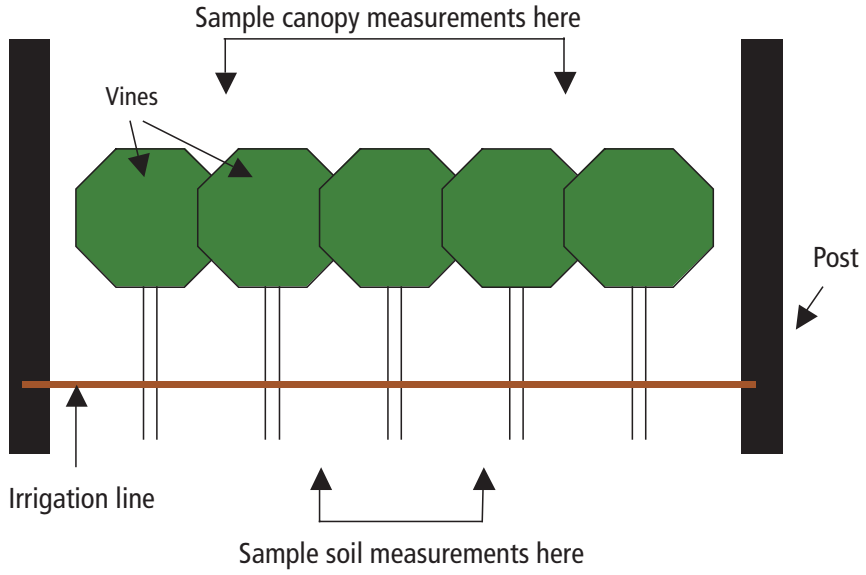
When using rows as experimental units, it is normally anticipated that a maximum of three treatments are trialed due to the potential workload expected. This trial has three treatments and six replications, again arranged in a randomised block design, with the blocks being groups of three adjacent experimental units.

It is recommended to only sample the middle vine in panels marked with an X (Designs 1 and 2) when taking vine measurements. If there are more than three vines per panel, only sample from the middle vines of the panels mentioned above (see Figure 1).

When taking soil measurements always sample from between two vines in the middle of each middle panel.

These recommendations will ensure that there is no contamination between plots; in some situations they may be waived provided that contamination is not a possibility. The approach described here also guarantees objectivity in the sampling, which will prevent the experimenter's bias from jeopardizing the results.

Figure 1: A diagrammatic explanation of where, within a panel, measurements can be taken.



Rust Mite Management

Aims

This trial aims to control Rust Mites by:

- Using different oil formulations
- Using different rates of oils

Important Points to Know

The grapevine rust mite is specific to grapevines and is one of the mite pests that causes most concern to the Australian viticultural industry. It is found throughout the grape growing regions of the world, including Australia and New Zealand. Too small to be seen with the naked eye, it is a microscopic pest 0.2 mm in length. It is similar in appearance to the grapevine bud and blister mites.

Rust mites feed on the upper and lower surface of grapevine leaves from spring to mid-late summer. The mite population may develop slowly in the cooler spring weather and can increase rapidly in hot summer weather causing the typical late summer bronzing of leaves. In mid to late summer they migrate from leaves to spend the winter under the bark of cordons and of the trunk near the vine crowns, and, to a much lesser extent, under the outer scales of dormant buds. In early spring they migrate from winter shelters to the swelling buds, where they lay their eggs. Rust mites disperse by active movement across overlapping foliage and canes, by wind, and other means such as human clothing (Bernard et al. 2001).

Two different types of rust mite damage symptoms occur on the vine: early spring and late summer symptoms. Early spring leaf distortion manifest as crinkling and shortening of growing shoots is most obvious soon after bud burst through to when 5-8 leaves are separated (E-L growth stages 12-15). After that, shoots and leaves progressively recover and damage is much less visible. However, residual signs of severe early spring damage can be detected in mature leaves throughout the growing season. If rust mite infection continues throughout the growing season, leaf crinkling is also visible in young leaves at the tips of shoots. The late summer/early autumn leaf bronzing symptoms caused by rust mite include the crinkled, distorted leaves resulting from early season rust mite damage and can often be mistaken for cold damage, phomopsis, bud mite, herbicide damage or restricted spring growth (RSG). Typical late summer/autumn reddish brown "bronzing" or darkening of leaves may occur from mid to late January to March. In red varieties, the bronzing often has a deep red hue. Affected leaves colour and fall early, showing dark markings overlaying the autumn colour. Berries may also be marked and may burst due to epidermal cell damage (Bernard et al. 2001).

Research by Bernard et al. (2001) has found that optimal timing of wettable sulphur sprays appears to be around the late woolly bud stage of Chardonnay. This also is at the onset of rust mite migration from winter shelters when the maximum daily temperature reaches 15°C. Sprays timed to the onset of spring migration have been found to be effective in controlling rust mite. Recent trials indicate that wettable sulphur sprays applied to control powdery mildew after budburst have no significant effect on reducing rust mite numbers. This could be due to the sulphur not acting on rust mite eggs or on poor spray coverage due to overlapping leaf canopy. Post harvest double rate wettable sulphur sprays appear to have no significant effect on reducing over-wintering rust mite numbers. Sprays that suppress predatory mite populations appear to induce rust mite outbreaks because predatory mites exert control of rust mites during the growing season (Bernard et al. 2000a, and Bernard et al. 2001).

It is important to note that when applying wettable sulphur sprays at woolly bud, the cordon needs to be drenched completely to reach its target. Therefore, when reducing the rate of oil added or the oil formulation it is important not to reduce the spray volume (Bernard et al. 2001).

Positive and Negative Aspects

It is important to determine the risks associated with a rust mite trial at the proposed site. These risks must be weighed up against the potential benefits that a particular treatment may impart. Some risks may preclude trialing treatments on a particular site. At other sites, it may be sufficient to monitor a potential risk and have a contingency plan in place to deal with it if it occurs.

The main risk involved in running a rust mite trial include:

- The possibility of phytotoxicity occurring on leaves if applying sprays later than the woolly bud stage
- The possibility of phytotoxicity occurring on vines that have buds more developed than woolly bud when testing winter oils
- Ineffective sprays if sulphur and oils are not mixed appropriately. Always mix chemicals as per manufacturers recommendations. In the case of oils and sulphur, always mix according to directions given on supastik™ label.

In light of these issues, some questions worth considering are:

- Which risks are important at your site?
- Which risks would not prevent the trial proceeding but should be monitored?
- What plans need to be put in place to reduce the impact of any risks occurring?

Cost Benefit Analysis

In order to determine the financial viability of a rust mite management program, a cost/benefit analysis should be completed, to relate the monetary requirement of spraying to a production basis. The risks associated with a spray application program against rust mites in vineyards must be weighed up against the benefits. This will justify the commitment to a spray program for rust mites in the long term.

Before You Get Started

The following points will help you prepare for this trial:

o Sulphur and a spray unit to deliver application is required.

Site Suitability

The site should have had a significant amount of autumn bronzing, caused by the rust mite, in the previous season.

Potential Treatments

1) Various oil formulations
a) Unrefined canola oil with standard sulphur application
b) Synertrol with standard sulphur application
c) Paraffin-based oils with standard sulphur application
d) Standard sulphur application (control)

2) Various application rates of oils
a) 2% oil at standard sulphur rate (to run-off at cordon)
b) 1% oil at standard sulphur rate (to run-off at cordon)
c) Standard application rate (control)

Measurements and Monitoring

The main measurement is listed below
The following table includes the measurement directly applicable to a rust mite trial, its time involvement, and difficulty.

Measurements	Time*	Difficulty*
Pest damage assessment	1	A

**Time is where 1 = few minutes per replicate, 2 = 15 minutes per replicate, 3 = >30 minutes per replicate; Difficulty is where A = easy, no laboratory skills and/or measurement equipment required, B = some laboratory skills and/or measurement equipment required, and C = laboratory skills and/or sophisticated measurement equipment required. Refer to complete Table 2.2 in Section #2: Trial Design and Variability.*

Trial Timelines

The trial involves the application of sulphur at woolly bud stage and the assessment of rust mite damage and population in early spring. The time required will be for application of chemical and assessment in early spring at the 5 leaves separated stage. The time required for assessing pest damage would be approximately 0.5 day.

Shaded areas in the following table indicate when measurements or samples suggested above are to be taken. See the measurement manual in this series for more information about measurement protocols.

	Dormancy	Bud burst	Shoots 10 cm	Flowering	50% capfall	Berry set	Berries pea-size	Bunch closure	Veraison	Harvest	Post-harvesty
Sulphur application											
Pest damage											

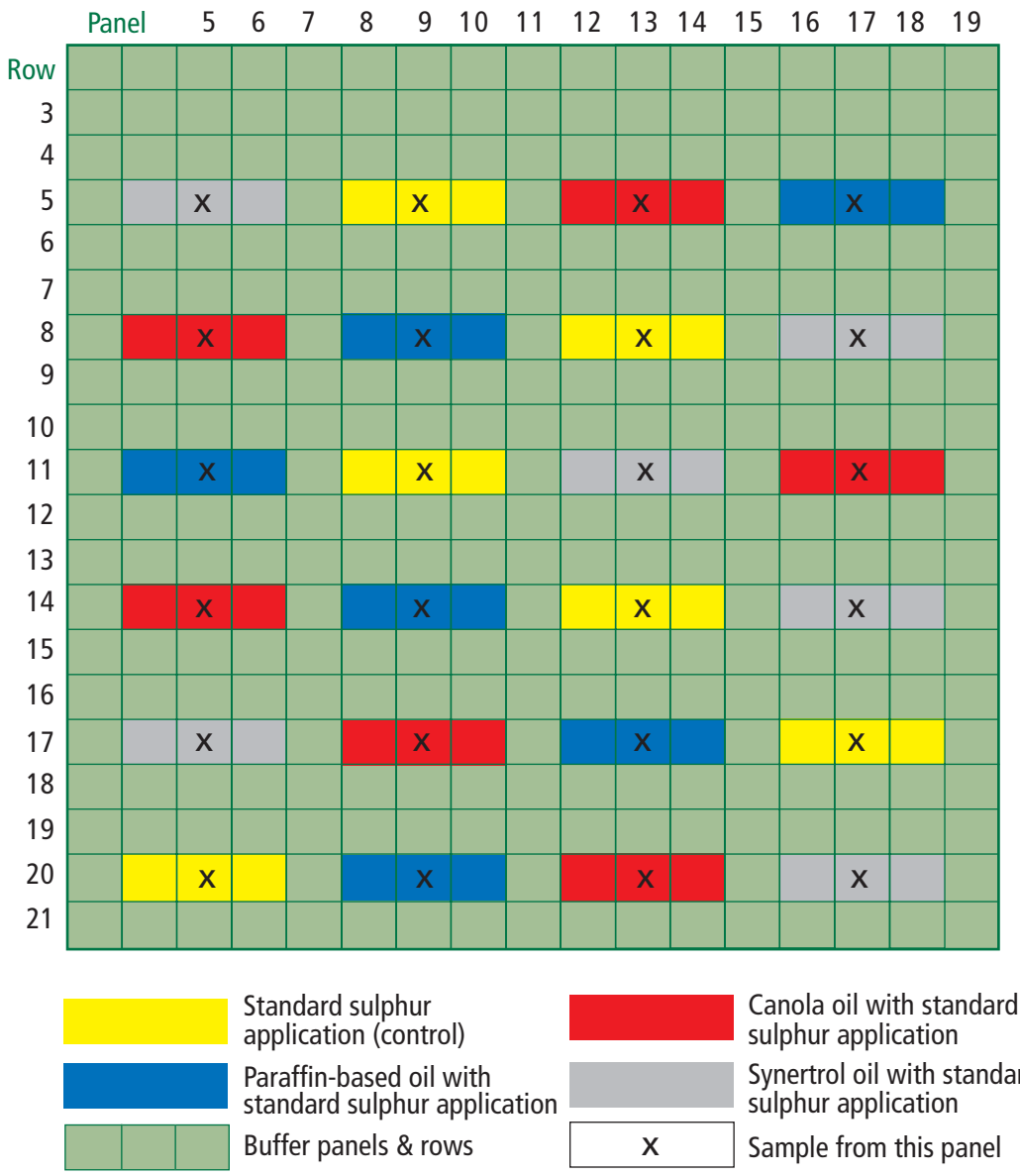
Rust Mite Trial Designs

Treatments will need to be replicated within the trial area at least six to eight times, more if the area is not very uniform. One of the treatments should be a control, which will often be current practice. It is advised not to have more than three or four treatments to allow enough time for management of the trial.

Plots (or experimental units) can be different shapes and sizes, but a common plot in a liming trial consists of three rows by three panels of vines. The middle panel is used for taking measurements (for example, Row 5 Panel 5).

Buffering is important to identify clear treatment areas and to avoid contamination between treatment areas. Buffer zones are marked as panels with grid-lines in the following designs.

Design .1: An example of a randomised block design that could be used to manage rust mites testing various oils (for example, paraffin-based oil, synertrol oil).



Design.1 gives an example of a trial layout in which the treatments are Three different oils plus a control (standard sulphur application). The trial has four treatments and six replications, arranged in a randomised block design, with the blocks being rows (or, more strictly, groups of 3 adjacent rows).

Design 2: An example of a trial design to test different oil application rates (2% oil, 1% oil) using rows as experimental units.

Row	Panel 5	6	7	8	9	10	11	12	13	14	15
3		X	Standard sulphur rates (control)						X		
4											
5		X	1% oil at standard sulphur rate						X		
6											
7		X	2% oil at standard sulphur rates						X		
8											
9		X	Standard sulphur rates (control)						X		
10											
11		X	2% oil at standard sulphur rates						X		
12											
13		X	1% oil at standard sulphur rate						X		
14											
15		X	2% oil at standard sulphur rates						X		
16											
17		X	Standard sulphur rates (control)						X		
18											
19		X	1% oil at standard sulphur rate						X		
20											
21			Standard sulphur rates (control)								
22											
23		X	1% oil at standard sulphur rate						X		
24											
25		X	2% oil at standard sulphur rates						X		
26											
27		X	1% oil at standard sulphur rate						X		
28											
29		X	Standard sulphur rates (control)						X		
30											
31		X	2% oil at standard sulphur rates						X		
32											
33		X	1% oil at standard sulphur rate						X		
34											
35		X	2% oil at standard sulphur rates						X		
36											
37		X	Standard sulphur rates (control)						X		
38											

2% oil at standard sulphur rates

1% oil at standard sulphur rate

Buffer panels & rows

Standard sulphur rate (control)

X Sample from this panel

Design 2 gives an example of a trial layout in which the treatments are two oil application rates plus a control. It uses rows as experimental units as opposed to panels. This can make management of the trial (i.e. spray application) a little easier.

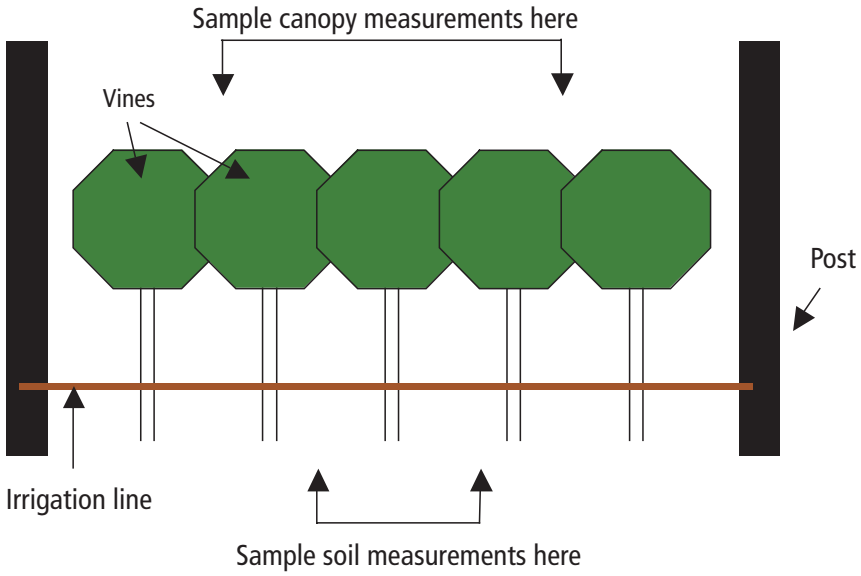
When using rows as experimental units, it is normally anticipated that a maximum of three treatments are trialed due to the potential workload expected. . This trial has three treatments and six replications, again arranged in a randomised block design, with the blocks being groups of three adjacent experimental units.

It is recommended to only sample the middle vine in panels marked with an X (Designs 1 and 2) when taking vine measurements. If there are more than three vines per panel, only sample from the middle vines of the panels mentioned above (see Figure 1).

When taking soil measurements always sample from between two vines in the middle of each middle panel.

These recommendations will ensure that there is no contamination between plots; in some situations they may be waived provided such contamination is not a possibility. The approach described here also guarantees objectivity in the sampling, thus preventing the experimenter's bias from jeopardising the results.

Figure 1: A diagrammatic explanation of where, within a panel, measurements can be taken.



Pathogenic Nematode Management

Aims

This trial aims to manage pathogenic Nematodes by:

- Comparing the efficacy of treatments for the reduction of the population levels of pathogenic nematodes - mainly: Meloidogyne sp. (root-knot nematode) and Pratylenchus sp. (root lesion nematode) in the soil.

Important Points to Know

Nematodes are unsegmented worms (microscopic wormlike animals) that live in the soil. They can survive in soil and plant material at low population levels in a dormant state in the absence of a host and by over-wintering during cooler months.

Plant-parasitic nematodes obtain their nutrients exclusively from living plants. Whilst feeding, they damage roots, which restricts nutrient uptake by the plant. This encourages secondary infestations from fungi and bacteria that may cause vine decline or eventual death. Pathogenic nematodes feed on the abundant fibrous roots located in the under vine row. Treating the under-vine row area may provide effective management of nematode populations in vineyards.

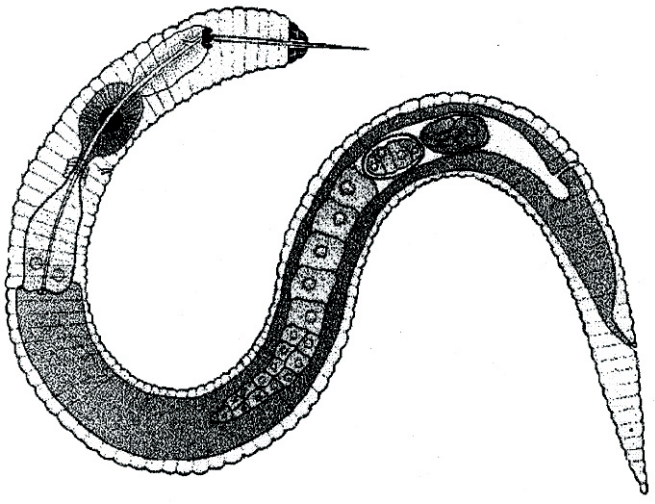


Figure 1: A typical plant-parasitic nematode (female)
(Esser, R.P. 2002)

The signs and symptoms that can be attributed to plant-pathogenic nematode presence includes:

- A reduction in grape yield
- Poor vine health
- Poor vine growth
- Sparse canopy
- Stunted vines
- Galling roots or lesions on the roots (may also be caused by phylloxera)
- Destruction of the feeder roots (root mass reduction)
- Vine decline or death (in severe cases)

Several nematode species have been identified as important pests throughout most viticultural regions within Australia. Each species has a different life cycle and biology. They are favoured by a variety of environmental conditions. Therefore, it is important to identify what species are present in each individual vineyard to establish a preferred method of treatment. Due to their microscopic size, nematodes cannot be identified in the field. It is necessary to collect soil and/or root samples. These samples need to be analysed by a laboratory, which identifies nematode species. If your vineyard is planted on rootstocks, it is essential to find out if your rootstock is nematode resistant as this may have an effect on your trial design. Different rootstocks may effect the numbers of nematodes in the soil and the treatments required for a nematode management trial.

Treatment methods vary from biofumigants to nematicides that can have different effects on vineyard sustainability. Nematicides control all types of nematodes and have a longer residual effect than biofumigants. The preferred method for controlling nematodes is to plant resistant rootstocks.

Positive and Negative Aspects

It is important to determine the risks associated with a nematode trial at the proposed site. These risks must be weighed up against the potential benefits that a particular treatment may impart. Some risks may preclude trialing treatments on a particular site. At other sites, it may be sufficient to monitor a potential risk and have a contingency plan in place to deal with it if it occurs. The advantages and disadvantages of biofumigant or nematicide application are listed below. These may be used as a guide to risks that may develop.

Advantages of Biofumigant applications in vineyards include:

- If a site with hard-setting and/or crusting has an impenetrable soil layer within 500
- Increase other beneficial microbes in the soil
- No chemical residue in/on fruit/vine
- Cheaper than nematicides
- More effective in young vineyards compared to older vineyards

Disadvantages of Biofumigant applications in vineyards include:

- Slow effect
- Can harvest some pests
- Low persistence in the soil
- May not penetrate inside the root
- Possible alelopathic effect High labour

Advantages of Nematicide applications in vineyards include:

- Quick effect on infestation
- Quick application
- Low labour requirements
- Systemic action

Disadvantages of Nematicide applications in vineyards include:

- Soil degradation
- Chemical residue in fruit
- Soil pollution
- Can kill other beneficial microbes
- Persistent in the soil

In light of these issues, some questions worth considering are:

- Which risks are important at your site?
- Which risks would not prevent the trial proceeding but should be monitored?
- What plans need to be put in place to reduce the impact of any risks occurring?

Cost Benefit Analysis

In order to determine the financial viability of a nematode program, a cost/benefit analysis should be completed to relate the monetary requirement of mulching to a production basis. The risks associated with a nematode program in vineyards must be weighed up against the benefits. This will justify the commitment to an irrigation program in the long term.

Before You Get Started

The following points will help you prepare for this trial:

- Cover crop, mulch and labour to apply
- If cover crop is used, fertiliser will be required for its establishment
- A seeder will be required to sow the cover crops
- A mower will be required to slash the cover crop under the vine
- A disc plough to cover the slashing with some soil
- Labour to sample soil for analysis
- Knowledge in use of equipment

Site Suitability

Previous cropping history

- Species of previous crops such as:
- Fruit crops
- Field crops
- Cover crops
- Vegetables
- Weeds
- Ornamentals

Climate

- Warm summer months (favours population increase in nematodes)

Soil

- Sandy soils (nematodes commonly favour these soil types as vines are more susceptible to stress from irrigation)
- Heavy clay
- Shallow soil
- Highly stratified soil
- Vertical distribution in the soil profile (nematodes usually mirror the distribution of the crop root system in the presence of a preferred host)

Vines

- Rootstock susceptibility or resistance to nematode infestations
- Own rooted vines
- Declining health of vines
- Declining productivity and/or quality
- Presence of lesions or galls on roots
- Low root density
- Discolouration or darkening of roots
- Nematode host plants growing on site

The following includes various plant species that are known to be host for nematodes ie. weeds, grasses and legumes.

Legumes	Grasses	Weeds
Faba Beans	Some varieties of Oats	Fat hen
Vetch	Triticale Prickly	lettuce
Clover	Rye	Purple Calandrinia
Field peas		Annual Sowthistle
		Love grass

Potential Treatments

1) Hot water treatment of plant material before being planted in the vineyard.
2) Different Biofumigation Treatments:
a) Green manure
i) Mustard inter-row
ii) Fodder rape
iii) Fodder radish
iv) Marigolds cv petite Yellow and cv Cracker Jack
b) Mulches
i) Mustard seed meal (under vine)
ii) Chicken litter
3) Variable sowing/application rates of the above treatments
a) Manufacturer sowing rates
b) Two times the manufacturer sowing rates
c) Half the manufacturer sowing rate
d) Usual crop in vineyard (if any) - control
4) A range of chemicals
a) Nematicide

** Few products are registered and available in Australia. For more information regarding suitable products, please contact your local chemical provider.*

Measurements and Monitoring

There are numerous measurements that are applicable to conducting a nematode management trial. Unfortunately there is no single set of measurements that are applicable to all trials. The correct measurements can only be selected once the objectives of the trial have been clearly defined. The following is a list of potential measurements.

The following table includes potential measurements for managing pathogenic Nematodes, their time involvement, and difficulty.

Measurements	Time*	Difficulty*
Soil temperature	1	A
Shoot length	3	A
Nematode population level	1	C
Baumé	1	A
pH	1	B
Titratable acidity	1	C
Colour (anthocyanin)	2	C
Yield	2	A
Pruning weight	2	A
Vine growth stages (phenology)	1	A

**Time is where 1 = few minutes per replicate, 2 = 15 minutes per replicate, 3 = >30 minutes per replicate; Difficulty is where A = easy, no laboratory skills and/or measurement equipment required, B = some laboratory skills and/or measurement equipment required, and C = laboratory skills and/or sophisticated measurement equipment required. Refer to complete Table 2.2 in Section #2: Trial Design and Variability.*

Trial Timelines

Trials involving biofumigants should be run for a minimum of 3 years. The impact of increasing soil biofumigant compounds is difficult to measure in short term trials. The cumulative effect of biofumigant over several years will result in a better effectiveness of the treatment. In addition, the initial cost of cover crops/ chicken litter application may be justified by showing benefits occurring for successive seasons. Cover crops are usually sown in autumn while other treatments are applied later as in the following example:

- Sow Brassica crops in autumn
- Spread chicken litter at Brassica during flowering
- Spread mustard seed meal early spring at the same time as slashing of Brassica
- Slash Brassica crop and throw under vine early spring
- Sample soil for nematode counting before harvest

The required time to take appropriate measurements would be approximately 0.5 day for any of the soil measurements, 0.5 day for pruning weights and shoot length, a full day (1.0) for nematode assessments and 0.5 day for bunch sampling for quality parameters at harvest.

Shaded areas in the following table indicate when measurements or samples suggested above are to be taken by shaded areas. See the measurement manual in this series for more information about measurement protocols.

	Dormancy	Bud burst	Shoots 10 cm	Flowering	50% capfall	Berry set	Berries pea-size	Bunch closure	Veraison	Harvest	Post-harvesty
Shoot length											
Grape quality											
Yield											
Pruning weights											
Soil temperature											
Root examination											
Nematode assessment											

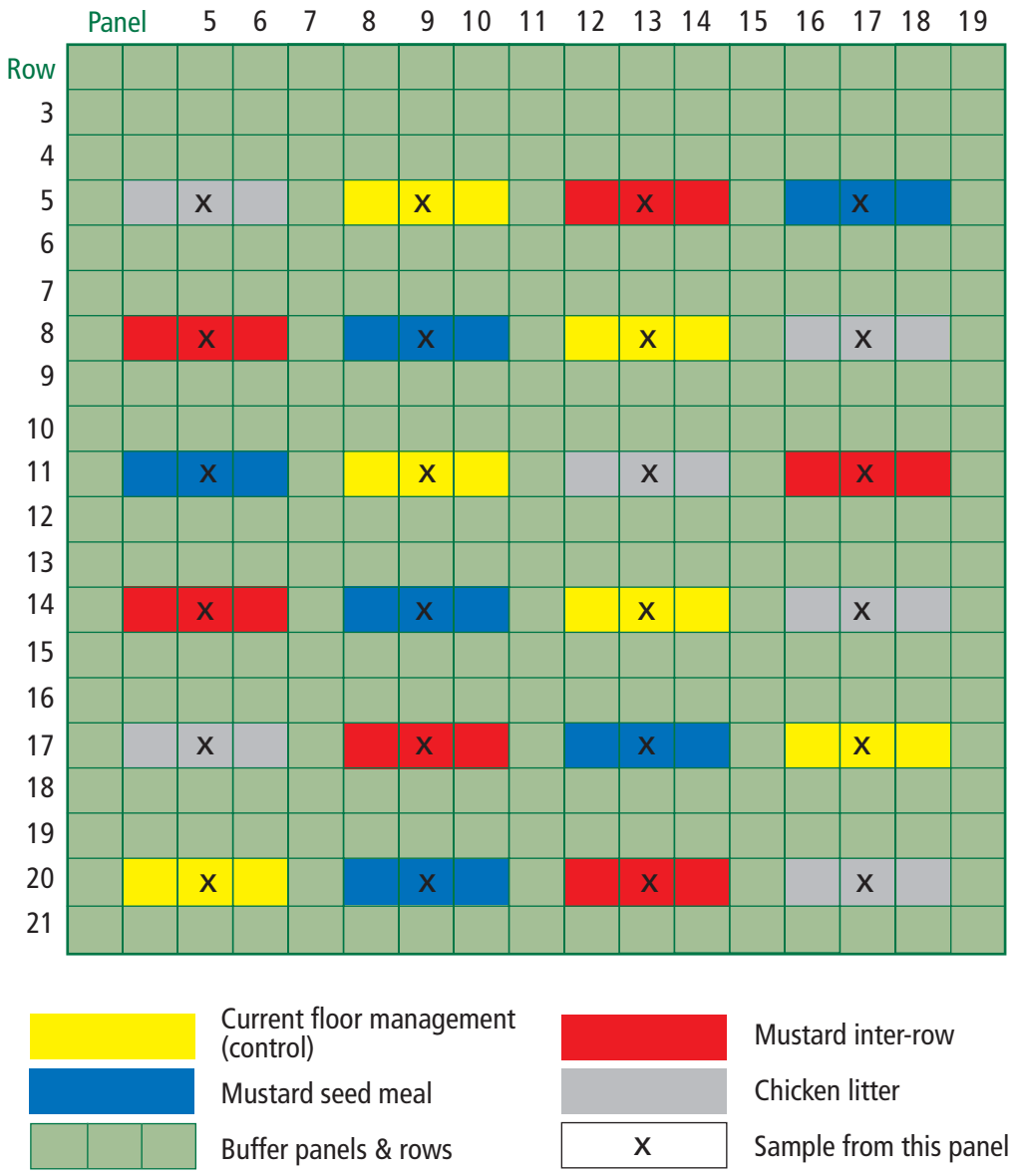
Nematode Trial Designs

Treatments will need to be replicated within the trial area at least six to eight times, more if the area is not very uniform. One of the treatments should be a control, which will often be current practice. It is advised not to have more than three or four treatments, to allow enough time for management of the trial.

Plots (or experimental units) can be different shapes and sizes, but a common plot in a biofumigation trial consists of three rows by three panels of vines.

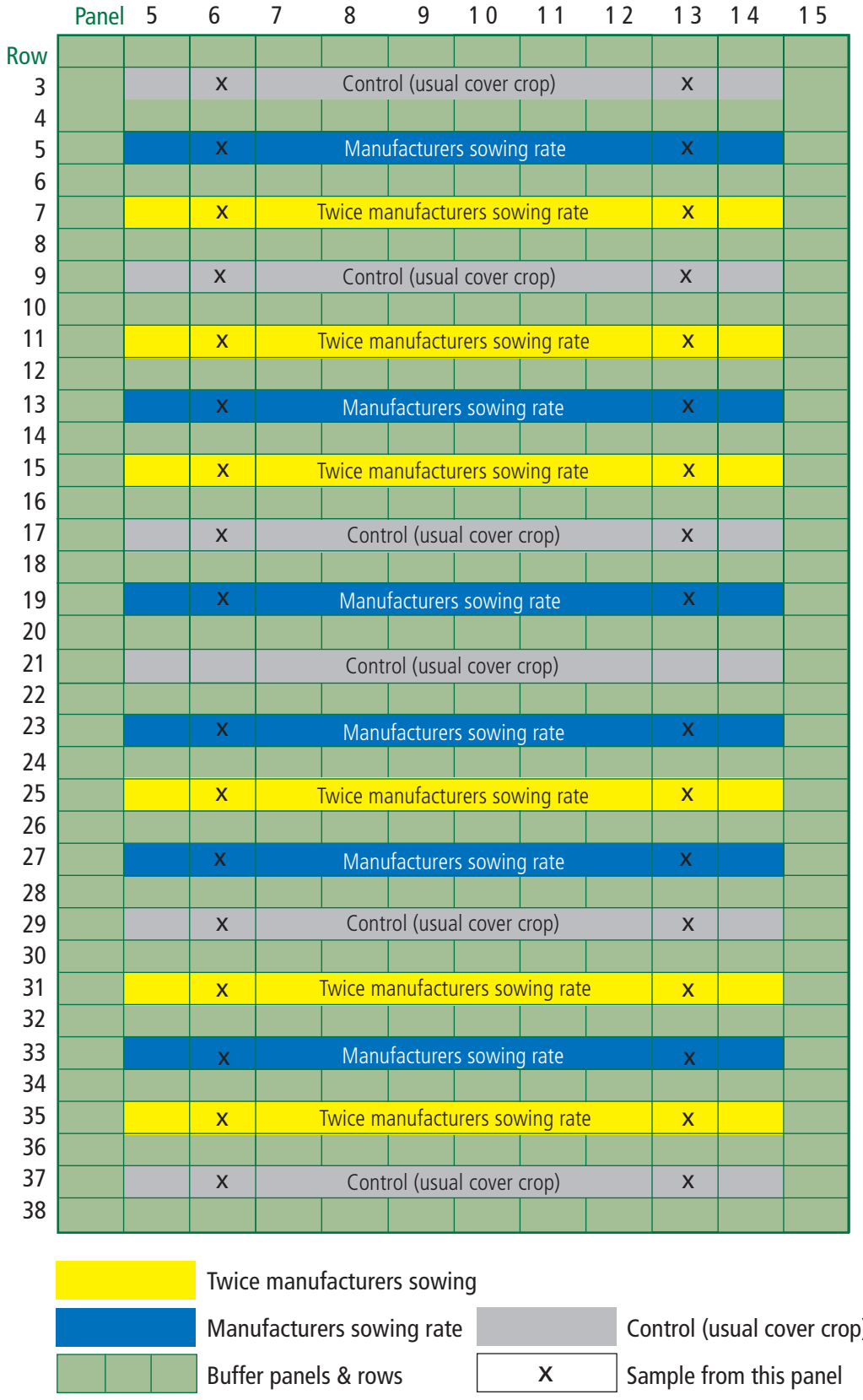
The middle panel is used for taking measurements (for example, Row 5 Panel 5). Buffering is important to identify clear treatment areas and to avoid contamination between treatment areas. Buffer zones are marked as panels with grid-lines in the following designs.

Design 1: An example of a randomised block design that could be used to test various biofumigants (for example, mustard seed meal, chicken litter).



Design 1 gives an example of a trial layout in which the treatments are three biofumigant applications plus a control (current floor management). The trial has 4 treatments and 6 replications, arranged in a randomised block design, with the blocks being rows (or, more strictly, groups of 3 adjacent rows).

Design.2: An example of a trial design to test different rates of cover crops (manufacturers sowing rate, double the rate, and half the rate) using rows as experimental units.



Design .2 gives an example of a trial layout in which the treatments are two biofumigant sowing rates plus a control. It uses rows as experimental units as opposed to panels. This can make management of the trial (i.e. sowing of biofumigant treatments) a little easier.

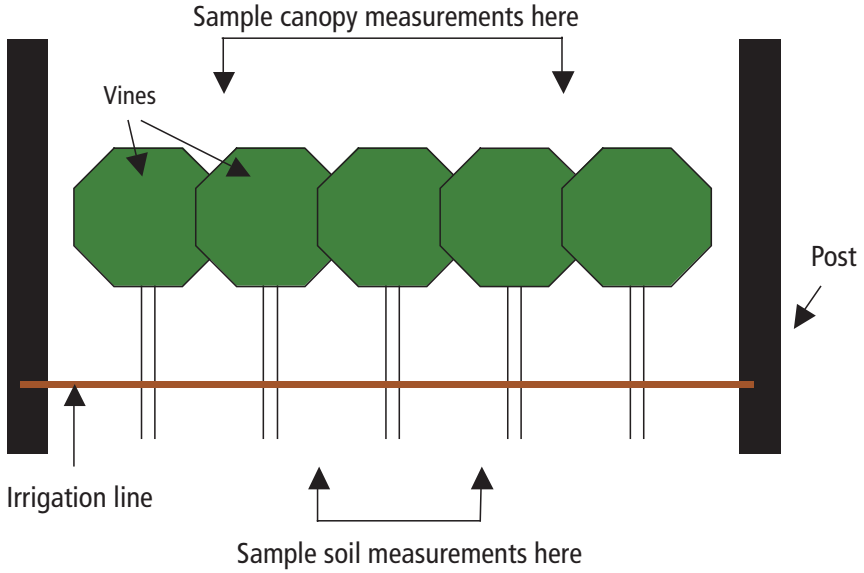
When using rows as experimental units, it is normally anticipated that a maximum of three treatments are trialed due to the potential workload expected. This trial has three treatments and six replications, again arranged in a randomised block design, with the blocks being groups of three adjacent experimental units.

It is recommended to only sample the middle vine in panels marked with an X (Designs 1 and 2) when taking vine measurements. If there are more than three vines per panel, only sample from the middle vines of the panels mentioned above (see Figure 1).

When taking soil measurements always sample from between two vines in the middle of each middle panel.

These recommendations will ensure that there is no contamination between plots; in some situations they may be waived provided that contamination is not a possibility. The approach described here also guarantees objectivity in the sampling, which will prevent the experimenter's bias from jeopardizing the results.

Figure 1: A diagrammatic explanation of where, within a panel, measurements can be taken.



Resources

Some useful resources for management of botrytis and other bunch rots include:

- Braybrook D., Whiting J., Cole M. and Hall B. (2002). Botrytis - how it infects and how growers should manage this major fungal disease. Australian Viticulture 6: 36 - 42
- Emmett R.W., Nair, T., Balasubramaniam R. and Pak H.A. (1994) Botrytis and other bunch rots In: Nicholas P., Magarey P. and Wachtel M. (edts) 'Diseases and Pests' (Winetitles, Australia) pp 17-21
- Hall B. and Emmett B. (2001) Australia's main bunch rots - symptoms and characteristics. Australian Viticulture 5: 62 - 72
- Nicholas P., Magarey P. and Wachtel T. (1994) Diseases and Pests. Winetitles, Adelaide

Some useful resources for management of rust mites include:

- Bernard M., Braybrook D., Hurst P., Hoffmann A. and Glenn D. (2000a) Mites - the classic 'who done it?' The Australian Grapegrower and Winemaker 438: 28 - 31
- Bernard M., Horne P. and Hoffmann A. (2001) Preventing restricted spring growth. The Australian Grapegrower and Winemaker 452: 16 - 22, 453: 26
- Bernard M., Hoffmann A. and Glenn D. 2000b. The biology and integrated management of grapevine rust mite, Calepitrimerus vitis (Nalepa) in Australia. Proceedings of the 5th International Symposium on Cool Climate Viticulture and Oenology. Melbourne, Australia
- Ludvigsen N. (2000) Mites - strategies for control. The Australian Grapegrower and Winemaker. 437: 13 - 14

Resources

Some useful resources for management of pathogenic nematodes include:

- Ingels C.A., Bugg R.L., McGourty G.T. and Christensen L.P. (1998) Cover cropping in vineyards: a grower handbook. University of California, Division of Agriculture and Natural Resources, Publication 3338: 113-125
- Nicol J. (1998) Integrated Pest and Disease Management Manual, Nematodes section, DNRE
- Rahman L., Somers T. and Creecy H. (2000) Distribution of nematodes in vineyards and relationship of root knot nematode (Meloidogyne sp) to vine growth and yield. The Australian Grapegrower & Winemaker Annual Technical Issue 438a: 53-57
- Rahman L. and Somers T. (2003) Distribution and control of root knot nematode using biofumigation in vineyards (in press)
- Riegel C. and Noe J.P. (2000) Chicken Litter Amendment Effects on Soilborne Microbes and Meloidogyne incognita on Cotton. The American Phytopathological Society. Publication no. D-2000-0925-02R, Plant Disease, December, p.1275-1281
- Stirling G., Nicol J. and Reay, F. (1999) Advisory Services for Nematode Pests, Operational Guidelines, Rural Research and Development Corporation, RIRDC publication No 99/41, April, 111 pages
- Walker G. and Morey B. (2000) Effects of lesion nematodes associated with cereals on grapevine growth. The Australian Grapegrower and Winemaker Annual Technical Issue 438a: 130 - 132

Web-based:

- University of Nebraska (2003) Plant and insect parasitic nematodes. Last accessed 20 May 2003. http://nematode.unl.edu/
- United States Department of Agriculture - Beltsville Agricultural research Centre (2002) Nematode basics. Last accessed 20 May 2003. www.barc.usda.gov/psi/nem/basics-r.htm
- Walker G. and Morey B. (2001) Seasonal variation in abundance of lesion ematodes in grapevines. Last accessed 20 May 2003. http://www.grapeandwine.com.au/feb01/010207.htm