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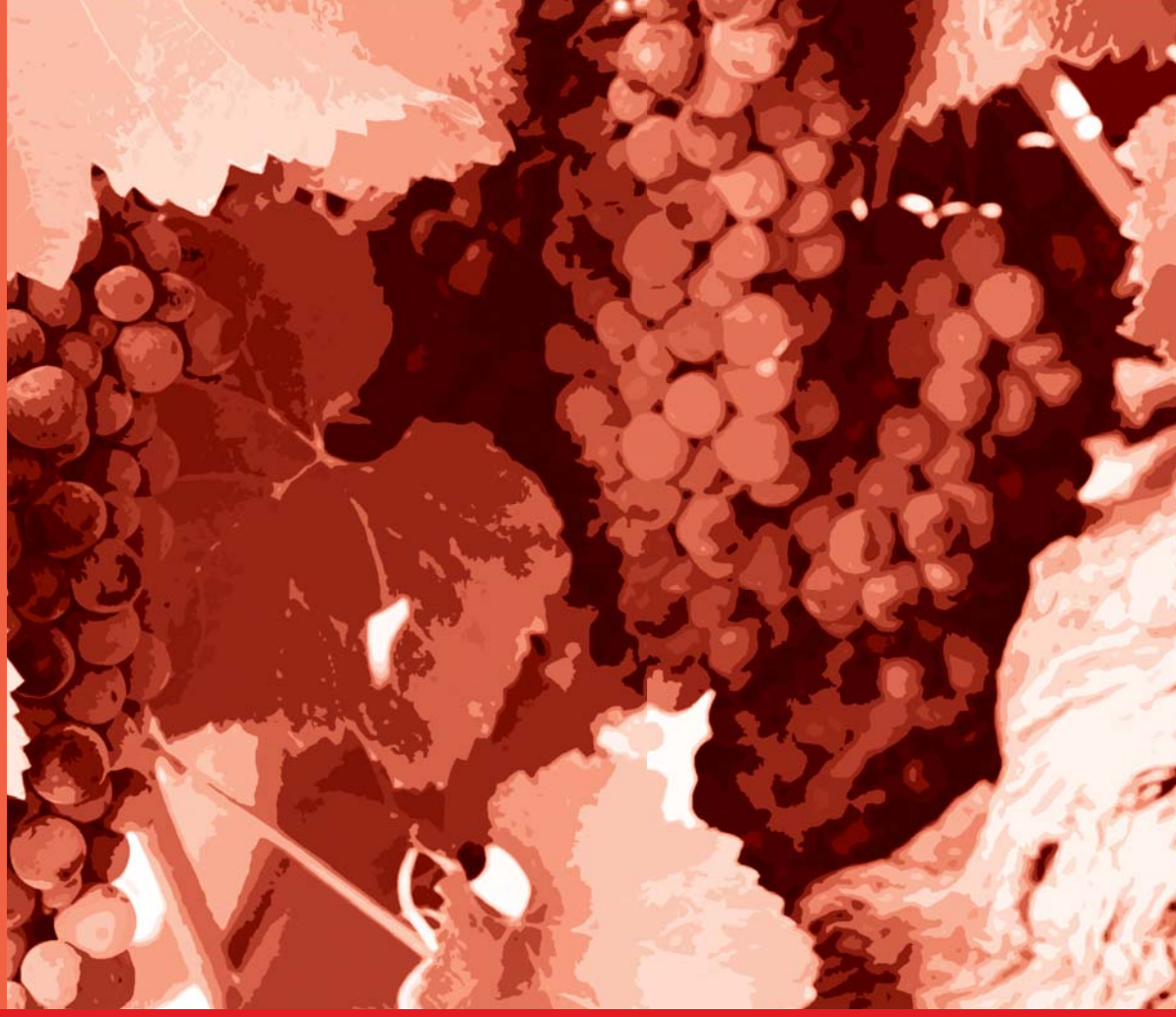

VITICARE ON FARM TRIALS

Manual 2.5 - Vine Nutrition

Managing nitrogen inputs to optimise grape yield and quality

Detecting phosphorous response in vineyards - forms of P, application methods and rates

Molybdenum and other trace element vineyard trials

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)
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Ms Cassandra Schefe, Department of Primary Industries, Rutherglen, Victoria (Manual 2.1, 2.5)
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Mr Ashley Wheaton, Melbourne University, Dookie College, Victoria (Manual 2.1, 2.3, 2.5, Manuals 3.1 - 3.3, editing)
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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 nitrogen inputs to optimise grape yield and quality, detect phosphorous response in vineyards - forms of P, application methods and rates, evaluate the vine requirement for Molybdenum and other trace elements.

Managing Nitrogen Inputs to Optimise Grape Yield and Quality

Aims

This trial aims to:

- Evaluate strategies for nitrogen management
- Decrease nitrogen use
- Improve overall vine health
- Reduce N loss through leaching
- Increase grape production

Important Points to Know

Excess nitrogen (N) can impact on grape production by increasing vigour and delaying fruit maturity. The shading of basal buds in vigorous vines can reduce yield potential and can be associated with a reduction in bud fertility and fruit set. Excess vigour at flowering may cause bunch shatter.

The nitrate form of N is a transient form present in the leaf/petiole. It is one of the easiest N forms to analyse and is a useful indicator of vine N status. However, N data gained from petiole tests at flowering should not be used in isolation to interpret vine requirements. Test results should always be compared to vigour and yield observations etc. For example, if N is being metabolised as rapidly as it is absorbed by the vine roots, the N concentration in the plant will be low and so petiole tests may not give an accurate picture.

Soil N requires the movement of water to travel towards the vine roots. If the availability of water in the soil is reduced, nitrogen availability will also be reduced. However, if soil water is adequate, the vine rapidly takes up applied N fertiliser. Tissue testing at this time will result in transiently high N values, which do not reflect the true N status of the vine.

Large changes occur in nitrate levels in grapevines during the growing season and are not always predictable. The vine itself has large reserves of complex-nitrogen in plant tissue, which is mobilised during the early part of the growing season. These N forms may not be detected in petiole tests for nitrate, and so cannot be accurately quantified.

Positive and Negative Aspects

It is important to determine the risks associated with a nitrogen 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 potential risks of nitrogen application in vineyards are listed below. These may be used as a guide to identify risks that may develop.

- High background soil levels of N
- High input of N from other sources eg. Organic amendments applied.
- Different varieties may respond to applications of N with more/less vigour, requiring different management practices/application rates required
- Fertigation output may not be uniform, resulting in variation in N application across the vineyard.

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 economic viability of a nutrition program, a cost/benefit analysis should be completed to relate the monetary requirement of Nitrogen application to a production basis. The risks associated with a nitrogen program in vineyards must be weighed up against the benefits. This will justify the commitment to an efficient irrigation program in the long term.

Before You Get Started

The following requirements will help you prepare for this trial:

- Nitrogen fertiliser
- Fertigation equipment - if through fertigation
- Portable injection unit - if through fertigation

Site Suitability

Vines

- Young vines slow to establish
- Low vegetative growth
- Declining health of vines
- Declining productivity
- Poor ability to ripen crop
- Poor fruit quality
- Yellow leaves

Water/Irrigation

- Equipment for fertigation
- Use saline irrigation water (>1.0 dS/m)
- Use pure irrigation water (<0.01 dS/m)

Potential Treatments

There are several different ways to conduct trials for N management:

1) Compare rates of nitrogen application:
   a) None
   b) Current rates
   c) 1/2 current rates
   d) Rates based upon crop removal (eg. 1.2 - 2.4 kg N/tonne grapes removed)
2) Examine impact of timing of application
   In each region different climatic conditions may alter optimal timing of N applications. For example, in cooler areas, early-season root growth may be delayed by cool soil temperatures, with a potentially short time period between harvest to leaf fall.
3) Examine differences in commercial products
   Different commercial products may vary in their effectiveness. These products can also be compared for their cost-effectiveness. For example, a certain product may be cheaper per tonne, but application rates may be higher than a more expensive product.

Measurements and Monitoring

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

The following table includes potential measurements, their time involvement, and difficulty.

Measurements	Time*	Difficulty*
Plant nutrient status (petiole analysis)	1	C
Vine vigour - shoot length	3	A
Baumé	1	A
PH	1	B
Titratable acidity	1	C
Colour (anthocyanins)	2	C
Yield	2	A
Pruning weight	2	A
Bud fruitfulness	1	A
Cane maturation	1	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 nitrogen application should be run for a minimum of three years. The impact of adequate nitrogen to the overall well being of the vine may be difficult to measure in short term trials. The time required to carry out the treatments (for example, nitrogen application) would be approximately 0.5 day. Samples taken at harvest could take approximately 0.5 day for quality parameters.

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
Bud fruitfulness											
Cane maturation											
Pruning weight											
Vine vigour/ Shoot length											
Vine growth stage (phenology)											
Grape yield											
PH											
Baumé											
Titratable acidity											
Colour											

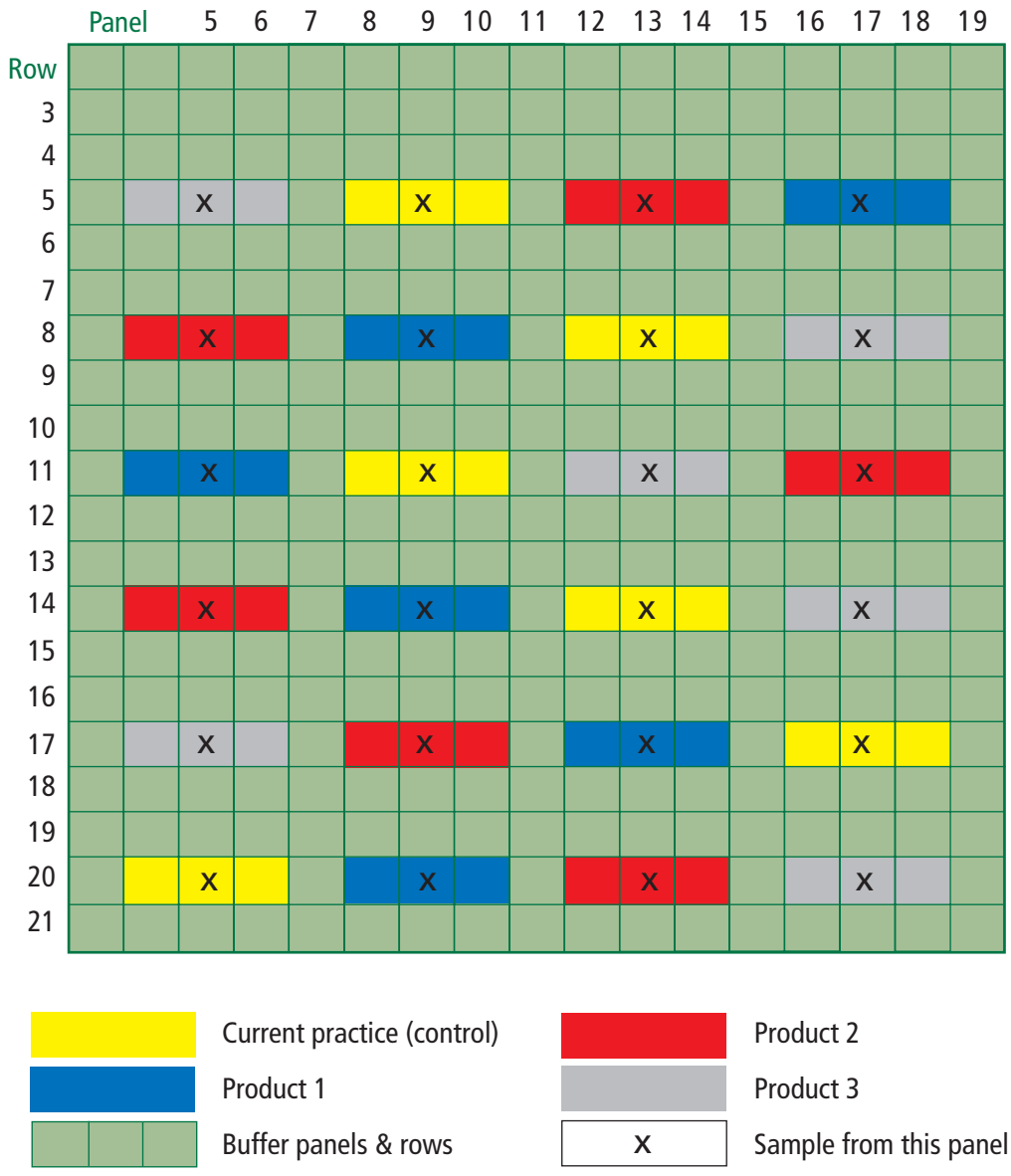
Nitrogen Trial Designs

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 vine nutrition trial consists of three rows by three panels of vines. The middle panel is used for taking measurements (for example, Row 5 Panel 5).

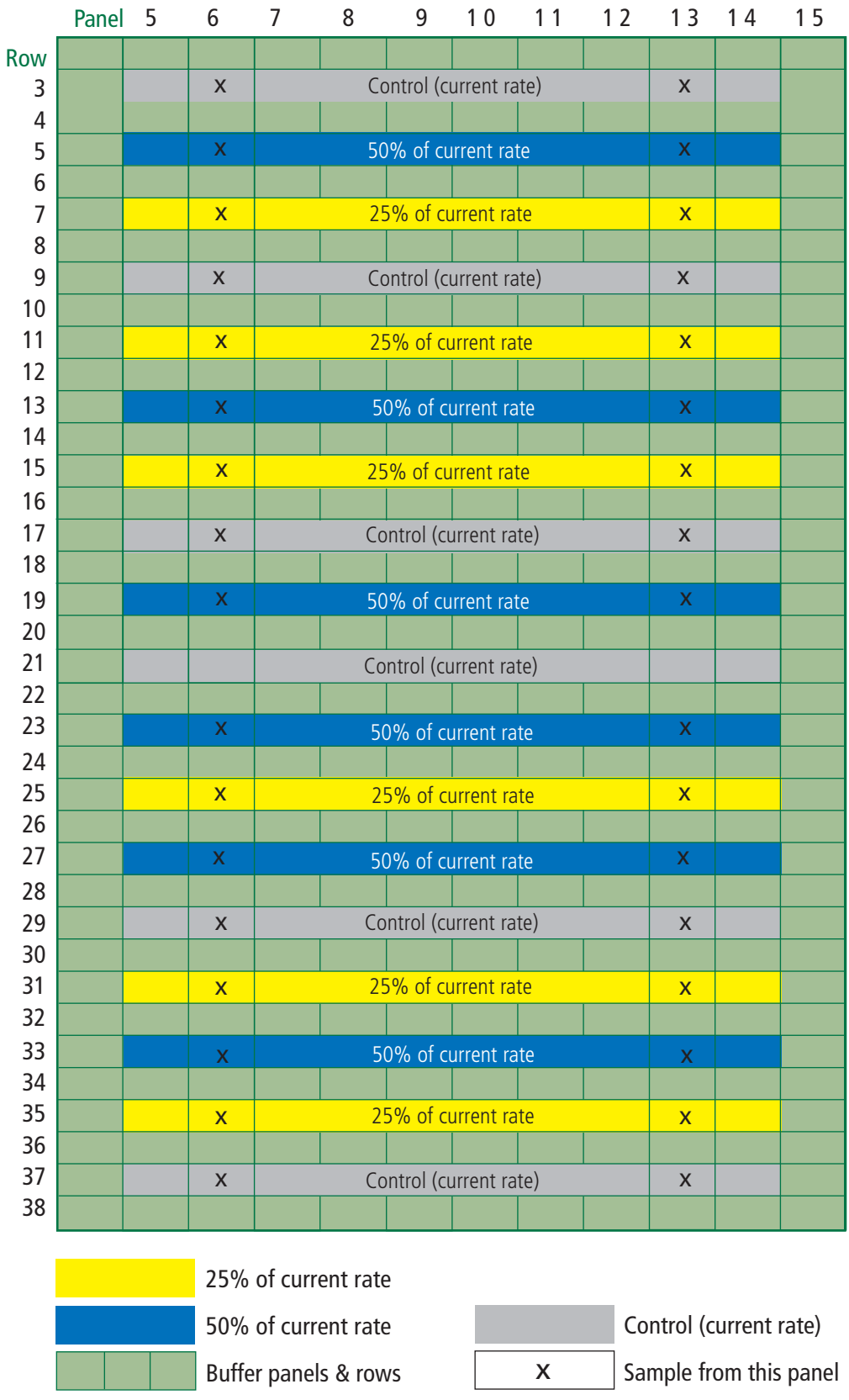
Buffering is important to identify clear treatment areas and to avoid contamination between treatment areas. Buffer zones are marked as panels with grid-lines in the designs shown on the following page.

Design 1: An example of a randomised block design that could be used to test various nitrogen products.



Design 1 gives an example of a trial layout in which the treatments are three nitrogen products plus a control (current practice, no application if applicable). 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 nitrogen products (25% of current rate, 50% of current rate) using rows as experimental units.



A replicated trial can cause difficulties when fertigation is to be used to supply the N due to the continuity of irrigation lines throughout blocks. If the preferred method of using a replicated trial is used, there are 2 potential ways to apply the N:

1. Add the N below the drippers and apply a short irrigation to 'wash' the N into the root-zone.
2. Add the N three-quarters of the way through the irrigation cycle.

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

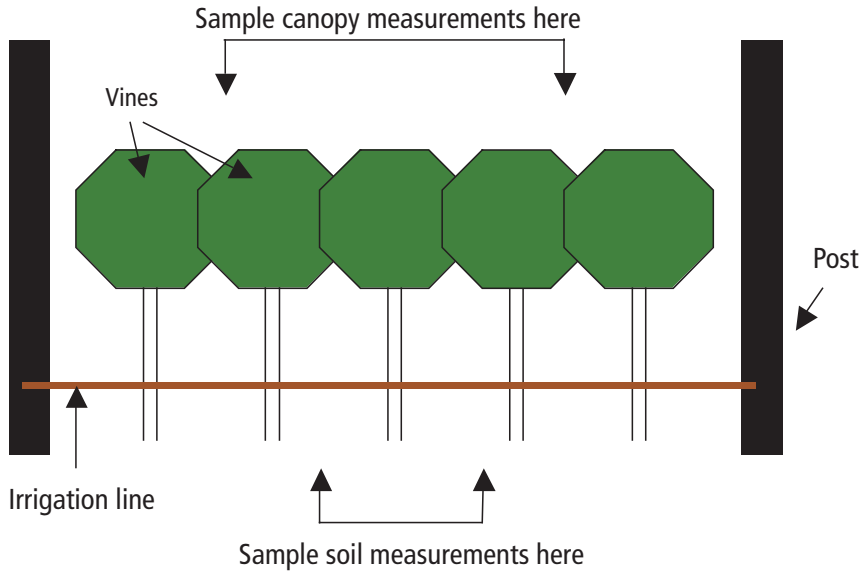
When using rows as experimental units, it is normally anticipated that a maximum of three treatments are trialed due to the potential workload expected. This trial has three treatments and six replications, again arranged in a randomised block design, with the blocks being groups of three adjacent experimental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



Detecting Phosphorus Response in Vineyards - Forms of P, Application Methods and Rates

Aims

The aim of this trial could be to evaluate grapevine responses to applied phosphorus (P) in terms of vine growth, grape yield or quality. Further optional aims could be to:

- Assess the performance of different P containing fertilisers in the vineyard
- Assess how different P contained fertilisers should be applied
- Compare the rates to use
- Decrease phosphorus use
- Improve overall vine health
- Reduce P loss through leaching
- Increase grape production

Important Points to Know

Phosphorus (P) is an important nutrient required for vine growth and grape development, with up to 0.6 kg of P present in each tonne of grapes. P has been shown to contribute towards berry set and structure, and overall bunch weights. Most Australian soils are low in P, with both acid (pH < 5.5) and alkaline (pH > 8.0) soils reducing the amount of P that is available to plants. See Appendix 3.5 for further information on phosphorus deficiency symptoms and other factors that need to be considered when diagnosing for a deficiency. As different P fertilisers are most effective in different soil conditions, it is important to determine which P fertiliser works best in your situation in order to achieve optimum results for the rate of fertiliser applied.

Positive and Negative Aspects

It is important to determine the risks associated with applying different rates of phosphorus 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 the application of phosphorus in vineyards are listed below. These may be used as a guide to risks that may develop.

Positives of the application of phosphorus in vineyards include:

- P application at adequate rates may increase vineyard productivity
- P is important in maintaining vine health
- Application rates more aligned with plant requirements
- Greater understanding of the nutritional requirements of grapevines

Negatives of the application of phosphorus in vineyards include:

- As granular P moves slowly through heavier soil types (clays and clay loams) it may be several seasons before the full benefit of P application is observed
- In very acid soils only a small proportion of applied P is available to plants. A liming program may be required prior to P application

It is important to apply lime to increase the pH prior to P application when soils are acidic. Ideally this should be done before planting, thus allowing lime incorporation into the soil. If applying lime under-vine, allow time for lime to move into the soil before applying P.

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 nutrition program, a cost/benefit analysis should be completed to relate the monetary requirement of Phosphorus applications to a production basis. The risks associated with irrigation comparison program in vineyards must be weighed up against the benefits. This will justify the commitment to the program in the long term.

Before You Get Started

Before setting up a trial to measure plant responses to P application - it is important to determine the severity of the P deficiency, if any. Before trial establishment;

- Conduct a site soil description, collect soil samples down the profile (0-15, 15-30, 30-45 cm layers), bulk over 10 soil auger holes and submit for soil classification and chemical analyses of the site.
- Examine chemical analyses of petioles at peak flowering for nutrient deficiency levels
- Knowledge of current P levels in the vineyard and previous fertiliser history
- Phosphorus fertiliser
- Labour to apply fertiliser and conduct monitoring
- Application equipment (dependent upon application method - vine specific, banded under-vine or broadcast)

Site Suitability

For a site to be suitable for a P trial, it is important to decide if your objective is to (a) determine the level of P deficiency, if any, and remedy it or (b) test the adequacy of current P practices.

Vines

- Young vines slow to establish
- Low vegetative growth
- Declining health of vines
- Declining productivity
- Poor ability to ripen crop
- Poor fruit quality

Water/Irrigation

- Equipment for fertigation
- Use saline irrigation water (>1.0 dS/m)
- Use pure irrigation water (<0.01 dS/m)

Potential Treatments

When considering trials for the amelioration of a P deficiency in vineyards there are three main factors to consider:

1) Different commercial products
a) Organic P sources
b) Ground rock phosphate
c) Single superphosphate
d) Triple superphosphate (TSP)
e) Phosphoric acid
f) Mono-ammonium phosphates (MAP)
g) Di-ammonium phosphates (DAP)

When considering which P fertiliser to use on large areas, the cost of cartage and spreading should be considered. The most economical form should be chosen on the basis of plant-available P per tonne applied. Other factors, such as the acidifying effects of the P source on the soil, P solubility and ease of application must also be considered.

2) Application method
a) Broadcasting
b) Banding
c) Sub-surface placement
d) Through drippers (fertigation)
3) Application rate
a) None (control)
b) Manufacturer rates
c) Half manufacturer rates
d) Rates based on soil and petiole tests

Measurements and Monitoring

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

The following table includes potential measurements for a phosphorus application trial, their time involvement and difficulty.

Measurements	Time*	Difficulty*
Vine petiole analysis	1	A
Soil testing (P)	1	A
Vine vigour/shoot length	3	A
Baumé/Brix	1	A
Titratable acidity	1	C
pH	1	B
Colour	2	C
Yield	2	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 P fertilisers should be run for at least three years to ensure a large proportion of the applied P has been utilised by the vine. The time required to carry out the treatments; eg: phosphorus application would be approximately 0.5 day. The time required for taking soil samples and other soil measurements would be approximately 0.5 day per week per measurements,Phosphorus Trial Designs

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											
Petiole analysis											
Pruning weight											
Yield											
Baumé/Brix											
Soil testing											
Soil pH											

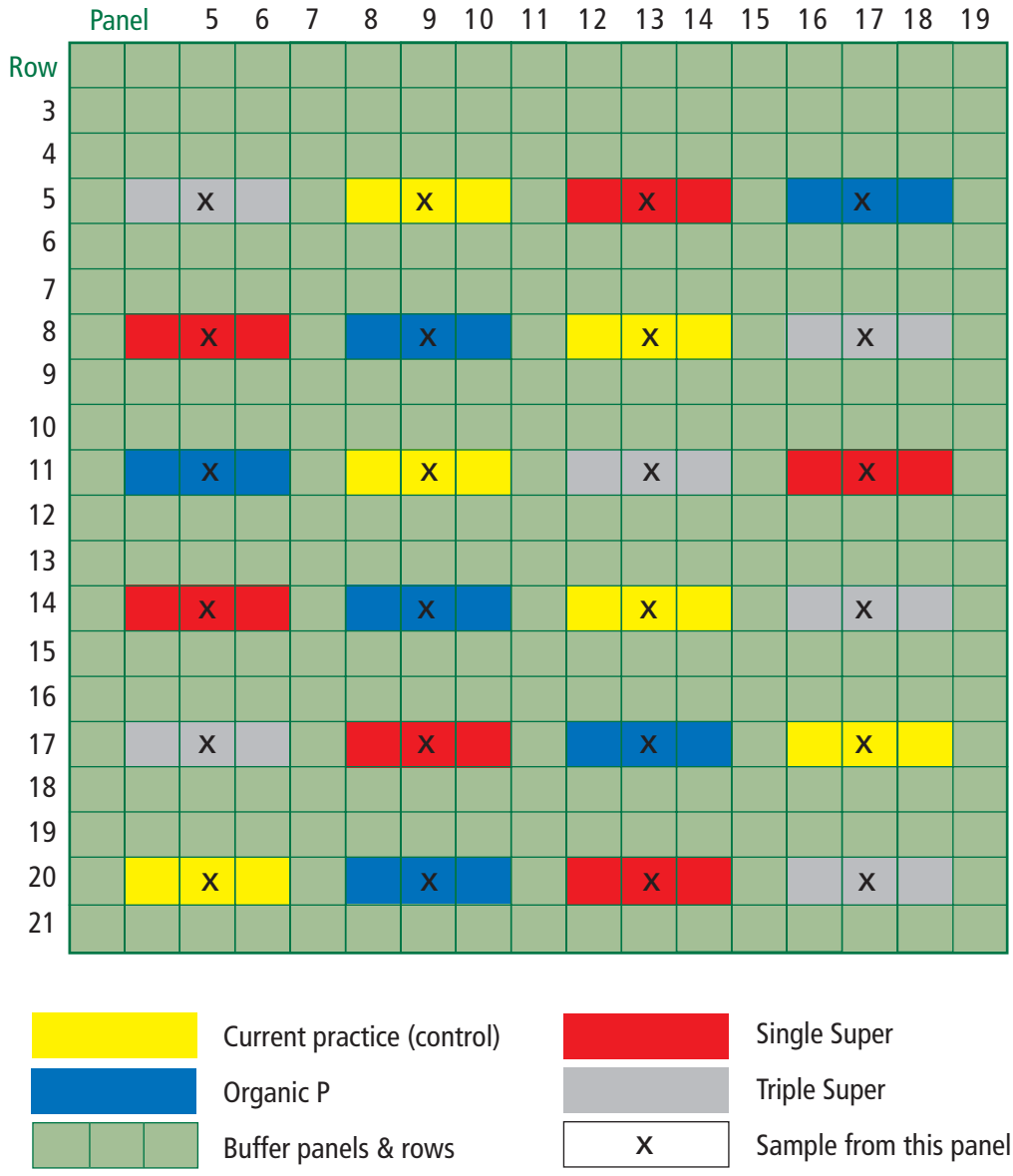
Phosphorus Trial Designs

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 soil improvement trial consists of three rows by three panels of vines.

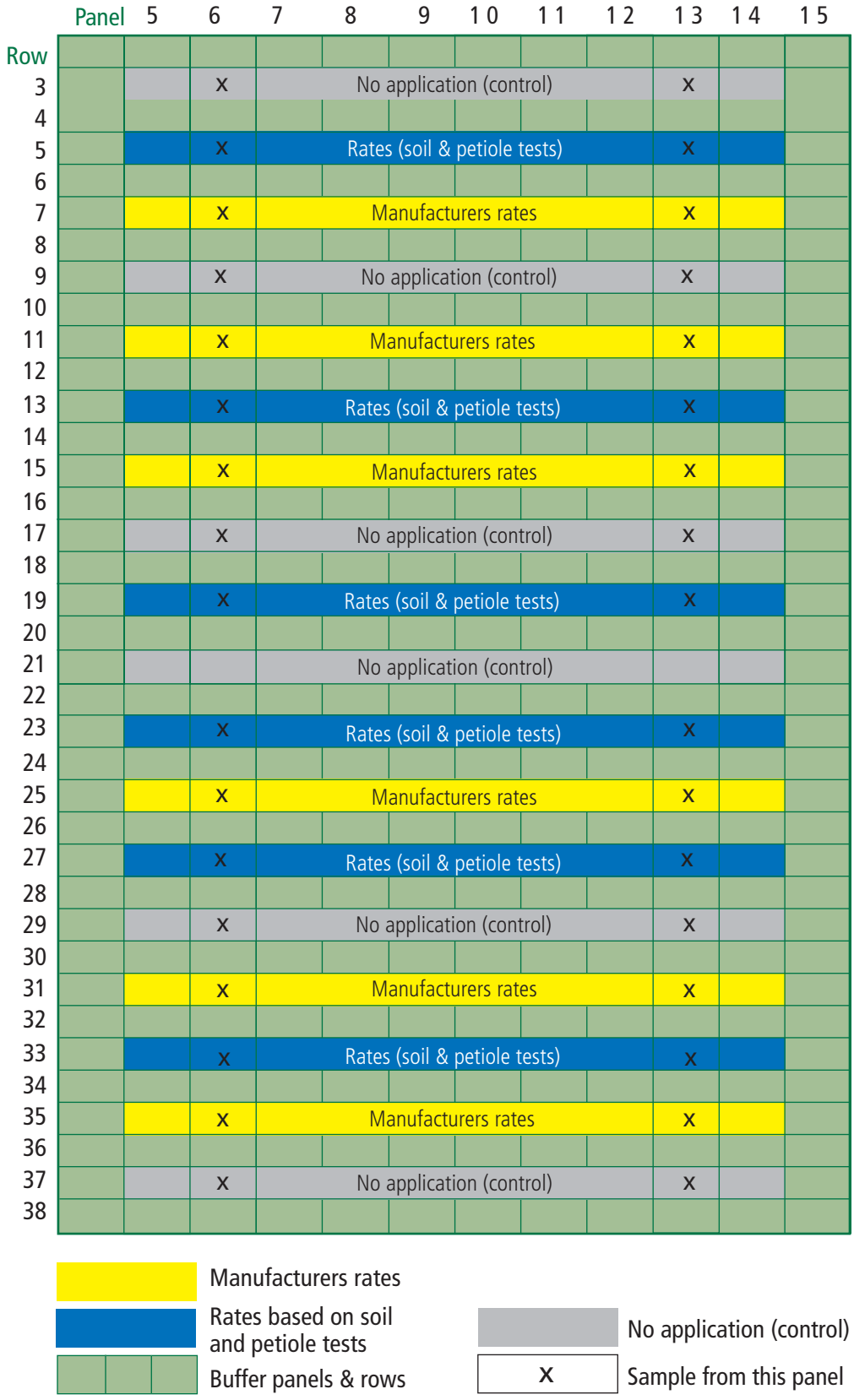
The middle panel is used for taking measurements (for example, Row 5 Panel 5). Buffering is important to identify clear treatment areas and to avoid contamination between treatment areas. Buffer zones are marked as panels with grid-lines in the following designs.

Design 1: An example of a randomised block design that could be used to test various phosphorus products.



Design.1 gives an example of a trial layout in which the treatments are various phosphorus products. 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 phosphorus products (25% of current rate, 50% of current rate) using rows as experimental units.



In order to obtain worthwhile results, a replicated trial should be used. However, this poses difficulties when fertigation is to be used to supply the P due to the continuity of irrigation lines throughout blocks. If the preferred method of using a replicated trial is used, there are 2 potential ways to apply the P:

1. Add the P below the drippers and apply a short irrigation to 'wash' the P into the root-zone.
2. Add the P 3/4 of the way through the irrigation cycle.

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

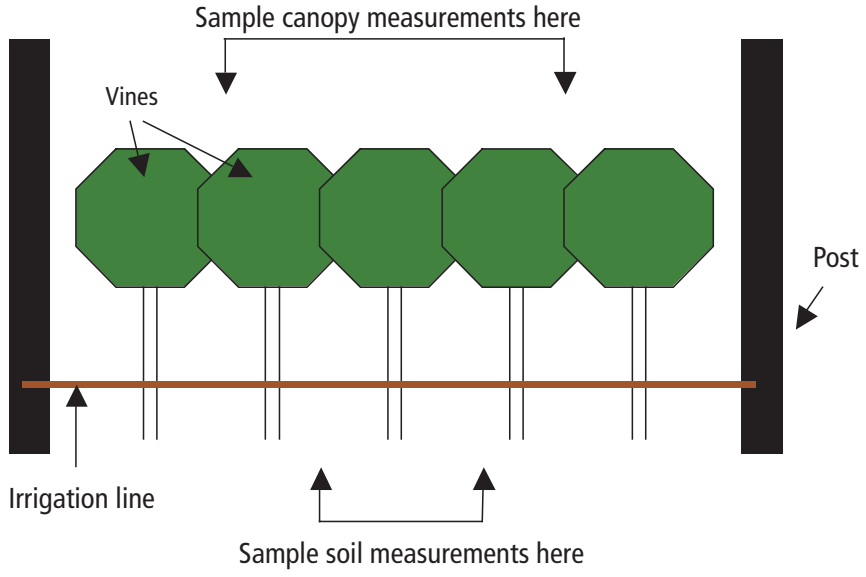
When using rows as experimental units, it is normally anticipated that a maximum of three treatments are trialed due to the potential workload expected. This trial has three treatments and six replications, again arranged in a randomised block design, with the blocks being groups of three adjacent experimental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



Detecting Molybdenum and Other Trace Element Vineyard Trials

Aims

This trial aims to evaluate the vine requirement for molybdenum (Mo) or other micronutrients by:

- Improving fruit set or berry size
- Improving growth on young vines
- Overcoming micronutrient/trace element deficiencies
- Reducing shot berry problems

Important Points to Know

The following information on how to set up a molybdenum trial may be modified for any micronutrient.

Micronutrients are elements essential for plant growth and development. They are only required by the plant in small quantities, usually less than 100 mg/kg or 100 ppm. They include boron (B), chlorine (Cl), copper (Cu), iron (Fe), manganese (Mn), molybdenum (Mo) and zinc (Zn). Micronutrient deficiencies impair the growth, flowering and fruit set of grapevines.

Mo deficiency has been associated with various disorders in newly planted (0-3 years) Merlot vines. These include poor berry development and "shot berries". This results in reduced bunch yields in varieties such as Merlot on own roots, especially when grown in cool temperate regions on acid soils (Williams et al. in prep.). If certain micronutrient deficiencies and/or unfavourable weather conditions occur at flowering, pollen tube growth to fertilize the ovary may be too slow. Furthermore, the tube leading to the female ovary may be damaged so that it cannot conduct pollen tubes through its central canal. Resulting disruption of fertilization may end in "shot berries" (Cholet et al. 2002) or blind bunches (Anon 1999).

Other micronutrient deficiencies such as zinc and boron have also been associated with the "shot berry problem", along with other factors such as low temperatures at flowering and stresses from the previous year (e.g. high crop load or high temperatures). Therefore, application of Mo may not remove the symptoms of green 'buckshot' berries, requiring further work to determine the alternative causes of these symptoms. See Appendix 3.4 for further information on micronutrient deficiency symptoms.

Most essential micronutrients are best applied as foliar sprays, which allows rapid movement of nutrients into plant tissue. Soil applied Mo fertilizer can bind with other compounds in the soil, which cannot be extracted by vine roots. Application of lime and/or phosphorus to acid soils, if correctly incorporated, may increase Mo extractability to the vine roots. However, this approach may take several years, and is highly soil-type dependent.

Positive and Negative Aspects

It is important to determine the risks associated with a molybdenum (or other trace element) application 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 molybdenum application in vineyards are listed below. These may be used as a guide to risks that may develop.

- No significant difference in grape production or vine growth may be evident after micronutrient application, as the deficiency may not occur in a given year.
- Different varieties have different critical levels for nutrient concentrations, resulting in a varied treatment response.
- There may be little published information on critical threshold levels for different micronutrients for different varieties.
- Lack of information on the effects of different micronutrients on fruit set, wine quality and residues
- There is a very fine line between deficiency and toxicity for micronutrients, hence care must be taken not to over-apply as these can have toxic effects on grapevines and reduce yield.
- Different commercial products may vary in their effectiveness. These products can also be compared for their cost-effectiveness. For example, a certain product may be cheaper, but application rates may be higher than a more expensive product. Things to consider and compare are what application rates and what form of fertilizer to use.

Positive aspects of restoring trace element deficiencies include:

- Correcting a trace element deficiency can restore normal growth of vines
- Correcting a trace element deficiency can improve fruit set
- Correcting a trace element deficiency can reduce the "shot berry problem"
- Correcting a trace element deficiency can reduce the number of green "buckshot" berries at harvest

Negative aspects of restoring trace element deficiencies include:

- No substantial differences may be evident upon bunch yield or vine growth after trace element application as deficiency may not occur in a given year
- Different varieties may have different critical nutrient levels and may respond to micro nutrient application to different degrees
- There may be no useful predictive soil or plant test published. That is, the critical nutrient range at any given stage of vine growth to describe what are deficient, marginal, adequate or toxic concentrations of a given micronutrient for optimal vine growth, bunch yield and berry size.
- Little research has been published on the effects of trace elements on fruit set, wine quality and residues in berries
- Recommended application rates of some micronutrients may not exist for vines
- Care must be taken not to apply excessive rates of trace elements (e.g. B and Mn), as these can have toxic effects on grapevines and reduce yield (Anon 1999)

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 impacts of any risks occurring?

Cost Benefit Analysis

In order to determine the economic viability of a micro-element program, a cost/benefit analysis should be completed, to relate the economic requirement of molybdenum (or any other micronutrient) application to a production basis. The risks associated with a micronutrient application program in vineyards must be weighed up against the benefits, which will determine the level of commitment to a micronutrient application program in the long term.

Before You Get Started

The following points will help you prepare for this trial:

Before trial establishment:

- Conduct a site soil description, collect soil samples down the profile (0-15, 15-30, 30-45 cm layers), bulk over 10 soil auger holes and submit for soil textural classification and chemical analyses of the site.
- Examine chemical analyses of petioles at peak flowering for nutrient deficiency levels

The resources required include:

- Micronutrient fertiliser (eg. sodium molybdate).
- Spray equipment (depending on mode of application eg knapsack or airblast spray rig, etc.).
- Scales for weighing amount of fertiliser per plot harvest yield.
- Labour to conduct the trial, including spraying, petiole and soil sampling, harvest and post harvest measurements.
- Knowledge of vine growth stages (e.g. first inflorescence appearance).
- Grape yield (bunch weight and number per vine, etc.)

Site Suitability

Vines

- Vines exhibit micronutrient deficiency symptoms (Appendix 3.4)
- High crop load in the previous year.
- Heat and water stress in the previous year.

Soils and Regions

- Low soil pH reduces Mo extractability from soils by vine roots, hence requiring greater application rates.

Climate

- Periods of cold, wet windy weather during flowering and early berry development.
- Cool, temperate growing conditions may cause soils to release less Mo in the spring for vine root uptake.
- Cool, wet spring conditions may accentuate Mo deficiency and 'hen and chickens' problems.

Potential Treatments

1) Compare rates of molybdenum application
a) None
b) Molybdenum application
2) Examine impact of timing of application
a) None (control)
b) Shoots at 10 cm (E-L 12 - 15) and at 10 leaves separated (E-L 15-18)
c) Start of flowering (E-L 19)
d) Combination of b. and c.
3) Compare different commercial products

If resources are limited, it is desirable to select a nil and an adequate rate, applied at the most effective time, using the most appropriate form of nutrient, as determined through consultation with a local consultant or state government agency.

Measurements and Monitoring

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

The following table includes potential measurements for this type of trial, their time involvement, difficulty, and during which period they are to be carried out.

Measurements	Time*	Difficulty*
Plant nutrient status (petiole analysis)	1	C
Shoot Length	1/2	A
Bunch dissection	2	B
Baumé/Brix	1	A
pH	1	B
Titratable acidity	1	C
Yield	1	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 micronutrients should be conducted for a minimum of three years. Vines may show more response in certain years, for example, cold, wet spring conditions in temperate regions may enhance the chance of vine responses to Mo sprays. The time required to apply the treatments by spray application would be approximately 0.5 day. The time required for taking soil samples and other soil measurements would be approximately 0.5, as well as 0.5 day for shoot length. The time required for measurements at harvest would be approximately one day for bunch sampling for quality parameters.

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	Shoots 20 cm	50% -80% capfall	Berry set	Berries pea-size	Bunch closure	Veraison	Harvest	Post-harvesty
Shoot length											
Spray Applications											
Petiole Sample											
Soil Sample											
Soil Nutrients											
Soil pH											
Soil texture											
Bunch Weights											
Bunch Dissections											
Quality											

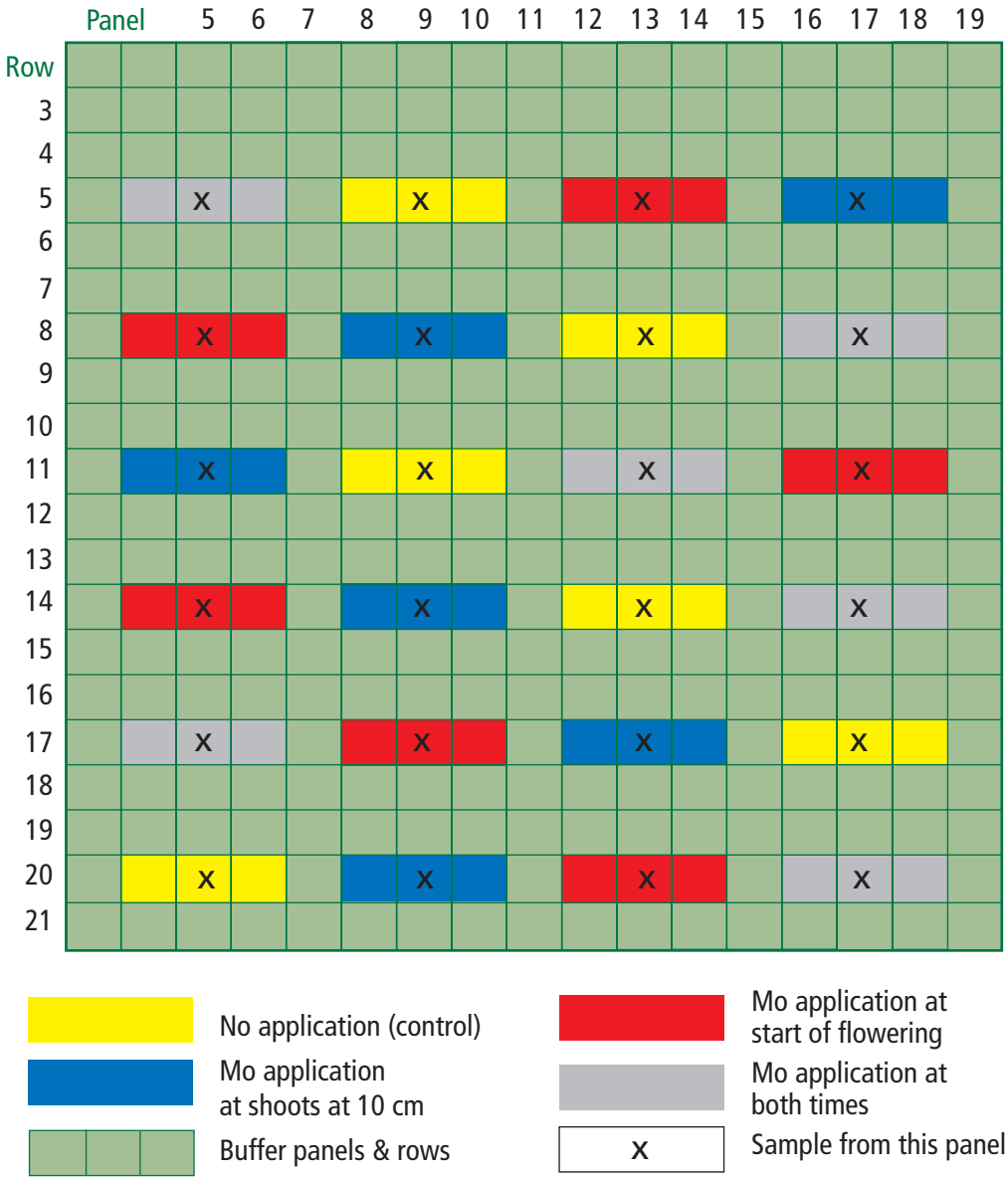
Molybdenum and Other Trace Elements Trial Designs

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 soil improvement trial consists of three rows by three panels of vines.

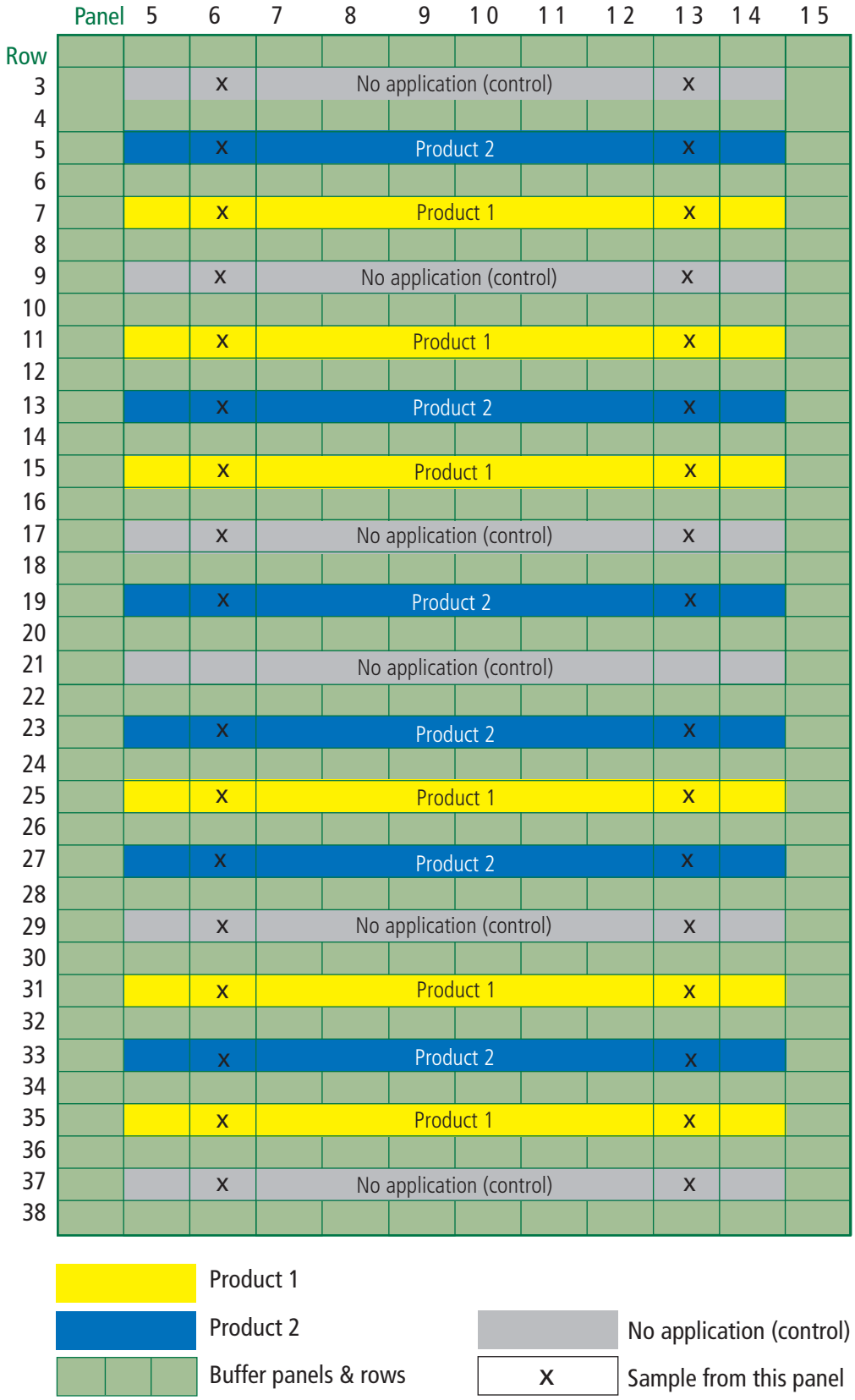
The middle panel is used for taking measurements (for example, Row 5 Panel 5). Buffering is important to identify clear treatment areas and to avoid contamination between treatment areas. Buffer zones are marked as panels with grid-lines in the following designs.

Design 1: An example of a randomised block design that could be used to test various application times of molybdenum.



Design 1 gives an example of a trial layout in which the treatments are three application times of molybdenum plus a control (no application). 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 molybdenum products using rows as experimental units.



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

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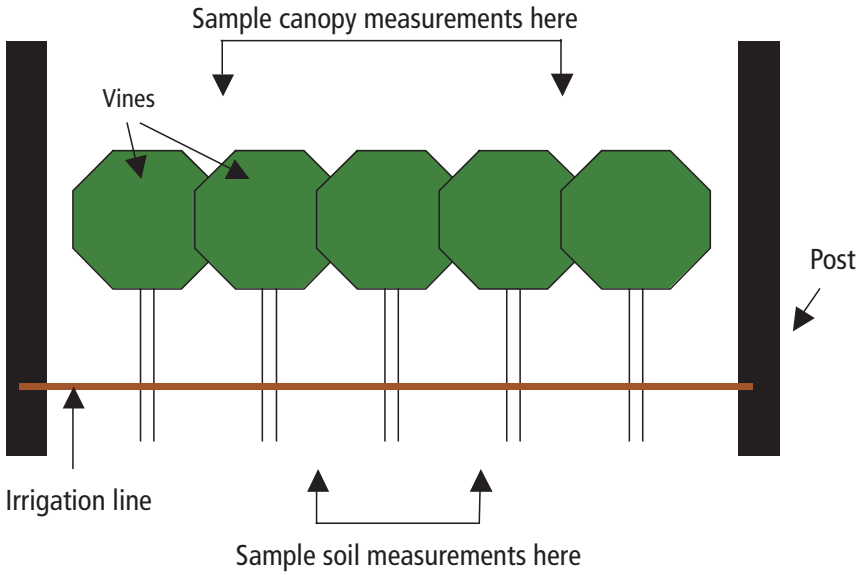

Resources

Some useful resources for nitrogen trials include:

- Braybrook D., Robinson B., Treeby M., Grieger G. and Retallack M. (2001) Nitrogen management for improved quality and sustainability. The Australian Grapegrower and Winemaker Annual Technical Issue 449a: 95 - 96
- Dale M. and McClure P. (1998) Control of nitrogen loss from irrigation. Australian Viticulture 2 (1): 40 - 45
- Hackett S. (1998) Sampling for a vine's nutritional needs. Australian Viticulture 2 (5): 29 - 30
- Williams C. and Bartlett L. (2003) Molybdenum and other trace element vineyard trials In: Laukart N. and Joyce D.C. (edts) 'Participatory On-Farm Trials for Viticulture Manual.' (Cooperative Research Centre for Viticulture, Adelaide, S.A.)
- Schefe C. and Slattery W. (2003) Trials to detect phosphorus response in vineyards: forms of P, application methods and rates In: Laukart N. and Joyce D.C. (edts) 'Participatory On-Farm Trials for Viticulture Manual.' (Cooperative Research Centre for Viticulture, Adelaide, S.A.)
- Nagarajah S. (2000) Improving grapevine nutrition by taking out the guesswork. Australian Viticulture 4 (3): 60 - 65
- Treeby M and Holzapfel B. (1998) Base management decisions on measurements plus research. Australian Viticulture 2(2): 14 - 15

Some useful resources for phosphorus trials include:

- Anon (1999) Grapevine nutrition: Research to Practice Training Workshop Manual. NRE and Scholefield Robinson HS, et al. (edts) Department of Primary Industries, 1999.
- Coombe B.G. and Dry P.R. (1992) Viticulture Vol. 2 Practices Winetitles: Adelaide
- Follett R.H., Murphy L.S. and Donahue R.L. (1981) Phosphorus Fertilisers In: 'Fertilisers and soil amendments' Prentice-Hall.
- Wheaton A.D. and Shearer D. (2003) Managing nitrogen inputs to optimise grape yield and quality In: Laukart N. and Joyce D.C. (edts) 'Participatory On-Farm Trials for Viticulture Manual.' (Cooperative Research Centre for Viticulture, Adelaide, S.A.)
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- McLaughlin, Coyle, Chittleborough (1995) Physical and chemical characterisation of phosphorus in soil solutions and soil leachates In: 'Nutrient Management in Irrigated Agriculture - Research and Implementation' Conference Proceedings, June 19-20, 1995, Agriculture Victoria, Institute of Sustainable Irrigated Agriculture.
- Tisdale S.L . (1993) Soil fertility and fertilisers. 5th Edition. Macmillan London.

Resources

Some useful resources for molybdenum trials include:

- Anon (1999) Grapevine Nutrition: Research to Practice, Training Manual. Editors NRE, Scholefield Robinson, et al. (1999). Department of Primary Industries, Victoria
- Cholet C., Mondolot L. and Andary C. (2002). New histochemical observations of shot grapevine berries. The Australian Journal for Grape and Wine Research 18: 126-131
- Coombe B.G. (1997) Grape Phenology. In: Coombe B.G. and Dry P.R. (edts) ' Viticulture: Volume 1 Resources' (Winetitles, Adelaide) pp 134-153.
- Wheaton A.D. and Shearer D. (2003) Managing nitrogen inputs to optimise grape yield and quality In: Laukart N. and Joyce D.C. (edts) 'Participatory On-Farm Trials for Viticulture Manual.' (Cooperative Research Centre for Viticulture, Adelaide, S.A.)
- Schefe C. and Slattery W. (2003). Trials to detect phosphorus response in vineyards: forms of P, application methods and rates In: Laukart N. and Joyce D.C. (edts) 'Participatory On-Farm Trials for Viticulture Manual.' (Cooperative Research Centre for Viticulture, Adelaide, S.A.)
- Reuter D.J. and Robinson J.B. (edts) (1997). Plant analysis: An interpretation manual. CSIRO Australia.
- Williams C., Maier N., Bartlett L. and Robinson J.B. (in press). Effects of molybdenum on the yield, berry development and petiole chemical composition of Merlot grapes grown on acid sandy loams in a cool climate. The Australian Journal for Grape and Wine Research.